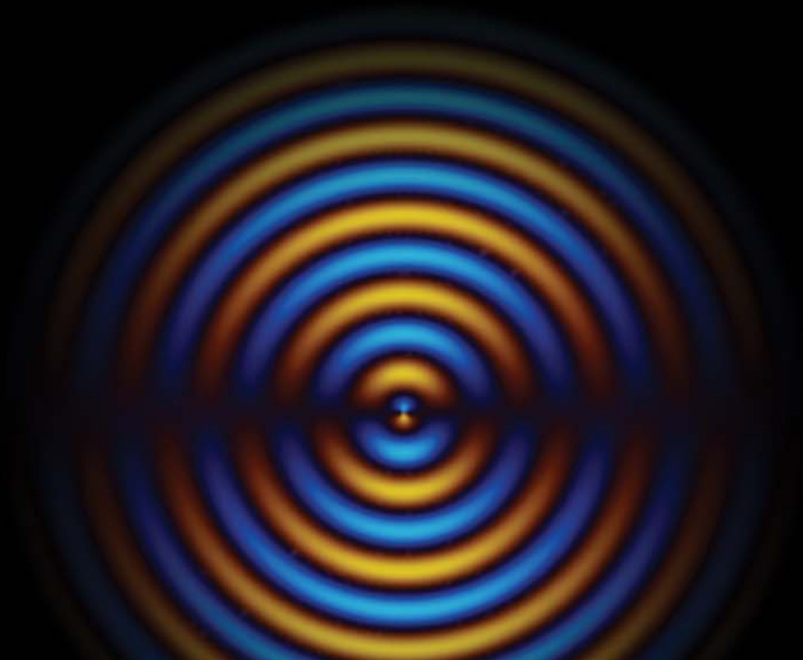
THE UNIVERSE IS ONLY SPACETIME

PARTICLES, FIELDS AND FORCES DERIVED FROM THE SIMPLEST STARTING ASSUMPTION



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Particles, Fields and Forces

Derived from the Simplest

Starting Assumption

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Original Draft – February 2010

Revision 7.0 – January 2013

Dedication: I dedicate this book to my wife, Enid, who has encouraged me and tolerated my idiosyncrasies over the years.

Acknowledgments: I wish to thank my friend, Dr. Nikolai Yatsenko, for volunteering to spend many hours teaching me aspects of quantum mechanics and general relativity. During these lessons I began the first steps of formulating a conceptually understandable model of the universe. Also Dr. Chris Ray has provided helpful comments on the text. Finally, I would like to thank Francis William Browne for editing the book.

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Introduction

In most introductory classes on quantum mechanics, the physics professor starts out by explaining to the students that they are going to learn about certain properties of subatomic particles that are simply not conceptually understandable. For example, subatomic particles can discontinuously jump from one point to another without passing through the surrounding space. Fundamental particles exhibit angular momentum even though they are virtually point particles. An isolated molecule can only rotate at specific frequencies. Two entangled photons can communicate faster than the speed of light over large distances – etc. These and many other quantum mechanical effects are not understandable when analyzed using current conceptual models of particles and forces.

To be fair, a strict application of the principles of quantum mechanics does not strive to give a physically understandable explanation of these phenomena. Instead, the objective of quantum mechanics is to describe rules of each quantum mechanical operation and mathematical equations which describe these operations. For example, an electron is described as a point particle because this mathematical simplification is adequate to obtain useful equations. As Paul Dirac said, the aim is "not so much to get a model of an electron as to get a simple scheme of equations which can be used to calculate all the results that can be obtained from experiment"[1].

Today, physicists have learned to suppress their innate desire for conceptual understanding. The explanation given for our inability to conceptually understand quantum mechanical phenomena ultimately implies that the human brain evolved to understand the macroscopic world. Therefore, we simply should not expect to conceptually understand the properties of subatomic particles or photons. These concepts are just too far removed from our hunter gatherer roots. Over time we reluctantly learn to accept abstract quantum mechanical concepts and regard the desire for conceptual understanding as a remnant of classical physics. However, the importance of a model that gives conceptual understanding should not be minimized. If there really is an underlying simplicity to all of physics, then understanding this most basic model not only simplifies the teaching of physics, but also makes it easier to extend this model and make testable predictions which advance science. Such a model would be a powerful new tool that would greatly accelerate the rate of new discoveries.

There is clear evidence that the current starting assumptions for quantum mechanical calculations contain at least one error. When calculations fall apart and yield an impossible answer such as infinity, these equations are screaming that a rigorous extension of the starting assumptions gives nonsense. Renormalization might seem to fix the problem, but this is merely artificially adjusted the answer so that it is no longer logically derived from the starting assumptions. Instead the unreasonable answer should be taken as an indication that the model being analyzed contains at least one erroneous assumption. Every time an incorrect

[1] P. A. M. Dirac, "Classical Theory of Radiating Electrons," Proc. Royal Soc., vol. 168, (1939)

assumption is utilized, the mathematical analysis must yield an incorrect answer (garbage in, garbage out). Our inability to conceptually understand parts of quantum mechanics is a further indication that we are using an incorrect model. The approach taken in this book is to explore the possibility that there really is an underlying simplicity beneath the counter intuitive complexity of quantum mechanics. This is equivalent to saying that we are looking for the fabled "Theory of Everything". A logical starting point for this search should be to start with the simplest possible starting assumption which is: **The universe is only spacetime**.

This simplest possible starting assumption implies that there is only one fundamental force, only one fundamental field and only one fundamental building block of all particles. Furthermore, even though forces, fields and particles appear to be very different, the starting assumption implies that on a deeper level they are all just different aspects of 4 dimensional spacetime. If this starting assumption is wrong, it should quickly become obvious because the properties of 4 dimensional spacetime are very limiting. Unlike the current state of physics which is free to postulate any number of dimensions, multiple universes, vibrating strings, messenger particles, etc., this starting assumption is very restrictive. All particles, fields and forces must be derived from only the properties of 4 dimensional spacetime.

Before the time of Galileo, the world was viewed as being full of mysterious occurrences which were either not questioned or attributed to the supernatural. With the dawn of the age of analytical science, it was realized that many of the mysteries were knowable and could be explained with laws of physics. The moon, planets and stars were not held above the earth by crystal spheres. The same gravity that caused a rock to fall here on earth also caused the moon to have a predictable orbit around the earth. What was previously considered an unknowable mystery was explained through deductive reasoning, mathematics and the application of the scientific method.

We have come a long way since the time of Galileo, but even today we have many mysteries that are considered beyond human understanding. For example, we have a multitude of mysterious effects that we attribute to different types of "fields". We can write equations that describe the effects of these "fields", but we really do not attempt to conceptually understand the "fields" themselves. I see an analogy to the time before Galileo and our present day attitude towards fields being physically unknowable. For example, how and why does matter cause a curved spacetime field? What is the physical difference between the field produced by a positively charged particle and a negatively charged particle? Do electric and magnetic fields produce a distortion of spacetime?

If the universe is only spacetime, then even mysterious "fields" should be knowable. For example, a new constant of nature will be proposed that quantifies the distortion of spacetime produced by an electric field and electromagnetic radiation. Also the concept that the universe is only spacetime has profound implications for science. This book makes the case that all particles, fields and forces are made of the single building block of 4 dimensional spacetime. However, this is not the quiet, smoothly curving spacetime envisioned by Einstein. His model of spacetime only describes spacetime on the macroscopic scale. All the action (energy) is on the quantum mechanical scale where spacetime is full of activity. This quantum mechanical model of spacetime is analyzed and found to possess the properties that allow it to be the single building block of everything in the universe.

Gravity is very well understood on one level, but it also has many mysteries. Why is the force of gravity vastly weaker than the other 3 fundamental forces? Why does gravity have only one polarity (always attracts)? Is gravity even a true force or merely the result of the geometry of spacetime? Can gravity be unified with the other forces? If we assume that the universe is only spacetime, then we bring a new perspective to explaining the mysteries of gravity. Both fundamental particles and the force of gravity can be derived from this starting assumption. There is no need to make an analogy to acceleration to explain the force of gravity. Furthermore, this approach makes a prediction about a previously unknown relationship between the gravitational force and the electromagnetic force. This prediction is easily proven correct and it confirms that these two forces are closely related.

The standard model of particle physics has passed many tests. However, many mysteries still remain. The conventional models say that fundamental particles are either point particles or Planck length vibrating strings that are virtually point particles. Neither of these models explains numerous quantum mechanical properties of fundamental particles. For example, how do fundamental particles discontinuously move from point to point without passing through the intermediate space? How do they possess angular momentum of ½ ħ when they are virtually points? How much of an electron's energy is stored in its electric/magnetic field? How does it exhibit both wave and particle properties? Is a fundamental particle made of some even more fundamental building block? This book shows that when fundamental particles are assumed to be made of spacetime (the quantum mechanical model of spacetime), then these counter intuitive properties can be explained. They become conceptually understandable and mathematically quantifiable. Furthermore, this model gives predictions about gravity and electric fields.

To most scientists this starting assumption (the universe is only spacetime) will initially seem impossible. How can matter, light, galaxies and the forces of nature be obtained from what appears to be the empty vacuum of spacetime? Well, the quantum mechanical model of spacetime proposed here is far from being a featureless void. Besides having well known properties such a speed of light and a gravitational constant, it also has impedance and a bulk modulus. Most important, the quantum mechanical version of spacetime is full of activity. Vacuum fluctuations (zero point energy) imply that vacuum has a vast energy density. Yet experiments and analysis seem to indicate an empty void. The measurable energy density of space from cosmology is about 10^{120} times less than the energy density implied by the quantum mechanical model of a vacuum. The common assumption is that something must cancel out the implied tremendous energy density of vacuum. The alternative proposed here is that the vacuum really does have this tremendous energy density, but there is a key difference between the energy that we can detect and the energy that we cannot detect. It is not necessary to assume energy cancelation, it is only necessary to understand the difference between the two types of energy (fermions/bosons versus vacuum energy).

This book attempts to show that the biggest mysteries of quantum mechanics become conceptually understandable when we adopt the model that builds particles and forces from the quantum mechanical properties of spacetime. Limitations of the human intellect have nothing to do with our inability to conceptually understand the mysteries of quantum mechanics and general relativity. We have been using the wrong models! The human intellect can understand anything in nature provided that we are using the correct model.

The model of the universe described here is shown to be compatible with existing laws and equations of physics. The concepts are checked to confirm plausibility by numerous calculations. Most of these are algebraic calculations so that the book is accessible to a wide audience of readers that are scientifically knowledgeable but not necessarily specialists. The few calculations that go beyond this basic level are handled in a way that the reader can grasp the result without necessarily following the mathematics.

The content of this book was not first presented in technical papers because the subject is just too large. It is necessary to lay out a series of introductory ideas, and then weave these concepts into a single coherent theory. A large part of the appeal of this approach is how a single starting assumption can answer so many diverse questions in physics.

(Note: The first three chapters lay important groundwork that prepares the reader to understand the proposed model. These chapters have a strong emphasis on physical interpretation and definitions. To establish a common base of physical interpretation, it is necessary to sometimes present explanations about quantum mechanics or general relativity that experts will find elementary. The objective of introducing these elementary concepts is to provide a shared explanation for the physical interpretations that are being used in the remainder of the book. Development of the wave based model of the universe starts in earnest in chapter #4.

Chapter 1

Confined Light Has Inertia

At the end of this chapter there is Appendix A that gives a more rigorous mathematical analysis of the concepts first presented using only algebraic equations. It is therefore possible to read this chapter on two levels.

Light in a Reflecting Box: The concepts presented in this book started with a single insight. I realized that if it was possible to confine light in a hypothetical 100% reflecting box, the confined light would exhibit many of the properties of a fundamental particle. In particular, a confined photon would possess the same inertia (rest mass) and same weight as a particle with equal internal energy ($E = mc^2$). If the box is moving, a confined photon also exhibits the same kinetic energy, same de Broglie waves, same relativistic length contraction and same time dilation as an equal energy particle.

It is an axiom of physics that a photon is a massless particle. Massless particles do not have a rest frame of reference. They are moving at the speed of light in any frame of reference. However, if light is confined in a box, it is forced to have a specific frame of reference. This "confined light" then exhibits properties normally associated with a rest mass of equivalent energy ($m = E/c^2$) in the frame of reference of the box. This will first be analyzed using the following special relativity equation:

$m^2 = \left(\frac{E}{c^2}\right)^2 - \left(\frac{p}{c}\right)^2$ where: p is momentum and E is energy (equation 1)

Note to the reader: The first time symbols are used, they will be identified in the text. All the symbols used in the book and the important equations are also available in Chapter 15. It is recommended that you take a moment and look at chapter 15. If you are reading this book online, it is recommended that you print out Chapter 15 (10 pages) as an essential quick reference.

If a "particle" has energy of $E = pc$, then substituting this into the above equation gives:

$$m^2 = \left(\frac{p^2c^2}{c^4}\right) - \left(\frac{p^2}{c^2}\right) = 0$$

In other words, when $E = pc$, then a "particle" has no rest mass. Now, momentum is a vector, so a very interesting thing happens when we apply equation #1 to confined light. For example, a single photon confined between two reflectors is a wave traveling both directions simultaneously. The total momentum of this photon is zero because the two opposite momentum vectors nullify each other. Substituting $p = 0$ into the equation #1 yields: ($m = E/c^2$). In other words, confined light satisfies the definition of rest mass.

Another example of a photon gaining rest mass is a photon propagating through glass. If the glass has an index of refraction of 1.5, then the photon propagates at only 2/3 the speed of light in a vacuum and the momentum of the photon is reduced. The photon does not change energy when it enters the glass, but some of its momentum is imparted to the glass upon entrance and this momentum is returned to the photon upon exit. While the photon is propagating in the glass, it can be thought of as possessing some rest mass because $E \neq pc$. In other words, glass that has light propagating through it has more total mass (more inertia) than the same glass without any light propagation. It is also possible to analyze this more deeply and get into forward scatter and phase shifts introduced by the atoms of the glass. This analysis implies that the light has undergone partial confinement as it propagates through the glass at less than the speed of light in a vacuum. This partial confinement adds a small amount of "rest mass" to the glass.

The following example gives a deeper physical insight into how it is possible for confined light to exhibit mass. Suppose that a laser cavity has a 1 meter separation between two highly reflective mirrors. This is a 2 m (6.67 ns) round trip for light reflecting within this cavity. Light exerts photon pressure on absorbing or reflecting surfaces. The force exerted on an absorbing surface is $F = P/c$ or twice this force is exerted on a reflecting surface $F = 2P/c$ where $F =$ force and $P =$ power. If the laser in this example had 1.5 x 10^8 watts circulating between the two mirrors (reflecting surfaces), the energy confined between the two mirrors would be equal to 1 Joule and a force exerted by the light on each mirror would be one Newton in an inertial frame of reference.

Suppose that the laser is accelerated in a direction parallel to the optical axis of the laser. In the accelerating frame of reference, there would be a slight difference in the frequency of the light striking the two mirrors because of the mirror acceleration that occurs during the time required for the light to travel the distance between the two mirrors. The front mirror in the acceleration direction would be reflecting light that has Doppler shifted to a lower frequency compared to the light that is striking the rear mirror. If we return to the example of 1.5 x 10^8 watts of light circulating between two mirrors separated by one meter, then the force exerted against the front mirror would be slightly less than one Newton and the force exerted against the rear mirror would be slightly more than one Newton because of the difference in Doppler shifts. This force difference can be interpreted as the force exerted by the inertia of 1 Joule of confined light. The inertia of 1 Joule of confined light exactly equals the inertia of a mass with 1 Joule of internal energy (1.11 x 10^{-17} kg). For comparison, this mass is equal to about 6.6 billion hydrogen atoms.

While general relativity treats energy in any form the same, particle physics does not. The Standard Model of particle physics suggests that leptons and quarks require the hypothetical Higgs field to create the inertia of these particles. Therefore, in this example 6.6 billion hydrogen atoms require a Higgs field for inertia but an equal energy of confined light exhibits equal inertia without the need of a Higgs field. In fact, the inertia exhibited by the confined light is ultimately traceable to the constancy of the speed of light.

If we place the laser with 1 Joule of confined light stationary in a gravitational field, the confined light will exert a net force on the two mirrors equivalent to the weight expected from 6.6 billion hydrogen atoms. If the laser is oriented with its optical axis vertical, then the net force difference comes from what is commonly called the gravitational red/blue shift. This name is a misinterpretation that will be discussed later. The point is that more force is exerted on the lower mirror than the upper mirror because of the gravitational gradient between these two mirrors. If the laser is oriented horizontally, there will be gravitational bending of the light. The mirror curvature normally incorporated into laser mirrors easily accommodates this slight misalignment. However, the bending of light introduces a downward vector component into the force being exerted against both mirrors. This vector component is the weight of the light. It is true that general relativity teaches that energy in any form exhibits the same gravity. Therefore the gravitational similarity is expected. However, this does not automatically translate into giving inertia to quarks and leptons.

Confined light also exhibits kinetic energy when it is confined in a moving frame of reference. Suppose that the laser with 1 Joule of confined light travels at a constant velocity relative to a "stationary" observer. Also suppose that the observer sees the motion as traveling with the optic axis of the laser parallel to the direction of motion. The stationary observer will perceive that light propagation in the direction of motion is shifted up in frequency and light propagating in the opposite direction is shifted down in frequency. Combining these perceived changes in frequency result in a net increase in the total energy of the confined light. (Appendix A) This energy increase is equal to the kinetic energy which would be expected from the relative motion of a mass of equal internal energy. Appendix A also shows that the energy increase (kinetic energy) is correct even for relativistic velocities. The kinetic energy of the confined light is ultimately traceable to the constancy of the speed of light.

Confined Black Body Radiation: Thus far, the example of confined light has used a laser with highly reflecting mirrors. An alternative example could use an ordinary cardboard box at a temperature of 300°K with an internal volume of 1 m^3. The blackbody radiation within this box would have infrared light being emitted and reabsorbed by the internal walls. For the stated conditions, the blackbody radiation within the box would be about 6.1×10^{-6} J of radiation in flight within the volume of the box at any instant. This energy is equivalent to the annihilation energy of about 40,000 hydrogen atoms. Even though the black body radiation example is slightly harder to see, the result is similar to having reflecting walls. The confined black body radiation exhibits inertia, weight and relative motion exhibits kinetic energy. Carrying this blackbody radiation example further, let's consider the sun with a core temperature of about 15,000,000°K. At this temperature, the radiation is primarily at x-ray wavelengths. This confined x-ray radiation has inertia equivalent to about a gram per cubic meter. At a higher temperature where a star can burn carbon, the inertia of the confined x-rays is equivalent to the inertia of an equal volume of water (density = 1000 kg/m^3). Once again, no Higgs field is required for confined radiation to exhibit inertia.

The examples used above had bidirectional light traveling in a laser or multi directional light traveling within a black body cavity. It would also be possible to confine light by having the light traveling in a single direction around a closed loop. For example, light could be confined by traveling around a loop made of a traveling wave tube or fiber optics. Also, it is not necessary to limit the discussion to light. Gravitational waves are also massless because they propagate energy at the speed of light. There are no known reflectors for gravitational waves, but it is hypothetically possible to imagine confined gravitational waves. If there were confined gravitational waves, they would also exhibit the rest mass property of inertia and exhibit kinetic energy when the confining volume exhibits relative motion.

A photon is often described as a "massless particle". We now see that a qualification should be added because only a freely propagating photon is massless. A confined photon possesses rest mass (possesses inertia). Both photons and gravitational waves are examples of energy propagating at the speed of light. In chapter 4 another form of energy propagating at the speed of light will be introduced (waves in spacetime). This also exhibits inertia when confined. From these considerations, the following statement can be made:

Energy propagating at the speed of light exhibits rest mass (inertia) when it is confined to a specific frame of reference.

Constraint on Higgs Mechanism: Imagine what it would be like if confined light (or confined gravitational waves) exhibited a different amount of inertia than a particle of equal energy. It would be possible to make a machine that violated the conservation of momentum. For example, suppose that we have a closed system that is capable of converting energy between photons and electron/positron pairs. If this closed system has a different amount of inertia when energy is in the form of photons compared to when this same energy is in the form of particles, then this would be a violation of the conservation of momentum.

The standard model of particle physics explains the inertia of a fundamental particle as resulting from an interaction with the hypothetical Higgs field. This explanation says that a muon interacts more strongly than an electron, therefore a muon has more inertia. However, the Higgs mechanism does not have a precise requirement for exactly how much inertia a muon or an electron should possess. Now we learn that the inertia of an electron with 511 KeV of internal energy must exactly match the inertia of 511 KeV of confined photons. Similarly, a muon with internal energy of 106 MeV must exactly match the inertia of 106 MeV of confined photons. Matching the inertia of a fundamental particle to the inertia of an equal amount of energy propagating at the speed of light but confined to a specific volume adds an additional constraint to any particle model. The particle model proposed later in this book perfectly matches the required inertia constraint. The Higgs mechanism does not currently satisfy this requirement.

de Broglie Waves: The similarity between confined light and particles does not end with the confined light possessing rest mass, weight and kinetic energy when there is relative motion. Next we will examine the similarity between the wave characteristics of confined light and the de Broglie wave patterns of fundamental particles. For example, particles with mass m and velocity v that pass through a double slit produce an interference pattern which can be interpreted as having a de Broglie wavelength λ_d given by the equation:

$\lambda_d = h/p$ where λ_d = de Broglie wavelength; h = Planck's constant; p = momentum

$\lambda_d = h/\gamma m_o v$ where $\gamma = \frac{1}{\sqrt{1-v^2/c^2}}$ m_o = particle's rest mass

$\nu_d = E/h$ where ν_d = de Broglie frequency E = total energy

The de Broglie waves have a phase velocity $w_d = c^2/v$ and a group velocity $u_d = v$. The phase velocity w_d is faster than the speed of light and the group velocity, u_d, equals the velocity of the particle, v.

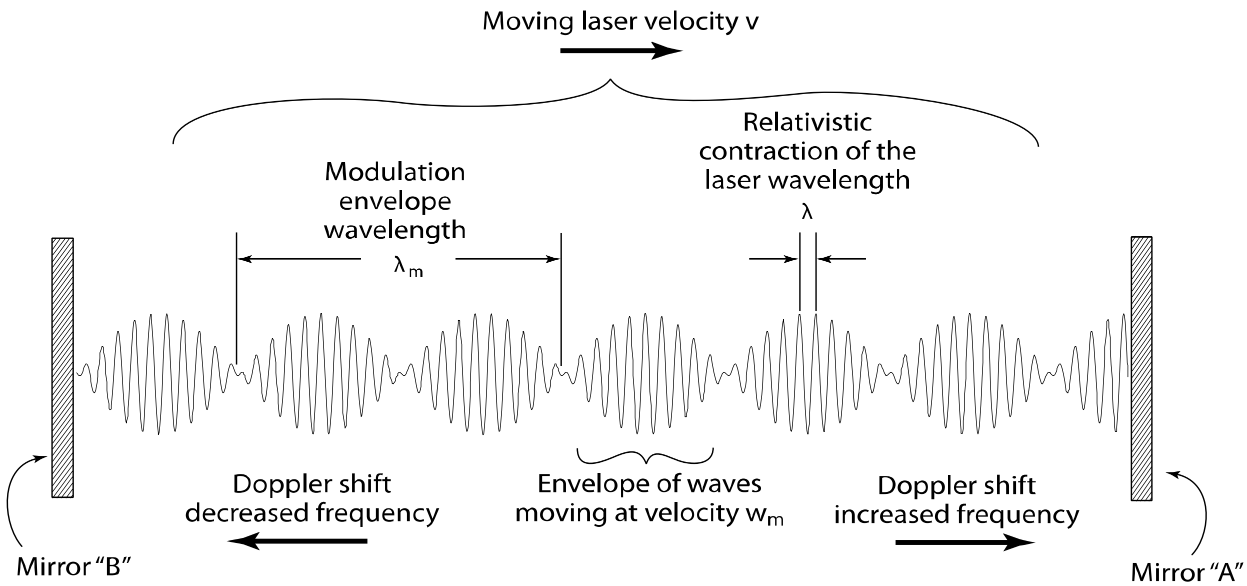


FIGURE 1-1 Wave pattern present in a moving laser due to Doppler shifts on the bi-directional light waves

There is a striking similarity between the de Broglie wave characteristics of a moving particle and the wave characteristics of confined light in a moving laser. Figure 1-1 shows a moving laser with mirrors A and B reflecting the light waves of a laser beam. Figure 1-1 is a composite because the light wave depicts electric field strength in the Y axis while the mirrors are shown in cross section. If the laser is stationary, the standing waves between the mirrors would have maximum electric field amplitude that is uniform at any instant. However, the laser in Figure 1-1 is moving in the direction of the arrow shown at velocity v. From the perspective of a "stationary" observer, light waves propagating in the direction of velocity v are Doppler shifted up in frequency, and light waves moving in the opposite direction are shifted down in frequency. When these electric field amplitudes are added, this produces the modulation envelope on the Doppler shifted bidirectional light in the laser as perceived by a stationary observer. This modulation envelope propagates in the direction of the translation direction but the modulation envelope has a velocity (w_m) which is faster than the speed of light ($w_m = c^2/v$) (calculated in appendix A). This is just an interference pattern and it can propagate faster than the speed of light without violating the special relativity prohibition against superluminal travel. No message can be sent faster than the speed of light on this interference pattern. The modulation envelope has a wavelength λ_m where:

$\lambda_m = \dfrac{\lambda_\gamma c}{v}$ λ_m = modulation envelope wavelength; λ_γ = wavelength of confined light

As seen in figure 1-1, one complete modulation envelope wavelength encompasses two nulls or two lobes. It will be shown later that there is a 180 degree phase shift at each null, so to return to the original phase requires two reversals (two lobes per wavelength).

The similarity to de Broglie waves can be seen if we equate the energy of a single photon of wavelength λ_γ to the energy of a particle of equivalent mass m. This will assume the non-relativistic approximation. Appendix A will address the more general relativistic case.

$E = \frac{hc}{\lambda_\gamma} = mc^2$ equating photon energy to mass energy therefore $m = \frac{h}{c\lambda_\gamma}$

$\lambda_\mathrm{d} = \frac{\mathrm{h}}{\mathrm{mv}}$ λ_d = de Broglie wavelength;

$\lambda_\mathrm{d} = \frac{\lambda_\gamma c}{v} = \lambda_\mathrm{m}$ de Broglie wavelength λ_d = modulation envelope wavelength λ_m

The modulation envelope not only has the correct wavelength, it also has the correct phase velocity ($w_d = w_m = c^2/v$). The "standing" optical waves also have a group velocity of v. Therefore these waves move with the velocity of the mirrors and appear to be standing relative to the mirrors.

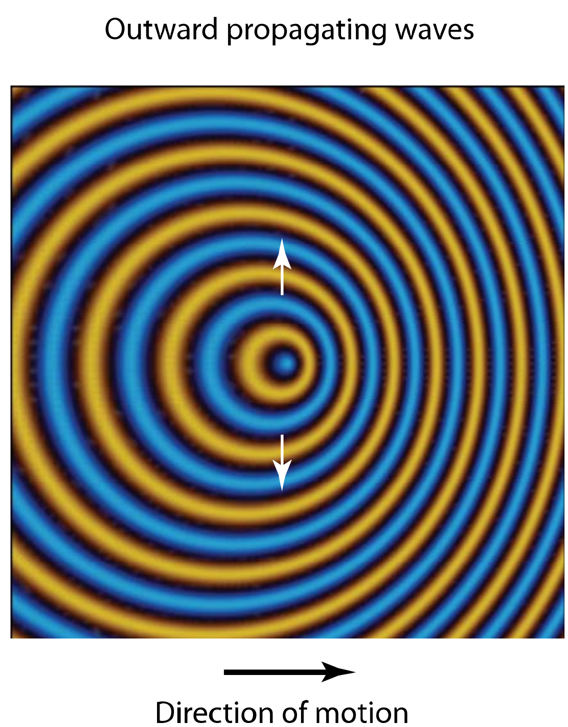


FIGURE 1-2 Doppler shift on outward propagating waves

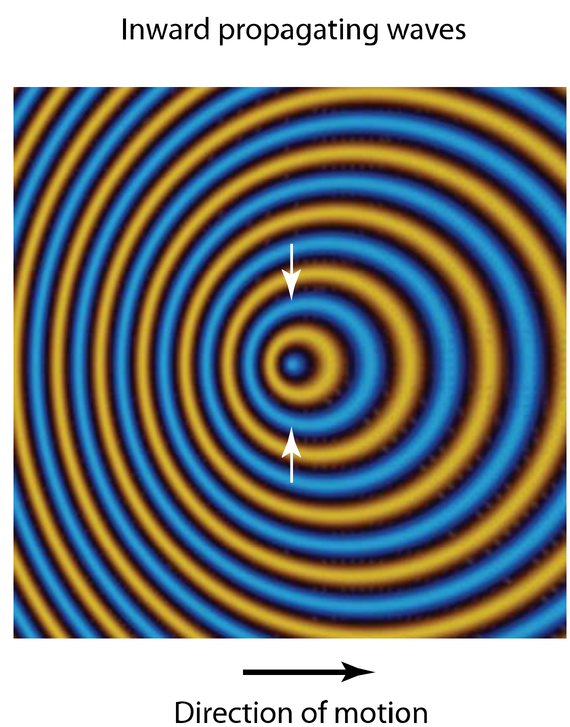


FIGURE 1-3 Doppler shift on inward propagating waves

de Broglie Waves in Radial Propagation: It is easy to see how the optical equivalent of de Broglie waves can form in the example above with propagation along the axis of translation.

However, it is not as obvious what would happen if we translated the laser in a direction not aligned with the laser axis. We will take this to the limit and examine what happens when the waves propagate radially into a 360° plane that is parallel to the translation direction. To understand what happens, we will first look at figure 1-2 that shows the Doppler shifted wave pattern produced by waves propagating away from a point source in a moving frame of reference. The source is moving from left to right as indicated by the arrow. Waves moving in the direction of relative motion (to the right) are seen as shifted to a shorter wavelength and waves moving opposite to the direction of travel are shifted to a longer wavelength. Figure 1-3 is similar to figure 1-2 except that only waves propagating towards the source are shown.

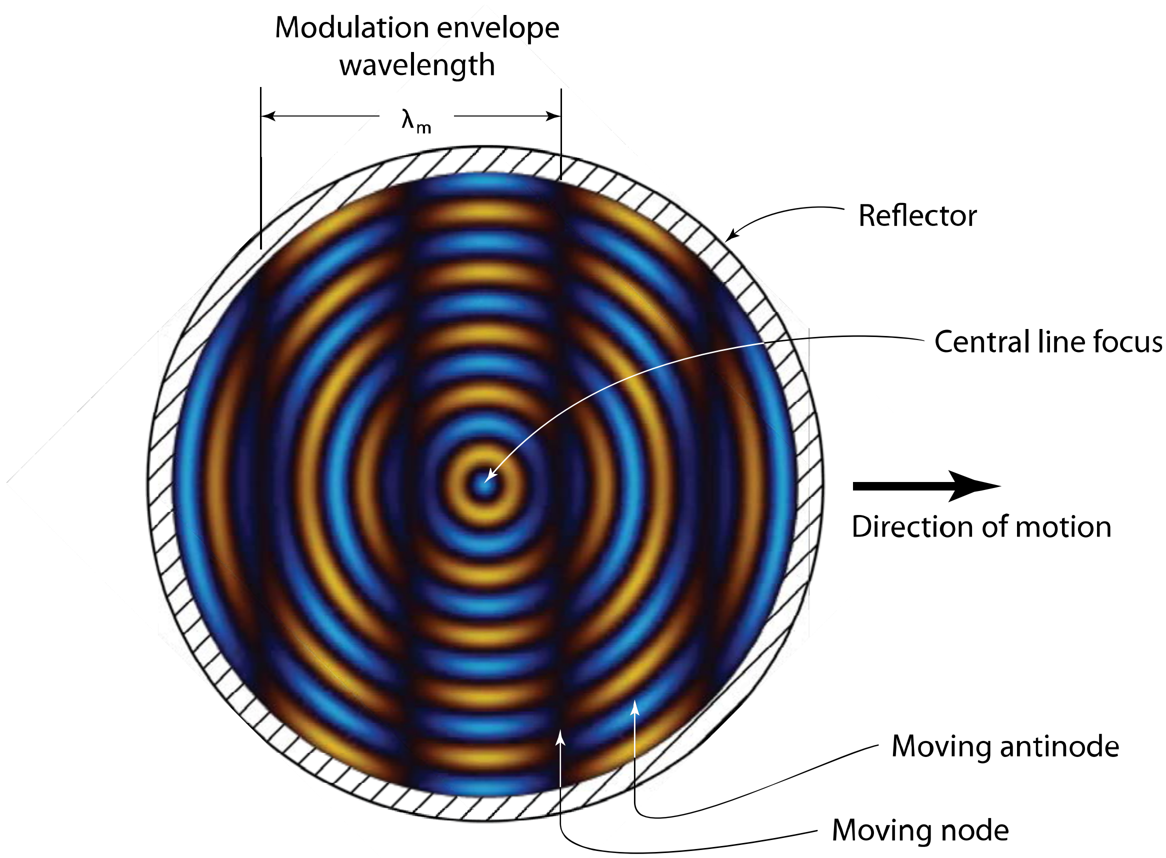


FIGURE 1-4 Wave pattern produced when radially propagating standing waves are observed in a moving frame of reference

Figure 1-4 shows what happens when we add together the outward and inward propagating waves shown in figures 1-2 and 1-3. Also a cross-sectioned cylindrical reflector has been added to figure 1-4. This reflector can be thought of as the reason that there are waves propagating towards the center. The central lobe of figure 1-4 can be thought of as a line focus that runs down the axis of the cylindrical reflector.

The vertical dark bands in figure 1-4 correspond to the null regions in the modulation envelope. These null regions can be seen in figure 1-1 as the periodic regions of minimum amplitude. There is a 180° phase shift at the nulls. This can be seen by following a particular fringe through the dark null region. If the wave is represented by a yellow color on one side of the null, this same wave is a blue color on the other side of the null. This color change indicates that a 180° phase shift occurs at the null. In figure 1-1, the reason that the wavelength of the modulation envelope λ_m is defined as including two lobes is because of this phase reversal that happens at every null. Therefore it takes two lobes to return to the original phase and form one complete wavelength.

The main purpose of this figure is to illustrate that de Broglie waves with a plane wavefront appear even in light that is propagating radially. This is a modulation envelope that is the equivalent of a plane wave moving in the same direction as the relative motion, but moving at a speed faster than the speed of light. Figure 1-4 represents an instant in a rapidly changing wave pattern.

There has also been an artistic license taken in this figure to help illustrate the point. Normally we would expect the electric field strength to be very large along the focal line at the center of the cylindrical reflector and decrease radially. However, accurately showing this radial amplitude variation would hide the wave pattern that is the purpose of this figure. Therefore the radial amplitude dependence has been eliminated to permit the other wave patterns to be shown. Another artistic license is the elimination of the Guoy effect at the line focus. The central lobe of a cylindrical focus should be enlarged by ¼ wavelength to accommodate the 90° phase shift produced when electromagnetic radiation passes through a line focus. Ultimately we will be transferring the concepts illustrated here to a different model that does not require this slight enlargement.

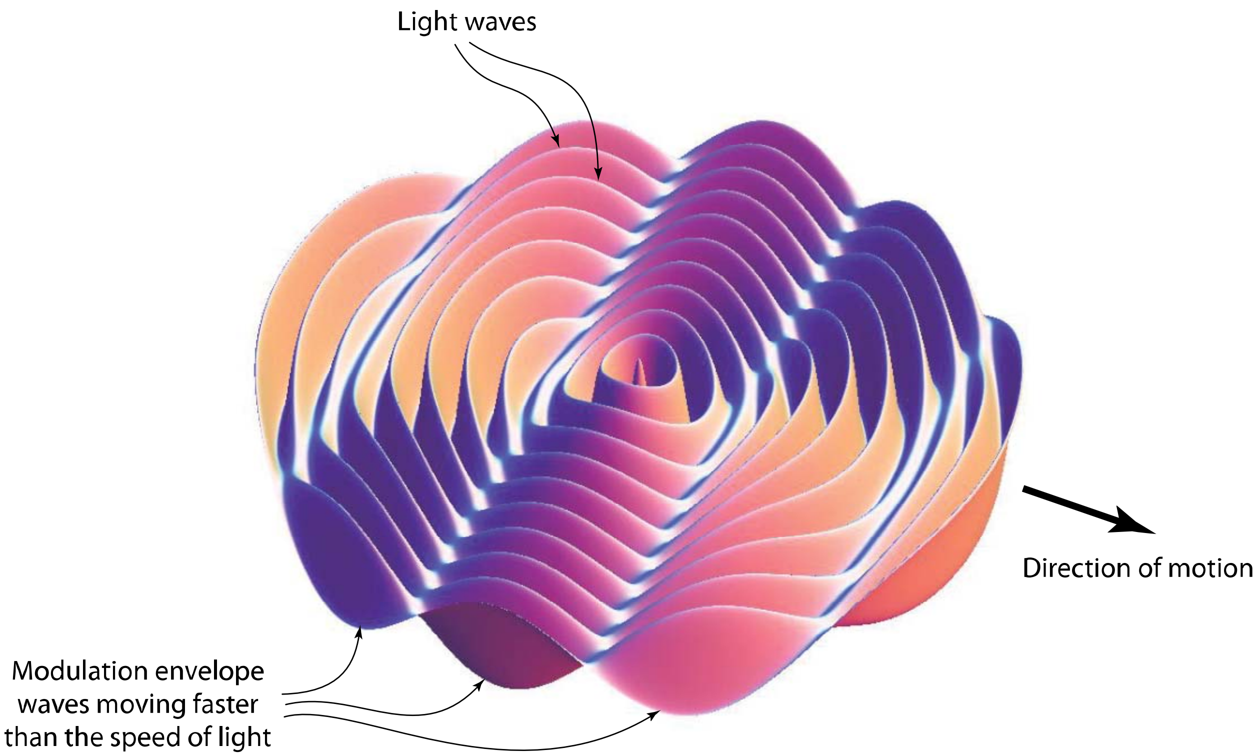


FIGURE 1-5 A three-dimensional representation of figure 1-4 where the Z axis is used to represent electric field

Figure 1-5 is a 3 dimensional representation of the wave pattern present in figure 1-4. In figure 1-5 the Z axis is used to represent the electric field. The cylindrical reflector has been removed from the illustration to permit the waves to be seen. Also as before, the radial amplitude dependence has been eliminated to permit the subtle modulation envelope to be seen. If figure 1-5 was set in motion, the concentric circular wave pattern would move as a unit. However, superimposed on this is the moving envelope of waves that are moving through this wave structure (waves on waves). This moving envelope of waves is moving faster than the speed of light in the same direction as overall motion ($w_m = c^2/v$).

The surprising part of figure 1-4 and 1-5 is that we obtain a linear modulation envelope imposed on the radial propagating waves. It does not make any difference what the propagation angle is, the equivalent of de Broglie waves are produced for all angles. The only requirement is that the wave has bidirectional propagation. If later we are successful in establishing a model of fundamental particles that exhibits bidirectional wave motion, that model will also exhibit de Broglie waves.

Next we are going to talk about relativistic length contraction. For illustration, we will return to figure 1-1. This figure shows the wave frozen in time and designates the distance that approximately corresponds to the laser wavelength λ. Actually, this distance only precisely equals the laser wavelength when there is no relative motion. In the example illustrated in figure 1-1, there is relative motion. The wave illustrated is the result of adding together a wave that has been Doppler shifted up in frequency to a wave that has been Doppler shifted down in frequency. The combination produces a peak to peak distance that is equal to the relativistic contraction of the laser wavelength.

This is reasonable when you consider that there are a fixed number of standing waves between the two mirrors. If the distance between the two mirrors undergoes a relativistic contraction, the standing waves must also exhibit the same contraction to retain the fixed number of standing waves. However, it is possible to reverse this reasoning. Rather than saying that the standing waves must contract to fit between the relativistic contracted mirror separation, it is possible to say that we might be getting a fundamental insight into the mechanics of how nature accomplishes relativistic contraction of physical objects. If all fundamental particles and forces of nature can ultimately be reduced to bidirectional waves in spacetime, then these bidirectional waves, will automatically exhibit relativistic contraction and the mechanism of relativistic contraction of even the nucleus of an atom would be conceptually understandable.

Similarly, the mechanism of relativistic time dilation would also become conceptually understandable. If we were to time the oscillation frequency of individual waves in the laser of figure 1-1, we would find that the oscillation frequency that results when we add these two Doppler shifted waves together slows exactly as we would expect for the relativistic time dilation of a moving object. Again this is traceable to the constant speed of light producing different Doppler shifts on the components of the bidirectional light. The sum of these two frequencies exhibits a net slowing that corresponds to relativistic time dilation.

Therefore the analysis in this chapter and appendix A shows that a confined photon in a moving frame of reference has the following 8 similarities to a fundamental particle with the same energy and same frame of reference:

1) The confined photon has the same inertia (rest mass): $m = \hbar\omega_c/c^2$
2) The confined photon has the same kinetic energy: $k_e = ½\, mv^2 = ½\,(\hbar\omega_o/c^2)\ v^2$
3) The confined photon has the same weight as the particle.
4) The confined photon (bidirectional propagation) has the same momentum.
5) The confined photon's envelope wavelength λ_s is the same as the particle's de Broglie wavelength: $\lambda_s = \lambda_d$
6) The confined photon's modulation envelope phase velocity is the same as the particle's de Broglie phase velocity: $v_s = w = c^2/v$
7) The photon's group velocity is the same as the particle's group velocity: $v_d = u$
8) The confined photon has the same relativistic length contraction: $\lambda_{dd} = \lambda_o/\gamma$

It is hard to avoid the thought that perhaps a particle is actually a wave with components exhibiting bidirectional propagation at the speed of light but somehow confined to a specific volume. This confinement produces standing waves that are simultaneously moving both towards and away from a central region.

Do we have any truly fundamental particles? If I defined a fundamental particle by the ancient Greek standard of indivisibility and incorruptibility, then there are none. An electron and a positron can be turned into two photons (and vice versa). An isolated neutron (2 down quarks and 1 up quark) will decay into a proton (2 up quarks and 1 down quark) plus an electron and an antineutrino. In fact, all 12 "fundamental" fermions of the standard model can be converted into other fermions and into photons. The simplest explanation for this easy conversion between "fundamental" particles is that there is a wave structure to these fermions. The truly fundamental building block of all fermions is the underlying wave in spacetime that allows these easy transformations. It is on the level of this truly fundamental building block that there is a similarity between confined light and particles. This thought process will be continued in chapter 4.

Note:
Chapters 2 and 3 lay groundwork that prepares the reader to understand the proposed model. Development of the spacetime based model of particles and forces starts in earnest in chapter 4.

Appendix A
Examination of the Similarities Between Confined Light and a Particle
Chris Ray

§ Confined Light

This appendix will investigate a photon confined in perfectly reflecting resonator. It will be shown that such a confined photon exhibits many particle-like properties including rest mass, relativistic contraction and a moving wave pattern that is similar to de Broglie waves.

We will begin by examining a standing wave in a resonator as viewed from a frame of reference in which the resonator is moving.

§ First View: Counter Propagating Waves

A 1-D standing wave can be modeled as a superposition of right and left moving plane waves.

$$\psi = e^{i(k_0 x - \omega_0 t)} + e^{i(-k_0 x - \omega_0 t)}$$

where $k_0 = \omega_0 / c$.

In the frame of reference where the resonator is at rest there are standing waves in the resonator set up by the counter propagating waves.

$$\begin{aligned} \psi &= e^{i(k_0 x - \omega_0 t)} + e^{i(-k_0 x - \omega_0 t)} \\ &= (e^{ik_0 x} + e^{-ik_o x}) e^{-i\omega_o t} \\ &= 2\cos(k_0 x) e^{-i\omega_o t} \end{aligned}$$

In the frame of reference where the resonator is moving to the right with velocity v, we have counter propagating waves with different frequencies, because the waves have been doppler shifted: $\omega_R = \gamma(1+\beta)\omega_0$ and $\omega_L = \gamma(1-\beta)\omega_0$, where $\beta = v/c$ and $\gamma = 1/\sqrt{1-\beta^2}$. The wave then is given by

$$\psi = e^{i(k_R x - \omega_R t)} + e^{i(k_L x - \omega_L t)}$$

where $k_L = -\omega_L / c$ and $k_R = \omega_R / c$.

Define ω_+ and ω_- as follows

$$\begin{aligned} \omega_+ &\equiv \tfrac{1}{2}(\omega_R + \omega_L) \\ &= \tfrac{1}{2}(\gamma(1+\beta)\omega_0 + \gamma(1-\beta)\omega_0) \\ &= \gamma\omega_0 \\ \omega_- &\equiv \tfrac{1}{2}(\omega_R - \omega_L) \\ &= \tfrac{1}{2}(\gamma(1+\beta)\omega_0 - \gamma(1-\beta)\omega_0) \\ &= \gamma\beta\omega_0 \end{aligned}$$

Now define k_+ and k_- in a similar way.

$$k_+ \equiv \tfrac{1}{2}(k_R + k_L) = \frac{1}{2c}(\omega_R - \omega_L) = \frac{\omega_-}{c} = \gamma\beta\frac{\omega_0}{c}$$

$$k_- \equiv \tfrac{1}{2}(k_R - k_L) = \frac{1}{2c}(\omega_R + \omega_L) = \frac{\omega_+}{c} = \gamma\frac{\omega_0}{c}$$

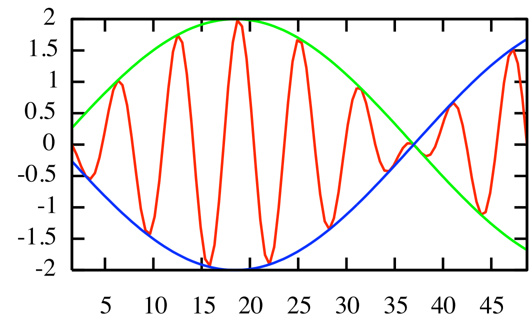
Note that

$$\begin{aligned} k_L &= k_+ - k_- \\ k_R &= k_+ + k_- \end{aligned} \qquad \text{AND} \qquad \begin{aligned} \omega_L &= \omega_+ - \omega_- \\ \omega_R &= \omega_+ + \omega_- \end{aligned}$$

Now we can write the wave as

$$\begin{aligned} \psi &= e^{i(k_L x - \omega_L t)} + e^{i(k_R x - \omega_R t)} \\ &= e^{i((k_+ - k_-)x - (\omega_+ - \omega_-)t)} + e^{i((k_+ + k_-)x - (\omega_+ + \omega_-)t)} \\ &= \left[e^{-i(k_- \ x - \omega_- \ t)} + e^{i(k_- \ x - \omega_- \ t)} \right] e^{i(k_+ x - \omega_+ t)} \\ &= 2\cos(k_- \ x - \omega_- \ t) e^{i(k_+ x - \omega_+ t)} \end{aligned}$$

The imaginary part of this is graphed below (in red) for $\beta = 0.085$ at $t = 0$.



This is a product of two traveling waves. We can compute wavelengths and velocities of these two parts.

$$\begin{aligned} v_+ &= \frac{\omega_+}{k_+} = \frac{\omega_+}{\omega_-/c} = \frac{c}{\beta} = \frac{c^2}{v} \\ v_- &= \frac{\omega_-}{k_-} = \frac{\omega_-}{\omega_+/c} = \beta c = v \\ \lambda_+ &= \frac{2\pi}{k_+} = \frac{2\pi c}{\gamma\beta\omega_0} = \frac{\lambda_0}{\gamma\beta} \\ \lambda_- &= \frac{2\pi}{k_-} = \frac{2\pi c}{\gamma\omega_0} = \frac{\lambda_0}{\gamma} \end{aligned}$$

where $\lambda_0 = \frac{2\pi c}{\omega_0}$ is the wavelength in the rest frame of the resonator.

First let us consider the "-" part of the wave. First we note that this part of the wave moves with the velocity of the resonator. Second we see that the wavelength has shrunk by a factor of γ relative to the wavelength in the rest frame. Thus the same number of wavelengths will fit in the similarly length-contracted resonator. Thus the cos() standing wave pattern has shrunk to fit the moving resonator and moves with the resonator.

Now consider the "+" part of the wave. This part of the wave moves with a velocity c^2/v. Which is the same as the phase velocity of a de Broglie plane wave for a massive particle: $\psi_d = e^{ipx/\hbar} e^{-iEt/\hbar}$.

$$\longrightarrow \quad v_{\text{phase}} = \frac{E/\hbar}{p/\hbar} = \frac{E}{p} = \frac{\gamma mc^2}{\gamma mv} = \frac{c^2}{v}$$

We can also see that the wavelength for the de Broglie plane wave: $\lambda_d = \frac{2\pi\hbar}{p} = \frac{2\pi\hbar}{Ev/c^2} = \frac{2\pi\hbar c}{E\beta} = \frac{2\pi\hbar c}{\gamma E_0 \beta}$ is also the same, if we assume that there is a single photon in the resonator and thus that the energy in the rest frame is $E_0 = \hbar\omega_0$. Since

$$\lambda_+ = \frac{2\pi}{k_+} = \frac{2\pi c}{\gamma\beta\omega_0} = \frac{2\pi\hbar c}{\gamma\beta E_0}$$

Thus we see that the "+" part of the resonator wave has the wavelength and phase velocity of a de Broglie plane wave of a massive particle with a rest energy equal to the energy of the photon in the resonator.

§ General From

In the rest frame of a general standing wave the amplitude of the wave is given by

$$\psi'(x', y', z', t') = f(x', y', z')e^{-i\omega_0 t'}$$

Where it is understood that the physical wave is the real part of the complex wave ψ. Note that the amplitude function $f()$ is a real valued function.

We will assume that the energy of this wave is

$$E_0 = \hbar\omega_0.$$

We will also consider this energy in the rest frame of the wave, divided by c^2, to be the mass of the system:

$$m \equiv \frac{E_0}{c^2} = \frac{\hbar\omega_0}{c^2}.$$

Since the wave is a standing wave the total momentum is zero: $p_0 = 0$.

In a General Frame

We want to know what the standing wave will look like in a frame in which the rest frame of the standing wave is moving in the positive x direction, with a velocity v. We can find this, if we assuming that the amplitude of the wave at a given space time point is the same in each frame, so that

$$\psi(x, y, z, t) = \psi'(x', y', z', t')$$

with x' and t' related to x and t via the following Lorentz transformation, while $y' = y$ and $z' = z$.

$$\begin{bmatrix} ct' \\ x' \end{bmatrix} = \begin{bmatrix} \gamma & -\gamma\beta \\ -\gamma\beta & \gamma \end{bmatrix} \begin{bmatrix} ct \\ x \end{bmatrix} = \begin{bmatrix} \gamma(ct - \beta x) \\ \gamma(x - \beta ct) \end{bmatrix}$$

So that

$$\begin{aligned} \psi(x, y, z, t) &= \psi'(x', y', z', t') \\ &= \psi'(\ \gamma(x{-}\beta ct), y, z,\ \gamma(ct{-}\beta x)/c\ ) \\ &= f(\gamma(x - \beta ct), y, z)e^{-i\omega_0\gamma(ct-\beta x)/c} \\ &= f(\gamma(x - vt), y, z)e^{i\omega_0\gamma\beta x/c}e^{-i\omega_0\gamma t} \\ &= f(\gamma(x - vt), y, z)e^{i(kx-\omega t)} \end{aligned}$$

In the last line we used the following definition.

$$\begin{aligned} \omega &\equiv \gamma\omega_0 \\ k &\equiv \gamma\beta\omega_0/c \end{aligned}$$

As was the case with the counter propagating plane waves, the wave function in the general frame is manifestly in the form of a plane wave ($e^{i(kx-\omega t)}$), with wavelength and velocity of a de Broglie wave, modulated with an standing wave pattern (f) that moves in the positive x direction with velocity v. In addition the characteristic length of the standing wave pattern has been length contracted in the x direction by the factor γ compared with the length in the rest frame. For examples suppose that there are two features in the standing wave, one at the position $x' = a$ and the other at the position $x' = b$. The distance between these features is $L = b-a$. The features could for example be two null points in the standing wave. These two features will also exist in the general frame, though they are moving. Let x_a and x_b the location of these features, then we know that

$$\begin{aligned} \gamma(x_a - vt) &= a \\ \gamma(x_b - vt) &= b \end{aligned}$$

Solving these two equations for $x_b - x_a$ we find that

$$L' = x_b - x_a = \frac{b - a}{\gamma} = \frac{L}{\gamma}$$

So the distance between the features has been contracted by a factor γ.

We also see, as in the case of counter propagating waves, that one part of the wave moves with the velocity v and the other moves with the velocity

$$\frac{\omega}{k} = \frac{\gamma\omega_0}{\gamma\beta\omega_0/c} = \frac{c}{\beta} = \frac{c^2}{v}$$

Energy and Momentum

We can also find the energy and momentum in the new frame, using the relativistic transformation of energy and momentum.

$$\begin{aligned} \begin{bmatrix} E \\ pc \end{bmatrix} &= \begin{bmatrix} \gamma & \gamma\beta \\ \gamma\beta & \gamma \end{bmatrix} \begin{bmatrix} E' \\ p'c \end{bmatrix} \\ &= \begin{bmatrix} \gamma & \gamma\beta \\ \gamma\beta & \gamma \end{bmatrix} \begin{bmatrix} E_0 \\ p_0 c \end{bmatrix} \\ &= \begin{bmatrix} \gamma & \gamma\beta \\ \gamma\beta & \gamma \end{bmatrix} \begin{bmatrix} \hbar\omega_0 \\ 0 \end{bmatrix} \\ &= \begin{bmatrix} \gamma\hbar\omega_0 \\ \gamma\beta\hbar\omega_0 \end{bmatrix} \\ &= \begin{bmatrix} \hbar\omega \\ \hbar kc \end{bmatrix} \end{aligned}$$

We see that the frequency and wavenumber of the plane wave part of the wave are proportional to the energy and momentum of the wave.

$$E = \hbar\omega$$

and

$$p = \hbar k$$

in accordance with de Broglie waves.

Using the definition $m = \hbar\omega_0/c^2$, we consider the mass of the light in our resonator to be equal to the energy in the rest frame divided by c^2. Thus we can rewrite the above as.

$$E = \gamma mc^2$$

and

$$p = \gamma mv$$

Chapter 2

Definitions and Concepts from General Relativity

The primary purpose of this book is to show how it is possible for the fundamental particles and the forces of nature to be conceptually explained using only 4 dimensional spacetime. This is nothing less than a new model of the universe. Presentation of this model would be an impossibly large task for a single person if every aspect of the model needs to be analyzed with the detail that might be expected from a technical paper covering a specific aspect of a mature subject. Therefore, the concepts will be introduced using simple equations that involve approximations and ignore dimensionless constants such as 2π or $½$. These simplifications permit the key concepts of this very large subject to be explained. Later, others can analyze and expand upon this large subject in more detail.

We will start by looking at the gravitational effects on spacetime in the limiting case of weak gravity. Much of the analysis to follow in subsequent chapters will deal with the gravity exhibited by a single fundamental particle such as an electron or a quark. Working with single particles or the interaction between two fundamental particles allows the proposed structure of such particles to be connected to the forces that are exhibited by these particles. At the same time, the extremely weak fields permit simplifications in the analysis.

In the following discussion, a distinction will be made between the words "length" and "distance". Normally, these words are similar, but we will make the following distinction. Length is a spatial measurement standard. This is not just a standardized size such as a meter or inch, but it also can include a qualification such as proper length or coordinate length. A unit of length can be defined either by a ruler or by the speed of light and a time interval. The concept of distance as used here is best illustrated by the phrase "the distance between two points". A distance can be quantified as a specific number of length units.

This chapter starts off with a discussion of the Schwarzschild solution to the Einstein field equation and physical examples of the effect of gravity on spacetime. This will seem elementary to many scientists, but new terminology and physical interpretations are introduced. Understanding this terminology and perspective is a requirement for subsequent chapters.

Schwarzschild Solution of the Field Equation: Einstein's field equation has an exact solution for the simplified case of a static, nonrotating and uncharged spherically symmetric mass distribution in an empty universe. This mass distribution with total mass m is located at the origin of a spherical coordinate system. The standard (nonisotropic) Schwarzschild solution in this case takes the form:

$dS^2 = c^2 d\tau^2 = (1/\Gamma^2)c^2 dt^2 - \Gamma^2 dR^2 - R^2 d\Omega^2$

$\Gamma = dt/d\tau = \frac{1}{\sqrt{1-\left(\frac{2Gm}{c^2R}\right)}}$ (explained below)

$dS = cd\tau =$ the invariant quantity for an interval of spacetime
$R =$ circumferential radius (circumference/2π) [explained below]
$\Omega =$ a solid angle in a spherical coordinate system ($d\Omega^2 = d\theta^2 + sin^2\theta\, d\Phi^2$)
$c =$ the speed of light constant of nature
$t =$ coordinate time (time infinitely far from the mass - effectively zero gravity)
$\tau =$ proper time – time interval on a local clock in gravity

The invariant quantity dS is the proper length of a one dimensional line segment. ($dS = cd\tau$). This is actually an abstract concept that is defined by the equation but does not have a clear physical interpretation.

Circumferential radius: Gravity warps the space around mass, so that the space around the test mass has a non-Euclidian geometry. The circumference of a circle around the mass does not equal 2π times the radial distance to the center of mass. To accommodate this warped space, the Schwarzschild equation uses a special definition of distance to specify the coordinate distance in the radial direction. Names like "R-coordinate" and "reduced circumference" are sometimes used to describe this radial coordinate that cannot be measured with a meter stick or a pulse of light. The name that will be used here is "circumferential radius" and designated with the symbol R. This is a distance that is calculated by measuring the circumference of a circle that surrounds a mass, and then dividing this circumference by 2π. If we measure the radius using a hypothetical meter stick or tape measure, then the "proper" radial distance will be designated by r. We can see from the Schwarzschild metric that if we set $dt = 0$, $dS = cd\tau = dr$ and $d\Omega = 0$ then:

$dr = \Gamma\, dR$

Gravitational Gamma Γ: The metric has been written in terms of the quantity Γ which this book will refer to as the "gravitational gamma Γ". The basic definition of Γ is:

$$\Gamma = dt/d\tau = \frac{1}{\sqrt{1+\left(\frac{2\varphi}{c^2}\right)}} = \frac{1}{\sqrt{1-\left(\frac{2Gm}{c^2R}\right)}} = \frac{1}{\sqrt{g_{oo}}}$$

where Γ = gravitational gamma and $\varphi = -Gm/R$ gravitational potential

$\Gamma = dt/d\tau$ in the static case when $dR = 0$ and $d\Omega = 0$.
g_{oo} is a metric coefficient commonly used in general relativity

The symbol of upper case gamma Γ was chosen because this equation can also be written as follows:

$\Gamma = \frac{1}{\sqrt{1-\left(\frac{V_e^2}{c^2}\right)}}$ where $V_e \equiv \sqrt{\frac{2Gm}{R}}$ = escape velocity

The similarity between Γ and γ of special relativity is obvious since: $\gamma = \frac{1}{\sqrt{1-\left(\frac{V^2}{c^2}\right)}}$

This analogy between the escape velocity in general relativity and the relative velocity in special relativity extends further in the weak gravity approximation. The time dilation due to gravity approximately equals the time dilation due to relative motion when the relative motion is equal to the gravitational escape velocity (weak gravity).

The Schwarzschild universe with only one mass has effectively "zero gravity" at any location infinitely far from the mass. At such a location $\Gamma = 1$. The opposite extreme of the maximum possible value of Γ is the event horizon of a black hole where $\Gamma = \infty$. If the earth was in an empty universe, then the surface of the earth would have a gravitational gamma of: $\Gamma \approx 1 + 7 \times 10^{-10}$. It is important to remember that Γ is always larger than 1 when gravity is present.

A stationary clock infinitely far away from the mass in Schwarzschild's universe is designated the "coordinate clock" with a rate of time designated *dt*. In the same stationary frame of reference, the local rate of time in gravity (near the mass) is designated $d\tau$. The relationship is: $\Gamma = dt/d\tau$

There is a useful approximation of Γ that is valid for weak gravity.

$\Gamma \approx 1 + \frac{Gm}{c^2 R}$ weak gravity approximation of Γ

Gravitational Magnitude *β*: The gravitational gamma Γ has a range of possible values that extends from 1 to infinity. There is another related concept where the strength of the gravitational effect on spacetime ranges from 0 to 1 where 0 is a location in zero gravity and 1 is the event horizon of a black hole. This dimensionless number will be called the "gravitational magnitude *β*" and is defined as:

$\beta \equiv 1 - \frac{d\tau}{dt} = 1 - \sqrt{1 - \frac{2Gm}{c^2 R}} = 1 - \frac{1}{\Gamma}$ $\beta =$ gravitational magnitude

In weak gravity the following approximation is accurate:

$\beta \approx \frac{Gm}{c^2 r}$ and $\Gamma \approx 1 + \beta$ weak gravity approximations

For example, the earth's gravity, in the absence of any other gravity is $\beta \approx 7 \times 10^{-10}$. The sun's surface has $\beta \approx 2 \times 10^{-6}$ and the surface of a hypothetical neutron star with escape velocity equal to half the speed of light would have $\beta \approx 0.13$.

In common usage, the strength of a gravitational field is normally associated with the acceleration of gravity. However, the acceleration of gravity depends on the gradient of gravitational potential. In contrast, the gravitational magnitude β and the gravitational gamma Γ are measurements of the effect of gravity on time and distance without regard for the gravitational gradient. For example, there is an elevation in Neptune's atmosphere where Neptune has approximately the same gravitational acceleration as the earth. However, Neptune has roughly 16 times the earth's mass and roughly 4 times the earth's radius. This means that Neptune's gravitational magnitude β is roughly 4 times larger than earth's at locations where the gravitational acceleration is about the same.

The gravitational magnitude approximation $\beta \approx Gm/c^2r$ will be used frequently with weak gravity. For example, this approximation is accurate to better than one part in 10^{36} for examples that will be presented later involving the gravity of a single fundamental particle at an important radial distance. Therefore, this approximation will be considered exact when dealing with fundamental particles. Note that this approximation includes the substitution of proper radial distance r for the circumferential radius R. ($r \approx R$). Using the approximation $\beta \approx Gm/c^2r$ we also obtain the following equalities for β in weak gravity:

$\beta \approx \frac{-\varphi}{c^2} \approx \frac{R_s}{r}$ $\varphi = -Gm/R$ and $R_s = Gm/c^2$ = classical Schwarzschild radius

$\beta \approx \frac{dt - d\tau}{dt}$ the rate of time approximation for weak gravity

All of these approximations will be considered exact when dealing with the extremely weak gravity of single fundamental particles in subsequent chapters.

Zero Gravity: Schwarzschild assumed an empty universe with only a single mass. Such a universe approaches zero gravity as the distance from the mass approaches infinity. However, is there anywhere in our observable universe that can truly be designated as a zero gravity location? There are vast volumes with virtually no gravitational acceleration compared to the cosmic microwave background. However, this is not the same as saying that these volumes have a gravitational gamma of $\Gamma = 1$ (a hypothetical empty universe). Everywhere in the real universe there is gravitational influence from all the mass/energy in the observable universe. Later, in the chapters on cosmology, an attempt is made to estimate the background (omni-directional) gravitational gamma of our observable universe compared to a hypothetical empty universe. While the presence of a uniform background Γ for the universe has implications for cosmology, we can only measure differences in Γ. There is ample evidence that general relativity works well by simply ignoring the uniform background Γ of the universe. Effectively we are assigning $\Gamma = 1$ to the background gravitational gamma of the universe and proportionally scaling from this assumption.

Therefore, a distant location which we designate as having $\beta = 0$ or $\Gamma = 1$ will be referred to as a "zero gravity location" or simply "zero gravity". The term "zero gravity" in common usage usually implies the absence of gravitational acceleration as might be experienced in free fall. However, in this book "zero gravity" literally means that we are using the Schwarzschild model of a distant location which has been assigned coordinate values of $\beta = 0$ and $\Gamma = 1$. The rate of time at this coordinate location will be designated dt and called "coordinate rate of time". A clock at this location will be designated as the "coordinate clock".

Gravitational Effect on the Rate of Time: The equation $dt = \Gamma\ d\tau$ is perhaps the most important and easiest to interpret result of the Schwarzschild equation. It says that the rate of time depends on the gravitational gamma Γ. This equation has been proven correct by numerous experiments. Today the atomic clocks in GPS satellites are routinely calibrated to account for the different rate of time between the lower gamma at the GPS satellite elevation and the higher gamma at the Earth's surface. Without accounting for this gravitational relativistic effect, the GPS network would accumulate errors and cease to function accurately after about one day. (There is also time dilation caused by the relative motion of the satellite. This is a much smaller correction than the gravitational effect and in the opposite direction.)

The difference in the rate of time with respect to radial distance in gravity will be called the "gravitational rate of time gradient". The gravitational rate of time gradient is not a tidal effect. An accelerating frame of reference has no tidal effects, yet it exhibits a rate of time gradient. Our objective is to provide an equation that relates the acceleration of gravity "g" to the rate of time gradient and utilizes proper length in the expression of the rate of time gradient. For example, inside a closed room it is possible to measure the gravitational acceleration. If we cannot measure any tidal effects, there is no information about the mass and distance of the object producing the gravity. Is it possible to determine the local rate of time gradient (expressed using proper length and proper time) from just the gravitational acceleration?

It has been shown[1] that a uniform gravitational field with proper acceleration g (measured locally), has the following relationship between redshift and gravitational acceleration:

[1] Edward A. Desloge, "The Gravitational Redshift in a Uniform Field" Am. J. Phys. 58 (9), 856-858 (1990)

$\upsilon/\upsilon_o = 1 - g\hbar/c^2$ where:

υ_o = frequency as measured at the source location with rate of time $d\tau_o$
υ = frequency as measured at the detector location with rate of time $d\tau$
$\hbar$ = vertical distance using proper length between the source and detector
g = acceleration of gravity

Reference [1] shows that this equation is exact if the following qualifications are placed on the above definitions. These qualifications are: 1) the source location (subscript o) should be at a lower elevation than the detector location. 2) the separation distance $\hbar$ should be the proper length as measured by a time of flight measurement (radar length) measured from the source location. A slightly different radar length would be obtained if this distance was measured from the detector elevation or measured with a ruler. However, in the limit of a gradient (infinitely small $\hbar$), this discrepancy disappears. Therefore with these qualifications:
$\upsilon/\upsilon_o = 1 - g\hbar/c^2$ is exact. It should be noted that the height difference $\hbar$ is a proper distance (radar length measured from the source) and not circumferential radius.

As will be show in the next chapter, the gravitational redshift is really caused by a difference in the rate of time at different elevations. There is no accumulation of wavelengths, so $\upsilon_o = 1/d\tau_o$ and $\upsilon = 1/d\tau$. After making these substitutions, this equation becomes:

$$g = c^2 \frac{d\tau - d\tau_o}{d\tau\, d\hbar}$$

This is also an exact equation if the above qualifications are observed. Here the ratio $(d\tau - d\tau_o)/d\tau d\hbar$ will be referred to as the gradient in the rate of time. There are two points to be noticed. First, the gradient in the rate if time is able to be determined from the acceleration of gravity with no knowledge about the mass or distance of the body producing the gravity. For example, a gravitational acceleration of g = 1 m/s^2 is produced by a rate of time gradient of 1.113 x 10^{-17} seconds/second per meter. The earth's gravitational acceleration of 9.8 m/s^2 near the earth's surface is caused by a rate of time gradient of about 10^{-16} seconds/second per meter of elevation difference in the earth's gravity. The most accurate atomic clocks using a laser cooled single atom of mercury or aluminum currently have an accuracy of roughly 1 part in 10^{16}. An atomic clock with this accuracy has a resolution comparable to one meter elevation change in the earth's gravity.

The second important point is that the rate of time gradient is a function of proper length in the radial direction. Even though $dt/d\tau$ is a function of circumferential radius, the relationship between rate of time gradient and gravitational acceleration is not a function of circumferential radius. This fact will become important in the next chapter when we examine how nature keeps the laws of physics constant when there is an elevation change. The connection between gravitational acceleration and rate of time gradient will also be an important consideration when we examine the cosmological model of the universe (chapters 13 & 14).

Previously, we defined the concept of "gravitational magnitude β" as: $\beta = 1 - d\tau/dt$. It is also possible to relate the acceleration of gravity to the gradient in the gravitational magnitude.

$$g = c^2\left(\frac{d\beta}{d\hbar}\right)$$

Inertial Frame of Reference: The concept that gravity can be simulated by an accelerating frame of reference sometimes leads to the erroneous interpretation that an inertial frame of reference eliminates all effects of gravity. Being in free fall eliminates the acceleration of gravity, but the gravitational effect on the rate of time and the spatial effects of the gravitational field remain. Another way of saying this is that the effects of the gravitational gamma Γ on spacetime are still present, even if a mass is in an inertial frame of reference. A clock in free fall still experiences the local gravitational time dilation.

A rigorous analysis from general relativity confirms this point, but two examples will be given to also illustrate the concept. Suppose that there was a hollow cavity at the center of the earth. A clock in this cavity would experience no gravitational acceleration and would be in an inertial frame of reference. The gravitational magnitude β in this cavity is about 50% larger than the gravitational magnitude on the surface of the earth (~10.5 x 10^{-10} compared to 7 x 10^{-10}). For example, ignoring air friction, the escape velocity starting from this cavity is higher than starting from the surface of the earth. The clock in the cavity has a slower rate of time than a clock on the surface. The inertial frame of reference does not eliminate the other gravitational effects on the rate of time and the gravitational effect on volume.

A second example is interesting and illustrates a slightly different point. The Andromeda galaxy is 2.5 million light years (~2.4 x 10^{22} m) away from Earth and has an estimated mass of about 2.4 x 10^{42} kg (including dark matter). The gravitational acceleration exerted by this galaxy at the distance of the Earth is only about 2.8 x 10^{-13} m/s^2. To put this minute acceleration in perspective, a 10,000 kg spacecraft would accelerate at about this rate from the "thrust" of the light leaving a 1 watt flashlight. In spite of the minute gravitational acceleration, the distant presence of Andromeda slows down the rate of time on the surface of the earth about 100 times more than the Earth's own gravity. This is possible because the gravitational magnitude ($\beta \approx Gm/c^2r$ for weak gravity) decreases at a rate of $1/r$ while the gravitational acceleration decreases with $1/r^2$. At the earth's surface, Andromeda's gravitational magnitude is about:

$\beta \approx Gm/c^2r = (G/c^2)$ (2.4 x 10^{42} kg/2.4 x 10^{22} m) ≈ 7 x 10^{-8} Andromeda's β at earth

Since the earth's gravity produces $\beta \approx 7 \times 10^{-10}$ at the surface, Andromeda's effect on the rate of time at the earth's surface is about 100 times greater than the effect of the earth's gravity. It does not matter whether a clock is in free fall relative to Andromeda or whether the clock is stationary relative to Andromeda and experiences the minute gravitational acceleration. In both cases the gravitational effect on time and volume exist. This example also hints that mass/energy in other parts of the universe can have a substantial cumulative effect on our local rate of time and our local volume. This concept will be developed later in the chapters dealing with cosmology.

Schwarzschild Coordinate System: The standard Schwarzschild solution uses coordinates that simplify gravitational calculations. This spherical coordinate system uses circumferential radius R as coordinate length in the radial direction and uses circumferential radius times an angle Ω for the tangential direction. While there is no distinction in proper length for the radial and tangential directions, we will temporarily make a distinction by designating proper length in the radial direction as L_R and designating proper length in the tangential direction as L_T. This distinction does not exist in reality since: $cd\tau = dL = dL_T = dL_R$. However, using these designations, the relationship between proper length and Schwarzschild's coordinate length is:

$dL_R = \Gamma\, dR$ radial length L_R conversion to Schwarzschild radial coordinate R
$dL_T = R\, d\Omega$ tangential length L_T to Schwarzschild tangential coordinate length

The equation $dL_R = \Gamma dR$ is obtained by setting $dt = 0$. If we are using the proper distance between two points as measured by a ruler, or the calculated circumferential radius, then this zero time assumption is justified.

Next we will calculate the coordinate speed of light $\mathcal{C}$ for the radial and tangential directions by starting with the standard Schwarzschild metric:

$dS^2 = (1/\Gamma^2)c^2dt^2 - \Gamma^2dR^2 - R^2d\Omega^2$ for light set $dS^2 = 0$,
$(1/\Gamma^2)\, c^2\, dt^2 = \Gamma^2dR^2 + R^2d\Omega^2$

$$c^2 = \Gamma^4\frac{dR^2}{dt^2} + \Gamma^2\frac{R^2 d\Omega^2}{dt^2}$$

If we separate this coordinate speed of light into its radial component ($\mathcal{C}_R$) and its tangential component ($\mathcal{C}_T$), we obtain:

$\mathcal{C}_R = dR/dt = c/\Gamma^2$ $\mathcal{C}_R$ = coordinate speed of light in the radial direction ($d\Omega = 0$)
$\mathcal{C}_T = Rd\Omega/dt = c/\Gamma$ $\mathcal{C}_T$ = coordinate speed of light in the tangential direction ($dR = 0$)

This apparent difference in the coordinate speed of light for the radial and tangential directions is not expressing a physically measurable difference in the proper speed of light. The difference follows from the standard (nonisotropic form) of the Schwarzschild metric. If we choose the isotropic form of the Schwarzschild metric the difference will disappear and $\mathcal{C}_R = \mathcal{C}_T \approx c/\Gamma^2$. However, the isotropic form has its own set of complexities, so we will be using the standard Schwarzschild metric.

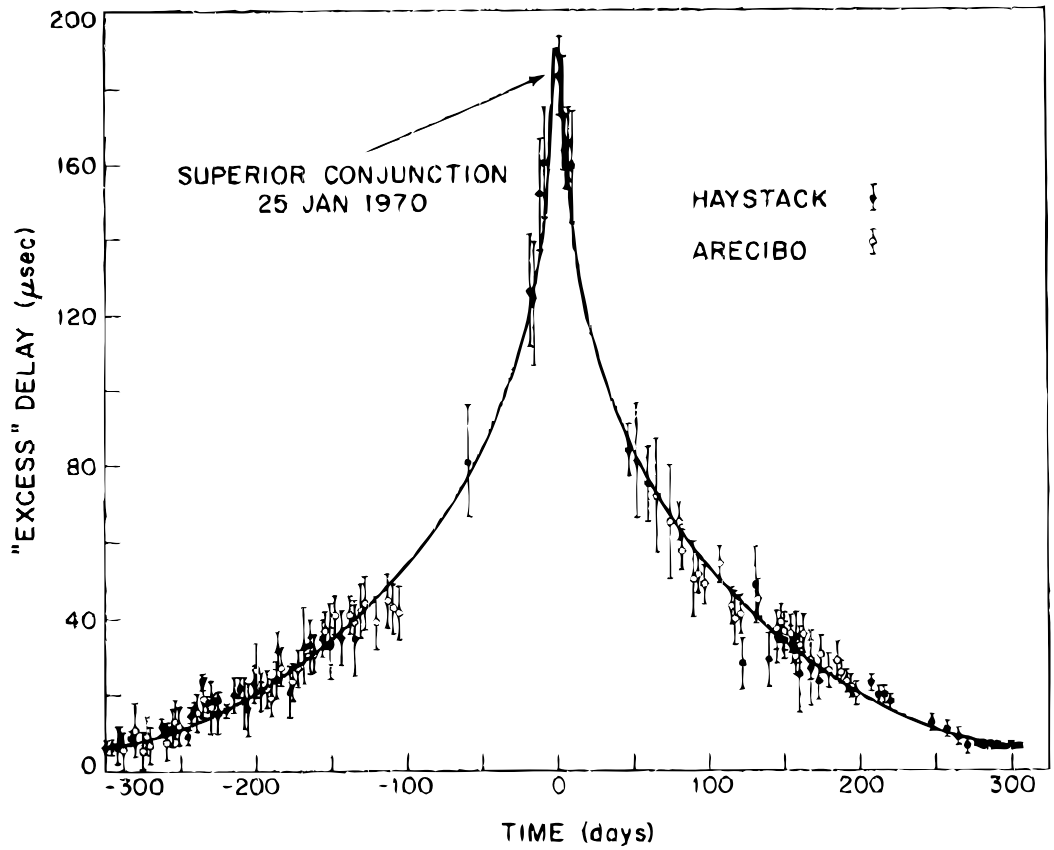


FIGURE 2-1 This is Irwin Shapiro's figure showing the relativistic time delay caused by the sun's gravity on the round trip time for radar to travel from the earth to Venus and back. The x axis is time in days before and after superior conjunction of Venus passing behind the sun.

The Shapiro Experiment: Next, we are going to switch to a discussion about the gravitational effect on proper length, proper volume and the coordinate speed of light. In 1964, Irwin Shapiro proposed an experiment to measure the relativistic distortion of spacetime caused by the Sun's gravity. This non-Newtonian time delay is obtained from the Schwarzschild solution to Einstein's field equation. The Sun is a good approximation of an isolated mass addressed by the Schwarzschild solution. The implication is that gravity affects spacetime so that it takes more time for light to make the round trip between two points in space when the mass (gravity) is present than when the mass (gravity) is absent. Shapiro and his colleagues used radar to track the planet Venus for about two years as Venus and the Earth orbited the Sun. During this time, Venus passed behind the Sun as seen from the Earth (nearly superior conjunction). The orbits of Venus and the Earth are known accurately, so it was possible to measure the additional time delay in the round trip time from the earth to Venus and back. The effect of the sun's gravity on this round trip time could be calculated from multiple measurements made over the two year time period. Figure 2-1 shows Shapiro's graph of the excess time delay over the two year period. The peak delay at superior conjunction was 190 μs on a half hour round trip transit time.

Variations of this experiment have been repeated numerous times in the normal course of the space program. Spacecraft on their way to the outer planets often start with an orbital path that at some point results in nearly superior conjunction relative to the Earth. The most accurate measurement to date was with the Cassini spacecraft. It was equipped with transponders at two different radar frequencies, therefore it was possible to determine and remove the effect of the Sun's corona on the time delay. The result was an agreement with the time delay predicted by general relativity accurate to 1 part in 50,000. With this type of agreement, it would seem as if there are no remaining mysteries about this effect and the physical interpretation should be obvious.

How exactly do length, time and the speed of light combine to produce the observed time delay in the Shapiro effect? For simplicity, we would like to look at the time delay associated with a radar beam traveling only in the radial direction. In the limit, we can imagine reflecting a radar beam off the surface of the Sun. This path would be purely radial. To make a measurement we need to have a round trip, but for simplicity of discussion, we will talk about the time delay for a one way trip. For light $dS = 0$, so the metric equation gives us that for light moving in the radial direction:

$$\left(\frac{1}{\Gamma}\right) cdt = \Gamma dR \rightarrow dt = \left(\frac{\Gamma^2}{c}\right) dR$$

We can compute the time Δt it takes to move between two different radii: r_1 and r_2 (where $r_2 > r_1$).

$$c\Delta t = \int c\ dt\ =\ \int_{r1}^{r2} \Gamma^2\ dR$$

$$c\Delta t = \left(\frac{2Gm}{c^2}\right) ln\left(\frac{r_2}{r_1}\right) + \left(\frac{2Gm}{c^2}\right) ln\left(\frac{\Gamma_1^2}{\Gamma_2^2}\right) \qquad \textit{weak gravity:}\ ln\left(\frac{\Gamma_1^2}{\Gamma_2^2}\right) \approx 0$$

$$\Delta t \approx \left(\frac{2Gm}{c^3}\right) ln\left(\frac{r_2}{r_1}\right)$$

Substituting the Sun's mass, radius and distance gives $\Delta t \approx 50$ µs. Therefore, in addition to a non-relativistic time delay (about 8 minutes), the one way relativistic time delay would be about an additional 50 µs. The 190 µs delay observed by Shapiro is roughly 4 times the one way 50 µs delay from the earth to the sun because of the additional leg to Venus and then the round trip doubling of the time.

Normally, on Earth we would interpret a 50 µs delay in a radar beam as indicating an additional distance of about 15 km. How much does the sun's gravity distort space and increase the radial distance between the earth and the sun's surface compared to the distance that would exist if we had Euclidian flat space? The additional non Euclidian path length will be designated (ΔL). Starting from: $dL_R = \Gamma\ dR$

$\Delta L = \int_{r1}^{r2} \Gamma\ dR$

$\Delta L \approx \left(\frac{Gm}{c^2}\right) ln\left(\frac{r_2}{r_1}\right)$ set $r_2 = 1.5 \times 10^{11}$ m, $r_1 = 7 \times 10^8$ m and $m = 2 \times 10^{30}$ kg

$\Delta L \approx 7.5$ km non-Euclidian additional proper distance between the Earth and Sun

Suppose that it was possible to stretch a tape measure from the earth to the surface of the sun. The distance measured by the tape measure (proper distance) would be about 7.5 km greater than a distance obtained from an assumption of flat space and a Euclidian geometry calculation. The use of a tape measure means that we are using proper length as a standard.

Gravity Increases Volume: If we use proper length as our standard of length rather than circumferential radius, then we must adopt the perspective that gravity increases the volume of the universe. However, an interpretation based on proper volume is often ignored since the use of circumferential radius as coordinate length eliminates this volume change caused by gravity.

In the Shapiro experiment, we calculated that there was a non-Euclidian increase in distance between the earth and the sun of 7.5 km. Suppose that we imagine a spherical shell with a radius equal to the average radius of the earth's orbit. This is a radial distance equal to one astronomical unit (AU $\approx 1.5 \times 10^{11}$ m). The sun's mass is $\approx 2 \times 10^{30}$ kg and the sun's Schwarzschild radius is $r_s \approx 2950$ meters. What is the change in volume (ΔV) inside this spherical shell if we compare the Euclidian volume of the shell (V_o) and the non-Euclidian volume of the shell (V) when the Sun is at the center of the shell?

$V = \int dV = \int 4\pi R^2\ \Gamma\ dR$

After integration, the difference $\Delta V = V - V_o$ is approximately:

$\Delta V \approx (5\pi/3) r_s (r_2^2 - r_1^2)$ set $r_2 = 1.5 \times 10^{11}$ m, $r_1 = 7 \times 10^8$ m and $r_s = 2950$ meters

$\Delta V \approx 3.46 \times 10^{26}$ m^3 non Euclidian volume increase

To put this non Euclidian volume increase in perspective, the sun's gravity has increased the proper volume within a radius of 1 AU by about 3.5×10^{26} m^3 which is more than 300,000 times larger than the volume of the earth (earth's volume is $\approx 1.08 \times 10^{21}$ m^3). Stated another way, the volume increase is about 20% smaller than the volume obtained by multiplying the non-Euclidian radial length increase (~ 7,500 m) times the surface area of the spherical shell with a radius of 1 AU. Obviously this non Euclidian volume increase would be much larger if we had chosen a larger shell radius (for example, the size of the observable universe). The implications of this will be explored in the chapters on cosmology.

Concentric Shells Thought Experiment: The concept that gravity increases the volume of the universe is important enough that another example will be given. Suppose that there are two concentric spherical shells around an origin point in space. The inside spherical shell is 4.4×10^9 m in circumference (about the circumference of the Sun). The outside shell is 2π meters larger circumference. With no mass at the origin and infinitely thin shells, this means that there is exactly a 1 meter gap between the shells. We could confirm the 1 meter spacing with a meter stick or a pulse of light and a clock.

Next we introduce the Sun's mass at the origin. This introduces gravity into the volume between the two shells with an average value of about $\Gamma \approx 1 + 2 \times 10^{-6}$. The circumference of each shell (proper length) does not change after we introduce gravity. However, the distance between the two shells would now be about $1 + 2 \times 10^{-6}$ meters. This is 2 microns larger than the zero gravity distance. This 2 micron increase in separation increases the proper volume between the two shells by roughly 10^{13} m^3.

In this example of two concentric shells we accepted the proper length of the circumference of the shells (tangential proper length). The question is whether there was also a decrease of this tangential length (relative to a "flat" coordinate system) when the sun's mass was introduced at the origin. It is possible to consider both radial and tangential directions affected equally. This results in gravity producing an even larger increase in proper volume than previously calculated. This will be discussed further in the chapters on cosmology.

Connection Between the Rate of Time and Volume: We are going to compute the effect of the gravitational gamma Γ on proper volume using the standard Schwarzschild metric. The use of this metric means that the standard Schwarzschild conditions apply: a static nonrotating and uncharged spherically symmetric mass distribution in an empty universe. This calculation involves terminology from general relativity that is not explained here. Readers unfamiliar with general relativity should skip the shaded calculation section below and move on to the conclusion.

If we know metric equations, we can compute the 3-dimensional volume and the 4-dimensional volume (includes time). The easiest way to do it is to use the following diagonal metric:

$$dS^2 = -g_{00}(dx^0)^2 + g_{11}(dx^1)^2 + g_{22}(dx^2)^2 + g_{33}(dx^3)^2$$

Then the 3-dimensional volume dV(3) is:

$$dV(3) = (g_{11} \cdot g_{22} \cdot g_{33})^{1/2} dx^1 dx^2 dx^3$$

And for 4-dimensional volume $dV(4)$

$$dV(4) = (-g_{00} \cdot g_{11} \cdot g_{22} \cdot g_{33})^{1/2} dx^0 dx^1 dx^2 dx^3$$

In the particular case of the standard Schwarzschild metric:
$g_{00} = -1/\Gamma^2$; $g_{11} = \Gamma^2$; $g_{22} = R^2$, $g_{33} = R^2 sin^2\theta$

The differentials of 4 dimensional coordinates in this case are:
$(dx^0) = cdt$; $(dx^1) = dR$; $(dx^2) = d\theta$; $(dx^3) = d\Phi$ So:

$dV(3) = (\Gamma^2 \cdot R^2 \cdot R^2 sin^2\theta)^{1/2} dR \cdot d\theta \cdot d\Phi$
$dV(3) = \Gamma\, R^2 sin\theta\, dR\, d\theta\, d\Phi$ note that volume (3) scales with Γ

$V(4) = (-(-1/\Gamma^2) \cdot \Gamma^2 \cdot R^2 \cdot R^2 sin^2\theta)^{1/2} \cdot cdt \cdot dR \cdot d\theta \cdot d\Phi$
$dV(4) = R^2 csin\theta dtdRd\theta d\Phi$ note that this is independent of Γ

The above calculation shows that proper volume (3 spatial dimensions) scales with the gravitational gamma Γ. This supports the previous examples involving the volume increase interpretation of the Shapiro experiment and also the volume increase that occurs in the thought experiment with two concentric shells. When we include the time dimension and calculate the effect of the gravity generated by a single mass on the surrounding spacetime, we obtain the answer that the **4** dimensional spacetime volume is independent of gravitational gamma Γ. The radial dimension increases ($\Gamma = dL_R/dR$) and the temporal dimension decreases ($\Gamma = dt/d\tau$). These offset each other resulting in the 4 dimensional volume remaining constant.

There is a simpler way of expressing this concept. Since $\Gamma = \left(\frac{dt}{d\tau}\right) = \left(\frac{dL_R}{dR}\right)$ therefore:

$$d\tau dL_R = dtdR$$

This concept will be developed further when we develop particles out of 4 dimensional spacetime and it also has application to cosmology.

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Chapter 3

Gravitational Transformations of the Units of Physics

Covariance of the Laws of Physics: From the event horizon of a black hole to the most isolated volume in the universe, there are big differences in the rates of time throughout the universe. How do the laws of physics remain the same when the rate of time is different between locations? Why does a rate of time gradient also not affect the laws of physics? It is an oversimplification to imagine that changing the rate of time is similar to running a movie in slow motion while keeping the laws of physics unchanged.

We are going to be looking at how nature maintains the laws of physics when the rate of time changes with gravitational gamma. This is not just an academic question. Gravity produces a rate of time gradient and a gradient in the coordinate speed of light. Therefore, even in earth's gravity, the simple act of lifting an object to a different elevation means that the object is moved to a location where there is a different rate of time and a different coordinate speed of light. Acknowledging that there are changes in the rate of time leads to surprising new physical insights.

When the rate of time is different between two locations, but the laws of physics are the same, there must also be other changes in the units of physics to offset the difference in the rate of time. For example, momentum scales proportional to $1/t$, force scales proportional to $1/t^2$, power scales proportional to $1/t^3$ and the fine structure constant is independent of time ($1/t^0$). This is time raised to four different powers, yet the laws of physics are constant even with this difference in time dependence. What additional changes are required to offset the change in the rate of time and preserve the laws of physics unchanged in different gravitational potentials?

If there is a coordinate rate of time in a zero gravity location that is different from the rate of time in a location with gravity, and if the coordinate speed of light is different in the two locations, shouldn't there also be a difference in at least some of the other units of physics? For example, is one Joule of energy or one Newton of force also different in the zero gravity location compared to the gravity location? To make a meaningful comparison of the units of physics between locations with different gravitational potentials, it would be necessary to use a single rate of time. This point is easy to see. The more difficult question is: How do we treat length in this exercise?

It is impossible to directly compare length between two locations with a different gravitational potential. Also vectors are ambiguous when compared between locations with different gravitational potential. For example, the direction of a vector can be different depending on the path chosen to transport a vector between two locations with different gravitational potentials. Therefore adopting the locally measured proper length as a standard of length for that location eliminates ambiguity, but is it the length standard we are seeking?

To be clear, this exercise is not interested in calculating the general relativistic effects on space and time. We will obtain this information from standard general relativity calculations. We will presume that we already know the gravitational gamma ($\Gamma = dt/d\tau$) for each location of interest. Instead we are interested in understanding how the laws of physics accommodate the spatial and temporal differences associated with these different values of Γ. The laws of physics always scale in a way that keeps the speed of light constant ($c = dL/d\tau$). For example, a zero gravity observer might perceive that that a location in gravity has a slow rate of time. However, the zero gravity observer also perceives that this location in gravity also has a proportionately slow coordinate speed of light. A speed of light experiment performed in gravity always results in the universal constant c because a zero gravity observer perceives a slow coordinate speed of light being timed by a slow clock. This results in not only a constant proper speed of light (c) but also the zero gravity observer can consider proper length as constant (independent of Γ). In other words, when the zero gravity observer applies his/her rate of time and adjusts for the different coordinate speed of light, then the unit of length (L) can be considered constant.

All the forces scale with proper length. This is true for not only the electromagnetic force, but even gravitational acceleration scales with proper length. In the last chapter we showed that $g = c^2 \Delta T / \Delta \hbar d\tau$. In this equation $\Delta \hbar$ is an increment of proper length in the elevation direction. General relativity tells us that there is a difference between circumferential radius R and proper length L. There is also one perspective where the tangential proper length decreases relative to coordinate tangential length when gravity is introduced into a volume of spacetime. However, fermions, bosons and forces know nothing about the general relativistic effects involving circumferential radius or coordinate tangential length. These particles and forces all scale with proper length. If gravity produces non Euclidian spatial geometry, these particles and forces merely accept the proper volume at a particular location and scale with proper length. Therefore since fundamental particles and forces scale with proper length and proper volume, for this exercise we need to adopt a coordinate system that recognizes proper length as a standard.

Normalized Coordinate System: The conclusion of this is that the analysis we wish to perform on the covariance of the laws of physics is best accomplished by adopting a coordinate system that uses coordinate rate of time from general relativity as the time standard and proper length as our length standard. This is an unconventional coordinate system that is a hybrid between the Schwarzschild coordinate system (coordinate time and circumferential radius) and the standard coordinates that use proper time and proper length. This coordinate system will be used to analyze the covariance of the laws of physics when two locations have different gravitational potentials and different rates of time. In this analysis we always assume both a constant distance between locations and static gravity. Further support for the use of this coordinate system will be offered by actually performing this analysis using this hybrid coordinate system and seeing if the results are reasonable.

The hybrid coordinate system that uses proper length and coordinate rate of time will be called the "normalized" coordinate system. The speed of light utilizing this coordinate system will be called the "normalized" speed of light. We will also be referring to the "normalized" unit of energy, force, etc. All of these units use proper length and zero gravity rate of time. The normalized coordinates cannot be used for general relativity calculations to determine spacetime curvature. The equations become so simplified that important information is lost. Instead, the normalized coordinate system accepts the value of Γ obtained from general relativity and utilizes this information to analyze other aspects of physics. By adopting proper length as our coordinate length and zero gravity rate of time we achieve a coordinate system that works well with quantum mechanics and gives insights into the forces of nature.

Length and Time Transformations: The following analysis will use dimensional analysis and therefore we will be using the symbols of dimensional analysis. These are: M, L, T, Q, and Θ to represent mass, length, time, charge and temperature respectively. For example, the units of energy are: kg m^2/s^2. The conversion to dimensional analysis terminology is:
kg m^2/s^2 → ML^2/T^2.
Also, the calculations to follow will be making transformations between the various units of physics when Γ changes. For example, to understand how the laws of physics are maintained going from a hypothetical location in zero gravity ($\Gamma = 1$) to a location with strong gravity ($\Gamma > 1$), we will be working with discrete units such as a Joule or a Newton. This means that the transformation of our coordinates also requires the use of discrete units of length and time rather than the differential form.

For example, $dt = \Gamma d\tau$ relates the rate of coordinate time (dt) to the rate of proper time in gravity ($d\tau$). In this case $dt > d\tau$. However, suppose we compare a unit of time, such as one second in a location with zero gravity to one second in a location with gravity. If each location sent out a light pulse lasting 1 second (according to a local clock), then any observer (independent of Γ) would agree that the light pulse from the location in gravity lasted longer than the light pulse from the zero gravity location. This will be represented as $T_g > T_o$. The subscript "g" represents a location in gravity and "o" represents a location with zero gravity. Therefore, $T_g > T_o$ represents that a unit of time in gravity is larger (longer) than a unit of time in zero gravity. When we convert $dt = \Gamma d\tau$ to express a relationship between units of time it becomes:

$T_o = T_g/\Gamma$ unit of time transformation from zero gravity to gravity

There is no new physics being expressed here. The difference is comparable to comparing a rate of pulses expressed as pulse per second compared to the time between pulses expressed as seconds per pulse.

Since proper length is adopted as our standard of length, this means that we are not making a distinction between proper length in any location or orientation. The way that this is expressed is:

$L_o = L_g$ unit of length transformation from zero gravity to gravity

Normalized Speed of Light: When the normalized coordinate system uses proper length and the zero gravity rate of time, then the normalized speed of light (designated with a capital "C") becomes: $C = dL/dt$. In other words, the normalized speed of light in the normalized coordinate system is the change in proper length divided by the rate of coordinate time dt.

$C \equiv dL/dt = cd\tau/dt = c/\Gamma$ C = normalized speed of light
$C_o = c$ C_o = normalized speed of light in zero gravity (when $\Gamma = 1$)
$C_g = c/\Gamma$ C_g = normalized speed of light in a location with gravity (when $\Gamma > 1$)
$C_o = \Gamma C_g$ relationship between C_o and C_g

If there are two locations (1 and 2) that have gravitational gammas Γ_1 and Γ_2 respectively, then they will have normalized speed of light of C_1 and C_2. The relation between these two different normalized speeds of light is: $\Gamma_1 C_1 = \Gamma_2 C_2 = c$.

In the equation $C_o = \Gamma C_g$ we have eliminated the need for Γ_1 because in zero gravity $\Gamma = 1$ and the need to mention Γ_1 disappears. It is informative to give an example of $C_o = \Gamma\ C_g$. The gravitational gamma Γ at the surface of the sun is: $\Gamma \approx 1.000002$. If we set the normalized speed of light in zero gravity to $C_o = 1$, then the surface of the sun has $C_g \approx 0.999998$. Since proper length is coordinate length in the normalized coordinate system, the non-Euclidian properties of space are interpreted as gravity creating additional proper volume in the space surrounding a mass. Therefore the non Euclidian volume surrounding the sun is merely accepted by the normalized coordinate system. If a beam of light passes through this non Euclidian volume of space, then the difference in optical path length across the width of the beam is taken into account. This difference in path length contributes to bending of the light.

Comparison of Coordinate Speed of Light: We previously designated the coordinate speed of light using Schwarzschild coordinates as $\mathcal{C}_R$ and $\mathcal{C}_T$. The comparison of the normalized speed of light in gravity C_g to the Schwarzschild coordinate speed of light is:

Length Transformation	Coordinate Speed of Light	Speed of Light Conversion	Coordinates
$L_o = L_g$	$C_g = dL/dt$	$c = \Gamma\ C_g$	Normalized speed of light conversion
$dR = \Gamma\ dL_R$	$\mathcal{C}_R = dR/dt$	$c = \Gamma^2\ \mathcal{C}_R$	Schwarzschild coordinates (radial)
$Rd\Omega = dL_T$	$\mathcal{C}_T = Rd\Omega/dt$	$c = \Gamma\ \mathcal{C}_T$	Schwarzschild coordinates (tangential)

The normalized speed of light is similar to the proper speed of light c in the sense that both are independent of orientation (radial or tangential). The only difference is that the normalized speed of light uses coordinate time which is an absolute standard for the rate of time and also is a faster rate of time compared to the proper rate of time in gravity (stationary frame of reference).

Internally Self Consistent: Another important similarity between the normalized speed of light and proper speed of light is:

$$dL = Cdt = c\ d\tau$$

The above relationship indicates that the normalized coordinate system is internally self consistent. By definition, the following is always true: $cd\tau = dL$ (any orientation or gravitational Γ). So also the following is always true: $Cdt = dL$ (any orientation or gravitational Γ).

In gravity, the normalized speed of light is slow $(C_g = c/\Gamma)$. However, a unit of time in gravity T_g is longer than the same unit of time in zero gravity $(T_g = \Gamma\ T_o)$. The combination of these two factors offset each other, thereby producing a constant length: $C_gT_g = (c/\Gamma)\ (\Gamma\ T_o) = L_o$. The combination of these two factors achieves the same length in any Γ or orientation. Therefore it is possible to say that $L_o = L_g$ and have a coordinate system that is internally consistent.

Energy Transformation: We know the transformation of units of length $(L_o = L_g)$ and time $(T_o = T_g/\Gamma)$, but we need to determine the transformation for units of mass before all other transformations can be easily calculated. It is not obvious what transformation mass would be if we used a standard unit of mass in zero gravity (M_o) to quantify the same proper unit of mass in gravity (M_g). Mass is not synonymous with matter. Mass is a quantification of inertia which implies force and acceleration. Both of these involve time, so it should be expected that mass may have some dependence on the rate of time. Since we cannot directly reason to the mass transformation, it is necessary to determine some other transformation between zero gravity and gravity that can be determined by physical reasoning. Then we will use that transformation to deduce the mass transformation indirectly. Fortunately, there are two additional transformations (energy and momentum) that can be determined by physical reasoning. The mass transformation can be determined from either of these. We will use the following proposed energy transformation:

$E_o = \Gamma\, E_g$ proposed energy transformation equation

Before proceeding, I just wanted to review the meaning of $E_o = \Gamma E_g$. The term E_o represents a unit of energy (such as 1 Joule or 1 eV) in a location with zero gravity ($\Gamma = 1$). Similarly, E_g represents the same unit of energy in a location with gravity ($\Gamma > 1$). Furthermore, we assume that both sources of energy can be considered essentially stationary relative to each other. Therefore since gamma is greater than one ($\Gamma > 1$) the equation $E_o = \Gamma\, E_g$ says that 1 Joule in zero gravity represents more energy than 1 Joule in a location with gravity ($\Gamma > 1$). The ratio of these two energies is $E_o/E_g = \Gamma$.

To make this comparison, both E_o and E_g must be measured using the same standard of energy which implies using the same rate of time for both measurements. Perhaps it is convenient to imagine using the zero gravity (coordinate) rate of time for both energy measurements, but the only requirement is that the same rate of time be used. For another example, an electron (511,000 eV) in gravity has less energy than an electron in zero gravity when the energies are compared using the same rate of time. The proportionality constant is the gravitational gamma:

$$\Gamma = \frac{1}{\sqrt{\left(1 - \frac{2Gm}{c^2 R}\right)}} = \frac{dt}{d\tau}$$

This concept is best explained with a thought experiment. Suppose that there is a planet that is in a highly elliptical orbit around a star. The planet's kinetic energy changes from a minimum kinetic energy at the orbital apogee to a maximum kinetic energy at the perigee. Does this change in kinetic energy produce any change in the gravity produced by the combination of the planet and star as the planet orbits the star? (Assume a probe mass located far from the star/planet). We know from general relativity that the total gravity produced by a closed system remains constant when there is no transfer of energy into or out of the closed system. The planet's total energy remains constant in free flight. The more general principle is that a body in free fall maintains a constant energy as it falls. This can be expressed as: $E_o = E_g + E_k$ where:

E_o is the internal energy of a mass m in zero gravity ($E_o = m_o c^2$) measured using the zero gravity standard of energy.
E_g is the internal energy of a mass in gravity but measured using the zero gravity standard of energy (measured using the coordinate clock).
E_k is the kinetic energy of mass m in free fall from infinity to distance r in the gravity of larger mass M. Also E_k is measured using the zero gravity standard of energy.

Therefore: $E_k = Gm_oM/r = E_o(GM/c^2r)$. In the following calculation we will use the approximation: $E_o(GM/c^2r) \approx E_g(GM/c^2r)$. This approximation is acceptable in weak gravity and in the context that it is used below.

We will derive $E_o \approx \Gamma\, E_g$ from $E_o = E_g + E_k$ using weak gravity approximations for simplicity.

$E_o = E_g + E_k$ $\qquad E_k \approx E_g(GM/c^2r)$ approximation from above

$E_o \approx E_g\,(1 + GM/c^2r)$ $\qquad$ *set:* $\Gamma \approx 1 + GM/c^2r$

$E_o \approx \Gamma\, E_g$ $\qquad$ this approximation is exact in a rigorous analysis

The gravitational red/blue shift can cause some confusion in the discussion of standards of energy and will be discussed later. Also, this equation can easily be misinterpreted if proper units of energy are used to measure E_g rather than always using normalized units of energy.

Mass Transformation from Energy: Next we will solve for the mass transformation using $E_o = \Gamma E_g$; $L_o = L_g$ and $T_o = T_g/\Gamma$. Energy has units of kg m²/s² which in dimensional analysis terms will be expressed as: $E \to M\,L^2/T^2$

$E_o = \Gamma E_g$ $\qquad$ set: $E_o \to \frac{M_o L_o^2}{T_o^2}$ and $E_g \to \frac{M_g L_g^2}{T_g^2}$

$$\frac{M_o L_o^2}{T_o^2} = \Gamma\left(\frac{M_g L_g^2}{T_g^2}\right) \qquad \text{set: } L_g = L_o \text{ and } T_g = \Gamma\, T_o$$

$$\frac{M_o L_o^2}{T_o^2} = \Gamma\left(\frac{M_g L_o^2}{\Gamma^2 T_o^2}\right)$$

$M_o = M_g/\Gamma$ $\qquad$ units of mass transformation obtained from the energy transformation

Again, both M_o and M_g represent the same units of stationary mass such as 1 kilogram. Furthermore, both units of mass are measured using a single rate of time. As suspected previously, the connection between mass and inertia means that the normalized unit of mass has a dependence on the rate of time (Γ dependence).

The transformation $M_o = M_g/\Gamma$ looks strange because it says that the normalized mass unit increases as gravity increases (as Γ increases). This will be analyzed later, but it relates to the inertia measured by a zero gravity observer. For now we will use this mass transformation along with the length and time transformations to generate all of the other transformations nature requires to maintain the laws of physics when the rate of time changes because of a change in gravitational potential. To summarize, here are the key transformations:

$L_o = L_g$ unit of length transformation
$T_o = T_g/\Gamma$ unit of time transformation
$M_o = M_g/\Gamma$ unit of mass transformation

This same mass transformation can be obtained from the conservation of momentum transformation: $p_o = p_g$. However, rather than going through this derivation, it will merely be shown that the three transformations (which includes the mass transformation), gives $p_o = p_g$.

Momentum *p* : $p_o \rightarrow \frac{M_o L_o}{T_o} = \frac{\left(\frac{M_g}{\Gamma}\right) L_g}{\frac{T_g}{\Gamma}} \rightarrow p_g$

Appendix B at the end of this chapter shows the details of derivation of the various transformations. Essentially this is just dimensional analysis where the dimensions of mass, length and time are transformed from zero gravity to gravity. The following transformation of force is typical of the other transformations.

Force F: $F_o \rightarrow \frac{M_o L_o}{T_o^2} = \frac{\left(\frac{M_g}{\Gamma}\right) L_g}{\frac{T_g^2}{\Gamma^2}} \rightarrow \Gamma F_g$

$F_o = \Gamma F_g$ force transformation

The table on the following page gives all of the important transformations.

Gravitational Transformation of Units and Constants: The following are transformations of units of physics from zero gravity $\Gamma = 1$ to a location in gravity $\Gamma > 1$. The relationships are expressed assuming a single rate of time and proper length. The gravitational gamma Γ is defined as: $\Gamma \equiv \frac{dt}{d\tau} = \frac{1}{\sqrt{1-\left(\frac{2Gm}{c^2R}\right)}} \approx 1 + Gm/c^2R$. The symbols of dimensional analysis L, T, M, Q and Θ are used to represent length, time, mass, charge and temperature respectively.

Normalized Transformations

$L_o = L_g$ unit of length transformation
$T_o = T_g/\Gamma$ unit of time transformation
$M_o = M_g/\Gamma$ unit of mass transformation
$Q_o = Q_g$ unit of charge expressed in coulombs – not stat coulombs
$\Theta_o = \Theta_g$ unit of temperature transformation
$C_o = \Gamma\, C_g$ normalized speed of light transformation
$dL = \Gamma\, dR$ proper length and circumferential radius transformation

$E_o = \Gamma E_g$ energy
$v_o = \Gamma v_g$ velocity
$F_o = \Gamma F_g$ force
$P_o = \Gamma^2 P_g$ power
$G_o = \Gamma^3 G_g$ gravitational constant
$U_o = \Gamma U_g$ energy density
$\mathbb{P}_o = \Gamma \mathbb{P}_g$ pressure
$\omega_o = \Gamma \omega_g$ frequency
$\rho_o = \rho_g/\Gamma$ density
$k_o = \Gamma\, k_g$ Boltzmann's constant
$\sigma_o = \Gamma^2\, \sigma_g$ Stefan-Boltzmann Constant
$I_o = \Gamma I_g$ electrical current
$V_o = \Gamma V_g$ voltage
$\varepsilon_{oo} = \varepsilon_{og}/\Gamma$ permittivity of vacuum
$\mu_{oo} = \mu_{og}/\Gamma$ permeability of vacuum

Units and Constants That Do Not Change in Gravity

$p_o = p_g$ momentum is conserved
$\mathcal{L}_o = \mathcal{L}_g$ angular momentum is conserved
$\hbar_o = \hbar_g$ Planck's constant (angular momentum is conserved)
$\alpha_o = \alpha_g$ fine structure constant (dimensionless constant is conserved)
$\Omega_o = \Omega_g$ electrical resistance
$\mathcal{B}_o = \mathcal{B}_g$ magnetic flux density
$Z_{oo} = Z_{og}$ impedance of free space
$Z_{so} = Z_{sg}$ impedance of spacetime

Fundamental Equations

$E_o = E_g + E_k$ relationship of internal energy and gravitational kinetic energy E_k
$E_o = E_g - E_{po}$ relationship of internal energy and gravitational potential energy E_{po}

Conversion to Normalized Perspective: When we calculate energy, velocity, force, mass, power, voltage, etc. using proper time, because of the covariance of the laws of physics, we obtain an answer that numerically equals the value in zero gravity. Therefore, to convert this proper value into normalized values, we merely substitute the proper value into the above transformations by replacing the zero gravity term (E_o, V_o, F_o, etc.) and solve for the normalized value (E_g, V_g, F_g, etc.). For example, an electron has energy of 8.187 x 10^{-14} Joules. In the normalized perspective, this is really the energy of an electron in zero gravity. However, the covariance of the laws of physics allows us to use this energy in locations with $\Gamma > 1$. To convert to normalized energy, we merely substitute the zero gravity energy (8.187 x 10^{-14} Joules) for E_o in the equation $E_g = E_o/\Gamma$ and solve for E_g. Since $\Gamma > 1$ for a location in gravity, this means that $E_g < E_o$. For example, at the surface of the sun $\Gamma \approx 1 + 2 \times 10^{-6}$. Therefore an electron at the surface of the sun has only 0.999998 the energy of an electron in zero gravity.

Insights from Transformations

Energy Transformation: We normally closely associate mass and energy. However, the normalized transformations treat mass and energy differently. When an object is moved to a location with a larger gravitational gamma (and slower rate of time), the normalized energy of the object decreases and the normalized mass (inertia) of the object increases. The mass transformation is discussed below, but when we transform $E = mc^2$ into the normalized time perspective, the gravitational effect on the normalized speed of light is squared and the gravitational effect on mass is raised only to the first power. The result is: $E_o = \Gamma\ E_g$. This equation applies only to stationary objects because this was an assumption used in the derivation. The term "stationary" means no change as a function of time in the optical path length between two objects or points.

The equation $E_o = \Gamma\ E_g$ says that a unit of energy in zero gravity is larger than the same unit of energy in a location with gravity. This applies to all forms of energy such as: the annihilation energy of mass, the energy stored in capacitors, the energy of chemical reactions, thermal energy, or the energy of atomic transitions. In all cases the normalized energy of stationary objects in gravity is diminished by the gravitational gamma factor. The loss of energy when an object moves to stronger gravity is easy to see. A meteor striking the earth generates heat. This heat is the lost internal energy of the meteor. The atoms of the meteor that remain in the earth's gravity have less internal energy than they had in space (once the heat is removed).

If we elevate a one kilogram mass by 1 meter in earth's gravity, we say that we have given the mass potential energy of 9.8 Joules. Where is this energy stored? I want to see and understand this mysterious gravitational potential energy. If we ignore the change in time over the one meter elevation, then the source of gravitational potential energy is a mystery. However, if we acknowledge that the rate of time is different when we change elevation, then we arrive at the conclusion that the energy expressed in normalized units of energy is also different at the two elevations. This insight allows us to obtain a partial insight into the storage of gravitational potential energy. The proposed particle model presented later will give a more complete explanation. Below, we will use the transformation $E_o = \Gamma\ E_g$ and compare E_g at two different elevations (1 and 2 where elevation 2 is higher than 1). We will use weak gravity approximations and the following symbols:

Normalized energy in gravity at elevation 1 and 2: E_{g1} and E_{g2},
Large mass (planet) and small test mass M and m
Radius from the center of the large mass to elevation 1 and 2: r_1 and r_2
Gravitational gamma and beta for elevation 1 and 2: $\Gamma_1, \Gamma_2, \beta_1$, and β_2

$E_{g2} = \frac{E_o}{\Gamma_2}$ and $E_{g1} = \frac{E_o}{\Gamma_1}$ normalized energy transformations

$E_{g2} - E_{g1} = \frac{E_o}{\Gamma_2} - \frac{E_o}{\Gamma_1} = E_o\left(\frac{1}{\Gamma_2} - \frac{1}{\Gamma_1}\right) = E_o(\beta_1 - \beta_2)$ set: $\frac{1}{\Gamma} = 1 - \beta$

$E_{g2} - E_{g1} \approx \left[\left(\frac{GM}{c^2 r_1}\right) - \left(\frac{GM}{c^2 r_2}\right)\right] mc^2 \approx \left(\frac{1}{r_1} - \frac{1}{r_2}\right) (GMm)$

since $r_2 - r_1 << r_1$ substitute: $\left(\frac{1}{r_1} - \frac{1}{r_2}\right) \approx \frac{r_2 - r_1}{r_1^2}$

$E_{g2} - E_{g1} \approx (r_2 - r_1)\left(\frac{GM}{r_1^2}\right) m$ set $r_2 - r_1 = \Delta\hbar$ and acceleration $\frac{GM}{r_1^2} = g$

$E_{g2} - E_{g1} \approx gm\,\Delta\hbar$ gravitational potential energy

Therefore, the change in the normalized energy between level 1 and 2 $(E_{g2} - E_{g1})$ equals the gravitational potential energy for mass m in gravitational acceleration g for a height change of $\Delta\hbar = r_2 - r_1$. It is interesting to do a numerical example using a one kilogram mass being elevated by one meter in the earth's gravity.

$M = 5.976 \times 10^{24}$ kg mass of the earth
$r_1 = 6.378 \times 10^6$ m radius of the earth
$\Gamma_1 \approx 1 + GM/c^2 r_1 = 1 + 6.977 \times 10^{-10}$ gravitational gamma of the earth at sea level
$\Gamma_2 \approx \Gamma_1 + (\Gamma_1 - 1)[(r_2 - r_1)/r_1] \approx 1 + 6.977 \times 10^{-10} + 1.091 \times 10^{-16}$
$\Gamma_2 - \Gamma_1 \approx 1.091 \times 10^{-16}$ difference in Γ when $\Delta\hbar = r_2 - r_1 = 1$ meter
$E_2 - E_1 \approx (\Gamma_2 - \Gamma_1)\, E_1 \approx 1.091 \times 10^{-16} \times mc^2$ $mc^2 \approx 8.99 \times 10^{16}$ J for 1 kg mass
$E_2 - E_1 \approx 9.8$ J difference in normalized energy of a 1 kg mass elevated 1 m

Therefore, when we use normalized units (coordinate time and proper length), we find that the internal energy of a mass changes with elevation by exactly the amount of gravitational potential energy. For example, a one kilogram mass has 9.8 Joules more energy when it is at an elevation 1 meter above sea level than it has when it is at an elevation of sea level when energy is expressed in normalized units of energy. There is also a change in the normalized speed of light and in the normalized mass. The combination of these factors results in a change in the normalized energy of a mass that is elevated or lowered in a gravitational field. The relationship between internal energy in zero gravity E_o, the normalized internal energy in gravity E_g and gravitational potential energy E_φ is:

$$E_o = E_g - E_\varphi$$

The minus sign in front of E_φ is the result of considering potential energy to be a negative number. This equation leads to the equation $E_o = E_g + E_k$ discussed above. A body in free fall does not change its normalized energy. Previously, a star and planet in an elliptical orbit were used in an example. Sensing the gravity of the star/planet combination by the use of a distant probe mass is equivalent to sensing the zero gravity energy of the star/planet combination.

Mass Transformation: The normalized mass transformation $M_o = M_g/\Gamma$ looks counter intuitive because it indicates that normalized mass increases when gravitational gamma Γ increases. There is no additional matter being created, there is just a change in the perceived inertia when we convert to a single rate of time and quantify units of inertia in locations with different values of Γ. The inertia (mass) exhibited by a body is defined by the force generated when a body is accelerated. Both force and acceleration incorporate units of time therefore mass (inertia) also exhibits a dependence on the rate of time. A combination of factors results in a unit of mass (inertia) in gravity being larger than the same unit of mass (inertia) in zero gravity

Even though normalized mass increases in gravity, normalized energy decreases as explained above. Since it is easier to conceptually understand energy decreasing in gravity, perhaps it is easier to imagine energy being more fundamental than mass (inertia). It is only a historical accident that we use mass as one of the 5 dimensional units of physics. In particle physics, energy is considered more fundamental than mass and units of eV or MeV are common. If energy replaced mass as one of the 5 dimensional units, then the energy transformation would be the single factor that offsets the gravitational effect on time.

The weak equivalence principle says that there is no difference between gravitational mass and inertial mass. This is true because they both scale proportionately to the gravitational gamma when a constant rate of time is used. Merely elevating a mass in the earth's gravitational field changes both the normalized gravitational mass and the normalized inertial mass. The gravitational field produced by the one kilogram mass scales with total energy, so elevating this mass increases the energy of the elevated mass. This energy increase exactly offsets the decrease in energy of whatever means was used to elevate the mass. The total normalized energy and total gravitational field of the earth is unchanged.

Gravitational Redshift: The gravitational red/blue shift is often misinterpreted[1]. Above it was shown that the internal energy of an atom changes with elevation by exactly the difference in the gravitational potential energy. Not only is there a change in the internal energy of an atom when it changes elevation, there is also a proportional change in the energy of the atom's energy levels when there is a change in elevation. Therefore, from the perspective of someone in zero gravity (normalized time), a particular atomic transition in gravity is less energetic and this transition emits a comparatively low energy and low frequency photon. This low energy is not detectable locally because all energy comparisons (such as 1 ev) have been similarly shifted to a lower energy by the gravitational effect on time and mass.

Now we will address the gravitational redshift. The formula for the red/blue shift is:

$\lambda_o = \Gamma \lambda_g$ where:
$\lambda_g =$ wavelength in gravity and $\lambda_o =$ wavelength in zero gravity

Suppose a photon in gravity starts at a lower elevation (level 1) and ends at a higher elevation (level 2). If the photon's energy is measured at level 1 and 2 with local instruments, then a loss of energy is observed at level 2. This redshift appears to be a decrease in frequency, a decrease in energy and an increase in wavelength. If it was possible to measure wavelength, frequency and energy from a single elevation (single rate of time), then it would appear as if there was no change in energy, no change in frequency, but the same increase in wavelength that was observed with a local measurement. The energy and frequency disagreement occurs because different rate of time and energy scales are being used at different elevations. The agreement in wavelength occurs because the transformation $L_o = L_g$ says that all observers are using the same length standard to measure wavelength.

If we look only at wavelength, then there is such a thing as gravitational redshift. This is because from all gravitational potentials, the same change in wavelength is observed. However, if we look at either energy or frequency using zero gravity rate of time, then there is no such thing as gravitational redshift. The apparent change in frequency and energy occurs because we measure energy and frequency using local standards of the beginning and ending elevations. At these different elevations (different values of Γ), it is our local standards of energy and time that have changed, not the photon's energy and frequency.

There is an interesting question that I would like to propose. We know that there appears to be a gravitational blue shift when a photon is generated at a high elevation (height 2) and is analyzed at a lower elevation (height 1). In other words, the photon seems to have gained energy. The question is: What would happen if we trapped a photon in a reflecting box at height 2, then lowered the box to height 1? Would the photon in a box have the same energy as a freely propagating photon when it reached height 1?

[1] L.B. Okun; Am. J. Phys. **68** (2), February 2000

I contend that the photon lowered in a box would appear to have less energy than the freely propagating photon. From a local perspective, the freely propagating photon appears to gain energy (blue shifted) and the photon in a box would appear to have the same energy as the energy at height 1. From the perspective of a zero gravity observer, the freely propagating photon retained its original energy when it propagated from heights 2 to 1 and the photon in a box lost energy. This lost energy was removed from the photon in the lowering process. As previously explained, a confined photon exhibits weight. Lowering a box containing a confined photon transfers energy from the photon to the apparatus used to lower the box. There are numerous ways to analyze this problem and I content that they all give the answer described here. However, this is a little off the subject, so I will not elaborate further.

Another question is: How is it possible for the wavelength to change with elevation if there is no change in the normalized frequency? The answer is that the normalized speed of light changes with elevation ($C_o = \Gamma C_g$). If a photon propagates from a lower elevation to a higher elevation, there is no change in frequency, but the normalized speed of light C_g increases with elevation. This increase in the normalized speed of light increases the distance traveled per cycle time (increases the wavelength). This change in wavelength is obvious from any location, but the constant frequency is only observable when all measurements are made from a single elevation (a single rate of time).

Finally, a word of caution about not using the redshift formula ($\lambda_o = \Gamma \lambda_g$) in transformations as a substitute for length. It is not correct to equate wavelength with the unit of length when there is a change in Γ. A photon generated from a local atom has a wavelength that is a good standard of length. However, a photon generated at another gravitational potential has a wavelength that changes with Γ. Therefore, a photon that is not generated locally cannot be used as a standard of length.

Electrical Charge Transformation: The transformation of electric charge needs special explanation. The transformations of $Q_o = Q_g$ is only correct if charge is expressed in coulombs rather than stat coulombs. Coulombs and stat coulombs are fundamentally different. The MKS unit of coulomb is 6.24 x 10^{18} electrons but the CGS unit of stat coulomb is related to electrostatic force and has units of $\sqrt{ML^3}/T$. The result is that charge is conserved in gravitational transformations if charge is expressed as a number of electrons (coulombs), but it is not conserved if charge is expressed in stat coulombs with units of $\sqrt{ML^3}/T$. If an electrostatic force equation is written in CGS units, then ε_o is missing and there is no normalization of permittivity. The following transformation must be used for charge expressed in stat coulombs:

$Q_o = \sqrt{\Gamma}\, Q_g$ (charge in stat coulombs)

Testing: The objective of these transformations is to offset the gravitational effect on the rate of time and keep the laws of physics covariant in any gravitational potential. It is interesting to make substitutions into various equations of physics and see that the transformations do indeed keep the same equations of physics when there is a transformation of gravitational gamma. This is saying that these transformations exhibit internal self consistency. However, it is also possible to see the implied physics behind these transformations upon close examination.

Shapiro Revisited: In the last chapter we talked about the Shapiro experiment detecting a relativistic increase in the time required for radar to travel radially in the sun's gravity. The delay was equivalent to a 50 μs delay in the time required for light to travel one way from the earth to the sun's surface. If we use Schwarzschild coordinates, then the 50 μs delay is due entirely to the slowing of the coordinate speed of light which scales according to the local value of Γ^2 along the radial path between the earth and the sun ($c = \Gamma^2 \, c_R = \Gamma^2 dR/dt$).

How do we interpret the 50 μs delay using the normalized coordinates? If a tape measure could be used to measure the distance between the earth and the surface of the sun, the distance measured by a tape measured would be about 7.5 km longer than the circumferential radius distance calculated by dividing the circumference by 2π. The normalized coordinate system uses proper length (tape measure length) as coordinate length. Therefore, the normalized coordinates gives the radar pulse credit for having traveled the additional 7.5 km of non-Euclidian distance between the earth and the sun. It takes about 25 μs for speed of light travel to cover 7.5 km, so the normalized coordinates attributes half the 50 μs delay to the time required to travel the non-Euclidian distance generated by the sun's gravity. The other half is due to the normalized speed of light being slowed according to $c = \Gamma C_g = dL_R/dt$. Integrating over the changing Γ along the optical path gives the additional 25 μs due to this slowing. Therefore, the 50 μs total delay is the same, but the interpretation is different.

The following chapters will primarily use the standard definition for the speed of light. This standard definition will be designated by lower case "c". Occasionally we will switch into using normalized speed of light to give another perspective. In this case we will use an upper case "C". Attention will be called to this change.

Appendix B

This appendix gives the details of the derivation of some of the additional transformations enumerated in the table titled "Gravitational Transformations of Units and Constants". This appendix can be skipped without the loss of any important information to the main points of this book if this backup information is not of interest to the reader.

Velocity v**:** $v_o \rightarrow \frac{L_o}{T_o} = L_g \frac{\Gamma}{T_g} \rightarrow \Gamma v_g$

$v_o = \Gamma\ v_g$ normalized velocity v_g decreases in gravity (just like C)

Gravitational Constant G: $G_o \rightarrow \frac{L_o^3}{M_o T_o^2} = \frac{L_g^3}{\left(\frac{M_g}{\Gamma}\right)\left(\frac{T_g^2}{\Gamma^2}\right)} \rightarrow \Gamma^3 G_g$

$G_o = \Gamma^3 G_g$ normalized gravitational constant (see comment below)

Energy Density U**:** $U_o \rightarrow \frac{M_o}{L_o T_o^2} = \frac{\frac{M_g}{\Gamma}}{L_g\left(\frac{T_g^2}{\Gamma^2}\right)} \rightarrow \Gamma U_g$

$U_o = \Gamma U_g$ normalized energy density

Electrical Charge: Next we come to transformations that have dimensions that include electrical charge in Coulombs. These include permittivity ε_o, permeability μ_o, current I, Voltage V and the impedance of free space Z_o. For this exercise, the symbol ε_{oo} will represent ε_o in zero gravity and ε_{og} will represent ε_o in gravity. Similarly we will use the symbols μ_{oo}, μ_{og}, Z_{oo}, and Z_{og}. A unit of charge will be represented by Q_o and Q_g.

It is not possible to use the above substitutions to determine the transformation of a unit of electrical charge when comparing change between zero gravity Q_o and a unit of charge in gravity Q_g using a single rate of time. It is true that the dimension of charge (expressed in Coulombs) does not contain either time or mass, so the two dimensions known to have Γ dependence are missing (stat Coulombs will be discussed later). So superficially it seems as if there should be no change in a unit of charge when the rate of time changes due to a change in Γ. However, we need to supplement this with some additional physical reasoning using the laws of physics.

From the conservation of charge and the Faraday law we know that charge is conserved when there is a change in elevation. This indicates that $Q_o = Q_g$. There is additional support for this contention because the impedance of free space Z_o has units that scale with $1/Q^2$ (dimensional analysis symbol Q). If there was a gravitational dependence on charge, then the impedance of free space would have a gravitational dependence. There would be a slight impedance mismatch when light changes elevation in gravity. This impedance mismatch would cause scattering of electromagnetic radiation from gravitational fields. For all these reasons we will assume that:

$Q_o = Q_g$

A unit of electrical charge in gravity (Coulombs) equals a unit of electrical charge in zero gravity. We will now use this transformation to generate additional electrical transformations.

Permittivity ε_o: $\varepsilon_{oo} \rightarrow \dfrac{Q_o^2 T_o^2}{L_o^3 M_o} = \dfrac{Q_g^2\left(\frac{T_g^2}{\Gamma^2}\right)}{L_g^3\left(\frac{M_g}{\Gamma}\right)} \rightarrow \varepsilon_{og}/\Gamma$

$\varepsilon_{oo} = \varepsilon_{og}/\Gamma$ normalized permittivity

Impedance of Free Space Z_o: $Z_{oo} \rightarrow \dfrac{M_o L_o^2}{T_o Q_o^2} = \dfrac{\left(\frac{M_g}{\Gamma}\right) L_g^2}{\left(\frac{T_g}{\Gamma}\right) Q_g^2} \rightarrow Z_{og}$

$Z_{oo} = Z_{og}$ impedance of free space

Voltage V: $V_o \rightarrow \dfrac{M_o L_o^2}{T_o^2 Q_o} = \dfrac{\left(\frac{M_g}{\Gamma}\right) L_g^2}{\left(\frac{T_g^2}{\Gamma^2}\right) Q_g} \rightarrow \Gamma V_g$

Temperature Θ: Finally we come to the transformation of Boltzmann's constant k and temperature. Boltzmann's constant is typically described as: $k = 1.38\ 10^{-23}$ Joule/molecule ^{0}Kelvin. This number, measured locally, does not change when gravitational gamma is changed. However, the standard of what constitutes a unit of energy (Joule) changes according to the previously derived transformation: $E_g = E_o/\Gamma$. Therefore, to an observer using normalized time, the energy per molecule per degree Kelvin decreases in gravity. Therefore, an acceptable interpretation for the zero gravity observer is that temperature in gravity equals the same temperature in zero gravity, but the Boltzmann "constant" depends on Γ.

$\Theta_o = \Theta_g$ temperature is unaffected by an change in gravity

Boltzmann Constant: $k_B \rightarrow ML^2/T^2\Theta$

$k_B = 1.38\ 10^{-23}$ Joule/molecule ^{0}Kelvin $\rightarrow ML^2/T^2\Theta$ molecule

$k_{Bo} \rightarrow \dfrac{M_o L_o^2}{T_o^2 \Theta_o}$ molecule $= \dfrac{\left(\frac{M_g}{\Gamma}\right) L_g^2}{\left(\frac{T_g^2}{\Gamma_2}\right) \Theta_g}$ molecule $\rightarrow \Gamma k_{Bg}$

$k_{Bo} = \Gamma k_{Bg}$ normalized Boltzmann's "constant"

Stefan-Boltzmann Constant: $\sigma_o \rightarrow \frac{M_o}{T_o^3 \Theta_o^4} = \frac{\frac{M_g}{\Gamma}}{\left(\frac{T_g^3}{\Gamma^3}\right)\Theta_g^4} \rightarrow \sigma_g / \Gamma^2$

$\sigma_o = \Gamma^2 \sigma_g$ normalized Stefan-Boltzmann "constant"

The Stefan-Boltzmann constant is the constant associated with the intensity of a black body emission $\mathcal{J} = \sigma\varepsilon T^4$ where σ = Stefan-Boltzmann Constant, ε = emissivity, T is temperature and Θ is the dimension of temperature. The equation $\mathcal{J} = \sigma\varepsilon T^4$ supports the idea that $\Theta_g = \Theta_o$ because temperature is raised to the fourth power. If there was a temperature dependence on Γ, we would have a Γ^4 dependence.

Chapter 4

Assumptions

"There has never been a law of physics that did not demand
'space' and 'time' for its statement."
John Archibald Wheeler

Starting Assumption: Physics today has a large body of experimental observations and mathematical equations that correspond to the experimental observations. Therefore, on a superficial level it would appear that we have a good theoretical understanding of nature up to a limit that will be called the frontier of knowledge. However, there are many counter intuitive physical interpretations of the mathematical equations and experimental observations. This book proposes alternative physical interpretations that not only fit the equations and experiments, but also offer improved conceptual understanding and new insights.

If we are looking for the fabled "theory of everything", it is best to start the quest with the simplest possible starting assumption. Only if the simplest assumption is proven to be inadequate, should we reluctantly move on to a more complex assumption. When I examined the similarities between light confined in a reflecting box and particles, I was struck by a big idea. This idea is:

Basic Assumption: **The universe is only spacetime.**

This idea will be taken as a basic assumption for the remainder of this book. If this simple starting assumption is correct, it should be possible to invent a model of the universe that uses only the properties of 4 dimensional spacetime. Ultimately, all matter, energy, forces, fields and laws of physics should logically be obtainable from just 4 dimensional spacetime. This is a large project that encompasses all of physics. It grew into this book length explanation rather than a few technical papers.

Initially, this might seem impossible because spacetime appears to be just a quiet vacuum that possesses three spatial dimensions plus time. However, the quantum mechanical model of spacetime has a vast energy density also known as vacuum energy, quantum fluctuations, zero point energy, etc. The spacetime model that is capable of forming matter, energy, forces and fields is a composite of quantum mechanical and general relativistic characteristics. Besides a specific speed of light and a gravitational constant, spacetime also possesses impedance, bulk modulus, energy density etc. The combination of these properties permits spacetime to become the basic building block for all matter and forces.

Spacetime does have some real advantages as the basic building block of everything in the universe. Spacetime is the stiffest of all possible mediums that support wave propagation. A disturbance in spacetime propagates at the speed of light. The characteristics of spacetime permit it to support any frequency wave up to Planck frequency (~10^{43} Hz). This is a tremendous advantage if we are attempting to find a medium that can hypothetically support the large energy density required to build a proton, for example. Some waves in spacetime will be shown to be capable of modulating the spatial and temporal properties of spacetime. This can serve as the basic building block of matter, forces and fields.

The simplicity of the starting assumption does have one advantage. It should be relatively easy to prove or disprove. Unlike string theory, this starting assumption hardly provides any "wiggle room". If the assumption is wrong, the error should be quickly evident. If the assumption is correct, the extreme limitations define a narrow path that should lead to both conformations and new insights. I will summarize the conclusions of chapter #1.

> A confined photon in a moving frame of reference has the following 8 similarities to a fundamental particle with the same energy and same frame of reference:
> 1) the same inertia, 2) the same weight, 3) the same kinetic energy when moving 4) the same de Broglie wavelength 5) the same de Broglie phase velocity, 6) the same de Broglie group velocity, 7) the same relativistic length contraction, 8) the same relativistic time dilation. It is hard to avoid the thought that perhaps a particle is actually a wave with components exhibiting bidirectional propagation at the speed of light but somehow confined to a specific volume. This confinement produces standing waves that are simultaneously moving both towards and away from a central region.

The assumption that the universe is only spacetime causes us to explore the possibility that waves in spacetime (dynamically curved spacetime) are the basic building blocks of particles, forces and fields. It also offers the opportunity to give a physical description of quantum mechanical operations such as the collapse of the wave function or making a measurement of a quantum mechanical state. The ultimate test is whether this assumption logically leads to gravity and compatibility with quantum mechanics.

The starting assumption that the universe is only spacetime requires that the reader change perspective about what is a cause and what is an effect. The standard physical interpretation of general relativity is that matter causes curved spacetime. The reverse perspective would be that a special type of curved spacetime (dynamic spacetime) causes matter. The static curved spacetime, normally assumed to be caused by matter, will be shown to be a minor residual effect of dynamic spacetime.

Creative Challenge: I started with two positions that are currently not connected. On the one hand, there is the current understanding of the fundamental particles, forces and physical laws. On the other hand, there is the basic assumption that the universe is only spacetime. An attempt to bring these two disconnected positions together requires a creative look at both the properties of spacetime and the properties of particles, forces and physical laws. The experimentally verified physical facts and equations are assumed to be correct, but it is not necessary to adopt the physical interpretations currently used to explain these facts and equations. For example, the equations of general relativity accurately describe gravity and the universe. However, the accuracy of these equations does not guarantee the accuracy of the physical interpretations currently associated with these equations. The idea that gravity is not a force, but the result of the geometry of spacetime is a physical interpretation of the equations of general relativity. Rather than focusing on explaining gravity or uniting quantum mechanics and general relativity, I merely start with what I believe is the simplest possible starting assumption (the universe is only spacetime) and attempt to reconcile this assumption with everything known to exist in the universe.

Planck Units: In 1899 Max Planck proposed a system of units based only on constants of nature. He used the reduced Planck constant $\hbar$ = 1.055 x 10^{-34} kg m^2/s, the Newtonian gravitational constant G = 6.672 x 10^{-11} m^3/s^2kg, the speed of light c = 2.998 x 10^8 m/s and the Coulomb constant $1/4\pi\varepsilon_o$ = 8.987 x 10^9 m^3kg/s^2C^2. This combination of constants can be used to make units of length, time, mass, and charge. Extrapolating further, it is possible to make all other units such as units of force, energy, momentum, power, electric field, etc.

It was immediately recognized that Planck units were fundamental because they were derived from constants of nature. However, it later became recognized that Planck units held an even more special place in physics. Planck units were actually based on the properties of spacetime and they represented the limiting values (maximum or minimum) for a single fermion or boson. For example, a group of particles can have mass in excess of Planck mass (m_p = 2.176 x 10^{-8} kg). However, the theoretical limit for a single fundamental particle (a single fermion) is Planck mass. If there was a fermion with Planck mass it would form a black hole. The inverse of Planck time is the maximum possible frequency for a photon. Planck length l_p = 1.616 x 10^{-35} m represents the theoretical limiting value (device independent) of any length measurement. Similarly, Planck time t_p = 5.301 x 10^{-44} s represents the limiting accuracy of any time measurement. When we are attempting to build the universe out of only spacetime, Planck units become the natural units for this analysis.

Spacetime: The Quantum Mechanical Model: The quantum mechanical view of space and time (including QED and QCD) is very different than the general relativistic view. We will first enumerate the quantum mechanical description. In quantum mechanics both space and time are quantized. Space is a locally violent medium filled with vacuum fluctuations. At the basis of the uncertainty principle there is energetic spacetime that is in a continuous state of flux. The distance between two points can only be specified to a limited accuracy (Planck length) because of the effect of these fluctuations on spatial measurement. Similarly the energy at a point undergoes wild fluctuations. This is usually considered as justification for the formation and annihilation of virtual particle pairs, but this energy fluctuation can also be considered merely an energetic distortion of spacetime. Even the rate of time at adjacent points can fluctuate slightly producing variations (differences between clocks) that can differ by Planck time.

These fluctuations produce measurable results. For example, the Casimir effect produces a force on two closely spaced metal plates which have been measured to an accuracy of 5% of the theoretical prediction. In a hydrogen atom there is an interaction between the electron and the vacuum fluctuations that produces a small shift in the energy of the $^2S_{1/2}$ energy level. This "Lamb shift" has been accurately predicted and experimentally measured. Vacuum polarization is another important effect in QCD which involves the interaction of a charged particle and shielding of that charge produced by virtual particles created in the vacuum.

An electron has a magnetic moment which would be precisely equal to 2 except for the anomalous magnetic dipole moment caused by vacuum fluctuations. This electron spin g-factor (g_s) has been predicted by QED calculations and experimentally verified to better than 10 significant figures for the anomalous contribution. The result is: $g_s \approx 2.00231930436$. This means that the magnetic moment of an electron is the most accurate prediction in all of physics. This accuracy depends on the accuracy of the quantum mechanical model of the fluctuations in spacetime. All of these examples are meant to illustrate that quantum mechanics requires that vacuum has vacuum fluctuations at a very large energy density.

One way of quantifying these fluctuations is to visualize a vacuum as being filled with harmonic oscillators at a temperature of absolute zero. The lowest quantum mechanical energy of each oscillator is $E = ½\,\hbar\omega = ½\,\hbar c/\lambda\!\!\!^{-}$ (where $c = \omega\lambda\!\!\!^{-}$ and $\lambda\!\!\!^{-}$ is pronounced lambda bar). This is the famous zero point energy. Each oscillator can be visualized as occupying a volume of $V = k\lambda\!\!\!^{-3}$ where k is a numerical factor near 1. For example, a wave can be confined in a reflecting cavity that is ½ wavelength on a side. The wave amplitude is zero at the walls and maximum in the center for this size cavity. Since we are standardizing on the use of ω for frequency and $\lambda\!\!\!^{-}$ for wavelength, it is possible to say that the wave has been confined to a volume of $\lambda\!\!\!^{-3}$ if we ignore numerical factors near 1. Using this volume designation, this means that the energy density U at frequency ω *is:* $U_\omega = \hbar\omega/\lambda^3 = \hbar c/\lambda^4 = \hbar\omega^4/c^3$. In words, the energy density at a specific frequency ω increases with the fourth power of frequency.

What is the total energy density of zero point energy at all frequencies? If ω is assumed to have no limit (infinite frequency) then the implied energy density would also be infinite. If we assume that zero point energy is associated with the properties of spacetime (proven later) then the maximum frequency that spacetime can support is Planck frequency ω_p which is the inverse of Planck time $\omega_p = 1/T_p = (c^5/\hbar G)^{1/2} \approx 1.85 \times 10^{43}\ s^{-1}$. Assuming Planck frequency ω_p, the implied energy density of the quantum mechanical model of spacetime is Planck energy density $U_p = \hbar\omega_p^4/c^3 \approx 4 \times 10^{113}$ J/m^3. This shocking large number will be extensively analyzed several different places later in this book. For now we will merely recognize that this is part of the quantum mechanical model of spacetime.

Spectral Energy Density: The normal way of treating energy density at a particular frequency is to designate the "spectral energy density" which is energy density per unit frequency interval. We will designate this spectral energy density as: $U(\omega)d\omega$. Every point in spacetime is treated like it is a quantized harmonic oscillator with energy $E = ½\,\hbar\omega$. This concept leads to a spectral energy density $U(\omega)d\omega$ that is:

$$U(\omega)d\omega = k\left(\frac{\hbar\omega^3}{c^3}\right)d\omega$$

This spectrum with its ω^3 dependence of spectral energy density is unique in as much as motion through this spectral distribution does not produce a detectable Doppler shift. It is a Lorentz invariant random field. All inertial observers are equivalent. Any particular spectral component undergoes a Doppler shift, but other components compensate so that all components taken together do not exhibit a Doppler shift. Therefore this spectral energy distribution satisfies the requirement that it should not be possible to detect any difference in the laws of physics in any frame of reference (at least up to the cut off at Planck frequency). It should also be noted that neither cosmological expansion nor gravity alters this spectrum[1]. The implications of having a finite cut off frequency are discussed as part of the cosmological analysis in chapter 14.

Quantum Foam: In 1955, John Wheeler proposed that spacetime is highly turbulent at the scale of Planck length. He proposed that as the scale of time and length approaches Planck time and Planck length, the energy fluctuations in spacetime increase. These fluctuations on the smallest scale possible cause spacetime to depart from its smooth macroscopic characteristic. John Wheeler suggested the term "quantum foam" to describe spacetime on this smallest scale.

[1] Puthoff, H.E. Phys. Rev. A Volume 40, p.4857, 1989 Errata in Phys. Rev A volume 44, p. 3385, 1991 See also New Scientist, volume 124, p.36, Dec. 2, 1089

In the book "Einstein's Vision", John Wheeler proposed that elementary particles were excited energy states (resonances) of the vacuum energy fluctuations. He pointed out that the density of a nucleus was ~ 10^{18} kg/m^3 and this density is negligibly small compared to the equivalent density of spacetime (~ 10^{97} kg/m^3 or an energy density of ~ 10^{113} J/m^3). While John Wheeler's description of spacetime has the same basic components as the spacetime model proposed in this book, his concept of how spacetime forms particles and forces is different.

To summarize, the quantum mechanical model of vacuum, spacetime is a sea of energetic activity that can be visualized several different ways. The uncertainty principle has distance, momentum, time and energy undergoing fluctuations. Field theory has a sea of harmonic oscillators, each with zero point energy of $E = ½\, \hbar\omega$. Particle physics has virtual particle pairs and virtual photons coming into existence and going out of existence. QCD has virtual particles with both color charge and electrical charge producing vacuum polarization. The quantum mechanical model of vacuum requires a minimum vacuum energy density of at least 10^{50} J/m^3 for many QCD calculations and some variations require the full Planck energy density of ~ 10^{113} J/m^3.

Spacetime: The General Relativity Model: General relativity visualizes spacetime as a smooth, well behaved medium consisting of 3 spatial dimensions plus time. Spacetime can be curved by energy in any form but it is not subject to the random fluctuations of the quantum mechanical model. General relativity is a classical theory that does not recognize Planck's constant, Planck length or Planck time. The distance between two closely spaced points is not considered to fluctuate but there is a limit as to the precision of the measurement. This precision limit is set by the possibility of forming a black hole if too much energy is required to make the measurement. However, even this limit is a mixture of quantum mechanics and general relativity. In general relativity there are no quantized operations.

General relativity (GR) teaches that energy in any form generates gravity. According to general relativity the universe would collapse into a black hole if the energy density of the universe exceeds the "critical" energy density. The cosmologically observed energy density of the universe (about 10^{-9} J/m^3) appears to be within the margin of error (within 1%) of equaling the critical energy density of the universe. Therefore, according to general relativity the quantum mechanical model of vacuum must be wrong because the quantum mechanical model requires energy density vastly exceeding the critical density of about 10^{-9} J/m^3. According to general relativity, an energy density of 10^{113} J/m^3 is ridiculous. This energy density would form a black hole even for a sphere that is Planck length in radius.

General relativity does have its share of predictions not shared by quantum mechanics. For example, the rate of time depends on gravity in GR while quantum mechanics considers the rate of time to be constant. Also, GR predicts that proper volume also is affected by gravity. Quantum mechanics does not recognize a gravitational effect on volume.

Reconciling the QM and GR Models: The discrepancy between the quantum mechanical energy density of vacuum (~10^{113} J/m^3) and the cosmologically observed energy density of the universe (~10^{-9} J/m^3) is the largest numerical discrepancy in all of physics. The difference is a factor of about 10^{122} but this is usually rounded off to "merely" a factor of 10^{120}. The standard interpretation is that there must be some other effect that cancels out what appears to be a ridiculously large quantum mechanical energy density. However, there is good evidence that the vacuum fluctuations exist. They are required for many current quantum mechanical effects. They cannot simply be canceled by another effect that somehow eliminates all the effects of these fluctuations. Furthermore, canceling out 10^{113} J/m^3 would require an equally large effect in the opposite direction. No effect that cancels 10^{113} J/m^3 has been proposed.

On close examination we really do not need a true cancelation of energy. We merely need one or more mechanisms that allow the quantum mechanical vacuum energy to exist but not interact with us or our observable universe except through the quantum mechanical interactions mentioned. It will be proposed later that the quantum mechanical model of spacetime is correct regarding the energy density of spacetime at the quantum scale of Planck length and Planck time. Also, the general relativity model is correct regarding the energy density of spacetime on the macroscopic scale that does not recognize fluctuations at the scale of Planck length and Planck time. Since the GR predictions are virtually universally accepted, we will concentrate on the energy density predictions of quantum mechanics which are generally presumed to be eliminated by some unknown offsetting property of spacetime. This seems obvious since we do not macroscopically interact with this tremendous energy density nor has it caused the universe to collapse as implied by general relativity.

It is proposed here that spacetime is a composite of the quantum mechanical model and the general relativity model. The quantum mechanical model with its quantum fluctuations and tremendous energy density is describing the portion of the universe that lacks quantized angular momentum and is as homogeneous as quantum mechanics allows. The general relativity model only recognizes the small portion of the energy in the universe that possesses quantized angular momentum (fermions and bosons). This portion is capable of forming energy concentrations such as massive bodies which distort the macroscopic homogeneity of the quantum mechanical model to form curved spacetime.

The rest of this book is devoted to explaining various aspects of the above statement.

The factor of 10^{120} discrepancy between the two models is the difference between the minute fraction of energy (particles, photons, etc.) that possesses quantized angular momentum and the vastly larger vacuum energy density that does not possess quantized angular momentum. This vacuum energy will later be shown to be a homogeneous superfluid and have other properties that prevent gravitational collapse. These statements are only made to alert the reader that the obvious objections will be addressed later.

Another objection addressed later is the contention that the large energy density of vacuum fluctuations is impossible because the volume of the universe is expanding yet the vacuum energy density is perceived to remain constant. This seems to imply that a vast amount of new energy is being added to the universe each second to accompany the new volume being created. This answer requires two chapters (13 & 14) for a complete explanation, but a key point in this explanation is that spacetime is undergoing a transformation that started at the Big Bang and continues today. The expansion of the proper volume of the universe is one result of this transformation. Another result is that our standard of a unit of energy is shrinking. A decreasing standard will make a constant amount of energy on an absolute scale to appear to grow on our shrinking scale. New energy is not being added to the universe but the properties of the vacuum fluctuations are changing. This will be explained in more detail in chapters 13 and 14.

Vacuum Fluctuations and Vacuum Energy: In the remainder of this book the terms "vacuum energy" and "vacuum fluctuations" will be used interchangeably. In both cases they refer to the quantum mechanical model of spacetime with energy density of about 10^{113} J/m^3. For example, "vacuum fluctuations" implies quantum mechanical fluctuations of the vacuum (fluctuations of spacetime) which will be described in the next section of this book. Such fluctuations also can be described as "vacuum energy". The reason for using two different terms is because sometimes it is desirable to emphasize the energy characteristics and sometimes it is desirable to emphasize the fluctuation characteristic.

In this book the terms "vacuum energy" and "vacuum fluctuations" will never imply dark energy or the cosmological constant. These are concepts from cosmology that imply a vastly lower energy density and a different explanation. Dark energy will be discussed in chapters 13 and 14. A model of the universe will be presented that is based on spacetime undergoing a transformation that produces the observed increase in proper volume and other observations without the need of dark energy.

Dipole Waves in Spacetime

Thus far we have talked about vacuum fluctuations and inferred that these can be considered waves in spacetime. Now it is time to be more specific about the properties of these waves in spacetime. Since the starting assumption of this book is that the universe is only spacetime, the goal is to see if it is possible to prove that all particles, fields and forces are formed out of 4 dimensional spacetime. A critical step is to "invent" a model of waves in spacetime that could possibly be the universal building block of all particles and forces. Once such a model is postulated, it must be tested to see if it actually corresponds to reality.

If fundamental particles are ultimately confined waves in spacetime, it is necessary to look for an explanation that incorporates waves in spacetime with characteristics that can be the basic building block for all matter and forces. Gravitational waves do not have the necessary properties to be both vacuum fluctuations and the basic building block of all particles and forces. We are looking for a wave in spacetime that changes both the rate of time (distorts the time dimension) and changes the distance between points in a way that changes proper volume. We know from general relativity that mass affects both the rate of time and proper volume (mass curves spacetime). **Therefore, if we are trying to build matter out of waves in spacetime, we must use waves in spacetime that possess the ability to affect both the rate of time and the distance between two points**. We must use waves that have the ability to dynamically curve spacetime. The only wave in spacetime that can affect the rate of time and proper volume is a hypothetical dipole wave in spacetime.

The immediate problem is that dipole waves in spacetime are forbidden by general relativity. In standard texts on general relativity the subject of dipole waves warrants just a brief mention because they are considered impossible. For example, perhaps the most authoritative text on general relativity is the 1300 page tome titled "Gravitation" by Charles Misner, Kip Thorne and John Archibald Wheeler. On page 975 of the 24th printing, dipole waves in spacetime receive a three line mention to the effect that *there can be no mass dipole radiation because the second time derivative of the mass dipole is zero* ($\ddot{\mathrm{d}} = \dot{\mathrm{p}} = 0$). This conclusion ultimately follows from the conservation of momentum. The generation of dipole waves in spacetime would require the center of mass of a closed system to accelerate in violation of the conservation of momentum. Furthermore, if a dipole wave in spacetime somehow existed, the passage of this wave past an electrically neutral, isolated mass would cause the center of mass to undergo an oscillating displacement which is also a violation of the conservation of momentum. Clearly, dipole waves in spacetime cannot exist on the macroscopic scale governed by general relativity.

However, if we are exploring the possibility of constructing the entire universe out of 4 dimensional spacetime, dipole waves in spacetime have a lot of appeal and deserve a closer look. Matter curves spacetime therefore dipole waves in spacetime need to be considered as the spacetime wave building block for matter. Are there any conditions where dipole waves in spacetime would be permitted? The answer is yes provided that the dipole waves conform to a severe limitation. The following is the second key assumption of this book:

Second Assumption: **Dipole waves in spacetime are permitted by the uncertainty principle provided that the displacement of spacetime caused by the dipole wave does not exceed Planck length or Planck time. This restriction will be called the "Planck length/time limitation".**

The spacetime based model proposes that dipole waves in spacetime can exist on the scale governed by quantum mechanics. This is to say that there are displacements of spacetime that are so small that the displacements are below the quantum mechanical detectable limit set by the uncertainty principle. This is analogous to the reasoning that permits virtual particle pairs to temporarily exist provided that they are permitted by the uncertainty principle. It is proposed that dipole waves in spacetime can exist provided that the spatial displacement of spacetime does not exceed Planck length and the temporal displacement of spacetime does not exceed Planck time. Like all Planck unit definitions it ignores numerical factors near 1. Therefore, a more precise statement of this limitation might include a numerical factor near 1 that is being ignored here.

A superficial analysis of the minimum detectable change in length would use the uncertainty principle equation: $\Delta x \Delta p \geq \frac{1}{2}\hbar$ and substitute for Δp the largest possible value of momentum uncertainty for a single quantized unit. This would be Planck momentum which is the momentum of a hypothetical photon with Planck energy or Planck mass times the speed of light. Using this maximum momentum for a single quantized unit the minimum value of Δx is: $\Delta x = L_p$ (Planck length). However, this question of the minimum length measurement has been given a more rigorous examination[2,3,4,5,6,7] that includes both quantum mechanics and general relativity. The conclusion of all these articles is that that there is a fundamental limit to length measurement (device independent) on the order of Planck length ($L_p \approx 1.6 \times 10^{-35}$ m). A similar analysis of time[2,3] has concluded that there is a fundamental minimum detectable unit of time (difference between clocks) which is on the order of Planck time ($T_p \approx 5.4 \times 10^{-44}$ s)

We will accept these conclusions and proceed assuming that a displacement of spacetime equal to Planck length or Planck time is fundamentally undetectable. This limitation is conceptually understandable if it is viewed as a signal to noise limitation. If the very nature of spacetime is

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that there are quantum fluctuations of Planck length and Planck time, then it is quite reasonable that it is impossible to make physical measurements below this noise limit. Therefore, quantum mechanics permits a dipole wave in spacetime to displace a particle's center of mass by Planck length without violating the conservation of momentum. Similarly, a dipole wave can displace time (the difference between clocks) at a specific location by Planck time compared to the surrounding volume without violating any conservation requirement. Even though the wave properties of spacetime dipole waves are undetectable, this does not imply that spacetime dipole waves are inconsequential. It will be shown that any dipole wave that possesses quantized angular momentum will produce detectable interactions without revealing its wave properties.

It is proposed that vacuum fluctuations, quantum foam, zero point energy, vacuum energy, the uncertainty principle etc. are all just different ways of describing dipole waves in spacetime with a spatial displacement amplitude in the range of Planck length ($\Delta L \approx L_p$) and a temporal displacement amplitude of Planck time ($\Delta T \approx T_p$). This says that the dimensionless strain wave amplitude for a reduced wavelength of $ƛ$ expressed using spatial properties and temporal properties would be:

$H = \Delta L/L = L_p/ƛ$ strain amplitude expressed using Planck length and $ƛ$
$H = \Delta T/T = T_p\omega$ strain amplitude expressed using Planck time and ω

It will be shown later that this restricted strain amplitude can still achieve Planck energy density (~10^{113} J/m^3) as well as achieve the energy required for electrons, quarks, photons etc. To give a clearer description of strain amplitude, imagine a sine wave that is drawn on graph paper. On the Y axis, the sine wave has a maximum value of $+L_p$ and a minimum value of $-L_p$. This maximum and minimum displacement is the quantum mechanical limitation. The strain amplitude produced by this wave at any point corresponds to the slope of this wave at that point. The maximum slope (maximum strain amplitude) occurs when the wave crosses the x axis ($y = 0$). This maximum slope is: $L_p/ƛ$ and leads to the following corollary:

Corollary Assumption: **The maximum strain amplitude permitted for a dipole wave in spacetime is $L_p/ƛ$ in the spatial domain and $T_p\omega$ in the temporal domain.**
$\boldsymbol{H_{max} = L_p/ƛ = T_p\omega}$

Symbols L_p and T_p Explained: We are going to interrupt the discussion of dipole waves to insert a note on symbols. A distinction is being made between static Planck length l_p and a wave amplitude that is a Planck length oscillation of spacetime. This will be called "dynamic Planck length" represented by the symbol L_p. The difference is that l_p represents a unit of ruler length. An example of "ruler length" is a 1 meter distance between two stationary points. This contrasts with "dynamic length" which is a wave amplitude with dimensions of length. For example, the dipole waves in spacetime are continuously affecting the distance between two stationary points by Planck length. This wave amplitude is "dynamic Planck length" and represented by the symbol L_p. This oscillation distance has units of length, but it is not the same as ruler length. In a sense, L_p in dipole waves in spacetime is similar to the Δl term in gravitational waves.

A unit of time corresponding to Planck time has the symbol t_p. When the rate of time is speeding up and slowing down in an oscillatory fashion by an amount equal to Planck time, then the symbol T_p will be used to represent dynamic Planck time. The symbol T_p has units of time, but is an oscillatory displacement of time. Angular frequency ω has units of s^{-1}; therefore $T_p\omega$ is a dimensionless number that will be used extensively to express a strain wave amplitude. The same way that stretching or compressing length represents a strain, so also speeding up or slowing down the rate of time requires a strain of spacetime. The following summary is provided for further clarification:

l_p - means static Planck length, a distance measurement of 1.616 x 10^{-35} meters
L_p - means dynamic Planck length, a wave displacement of 1.616 x 10^{-35} meters
t_p - means Planck time, a unit of time corresponding to 5.39 x 10^{-44} seconds
T_p - means dynamic Planck time, a wave displacement of time of 5.39 x 10^{-44} seconds

What Are Dipole Waves In Spacetime? We will start the examination of dipole waves in spacetime by making an analogy to electromagnetic dipoles. For example, a carbon monoxide molecule has a carbon atom that is positively charged and an oxygen atom that is negatively charged. The bond between these two atoms has similarities to a mechanical spring. When the carbon monoxide molecule is given energy it will vibrate and emit infrared electromagnetic radiation. This is an oscillating electromagnetic dipole emitting electromagnetic dipole radiation. Another possibility is for the molecule to rapidly rotate around a transverse axis. This is a rotating electromagnetic dipole which also produces infrared electromagnetic radiation (infrared dipole radiation). Atoms and plasmas also emit electromagnetic radiation, but the dipole characteristic of the emission is best illustrated by a polarized molecule.

In contrast to dipole emission, suppose that we had a diatomic molecule where both of the atoms were positively charged. Oscillating or rotating this molecule would also produce electromagnetic radiation, but at a much lower efficiency and into a different emission pattern known as a quadrupole emission pattern. Even though quadrupole emission is different than dipole emission, the photons produced by quadrupole emission have the same fundamental properties as photons produced by dipole emission. Both are electromagnetic radiation with transverse wave properties. This is where the electromagnetic analogy to dipole waves in spacetime breaks down because waves in spacetime have a fundamental difference between dipole waves compared to quadrupole waves (gravitational waves).

Mass has only one polarity. It is impossible to generate dipole waves in spacetime by oscillating or rotating two connected masses. The lowest order wave obtainable by unsymmetrical acceleration of mass such as an oscillating ellipsoid or a rotating rod is quadrupole gravitational waves. In either case there is no displacement of the center of mass. To obtain dipole waves in spacetime by accelerating mass, it would be necessary to have the center of mass of a closed system accelerate in violation of the conservation of momentum. Another impossible alternative would require a mass that exhibited anti-gravity. A mass with anti-gravity would be the equivalent of a negative gravitational charge and it could be combined with an ordinary mass to form an oscillating or rotating mass dipole. This also would hypothetically produce dipole waves in spacetime. Even though general relativity forbids dipole waves in spacetime, they are permitted by quantum mechanics provided that they are subject to the Planck length/time limitation. We will therefore move on and examine the theoretical properties of these quantum mechanical dipole waves in spacetime.

Envisioning a Dipole in Spacetime: What exactly is a dipole wave in spacetime? Chapter 5 will give a more detailed description of a dipole in spacetime including figures. The following brief description is only intended to be sufficient to allow other concepts to be introduced.

Imagine a volume of space that has flat spacetime with no vacuum fluctuations at any scale. There is no such volume of spacetime but this concept will be used for illustration. Within this volume the rate of time would be perfectly uniform and Euclidian geometry would perfectly describe the geometrical characteristics. Now we will imagine this volume filled with multiple small amplitude dipole waves in spacetime. These waves are chaotically rearranging themselves at the speed of light. If it was possible to momentarily freeze this rearrangement, we would find that the volume is not flat spacetime. Some locations have a slightly larger volume than expected from Euclidian geometry and other locations have slightly less proper volume than expected from Euclidian geometry. Perhaps most important, some locations have a rate of time that is slightly faster than the local norm and other locations have a rate of time that is slightly slower than the local norm. These same variations in volume and rate of time are observed at any scale down to a minimum of Planck length. Since the maximum displacement of spacetime is always Planck length and Planck time regardless of scale, the strain of spacetime increases when the scale gets smaller.

In contrast, a volume filled with chaotic gravitational waves (quadrupole waves) would have no oscillation of the rate of time and no oscillation in proper volume. There would be an effect on the distance between points, but an increase in distance in one dimension is offset by a decrease in distance in an orthogonal dimension so that there is no net change in volume. The way that gravitational waves affect spacetime means that they can produce a measurable oscillation in the distance between two points (greater than Planck length). This is a fundamental difference between dipole waves in spacetime and gravitational waves. The wave properties of gravitational waves are detectable, the wave properties of dipole waves are not detectable.

Definition of Dipole Wave in Spacetime: We need to define the term "dipole wave in spacetime". It will be cumbersome in the remainder of this book if it is always necessary to keep reminding the reader that the term "dipole wave in spacetime" implies the Planck length/time limitation. Therefore, the term "dipole wave in spacetime" will be defined as a dynamic oscillation of both the rate of time and spatial distance between stationary points in space. This oscillation in spacetime propagates at the speed of light and is subject to the Planck length/time limitation. This concept will be developed further in this and the next chapter.

Planck Scale: The mention of Planck length and Planck time does not necessarily imply "Planck scale". The term "Planck scale" has come to imply the conditions that would exist if particles or photons had Planck energy ($E_p \approx 1.22 \times 10^{19}$ GeV or 1.96×10^{9} Joule). For example, a hypothetical particle with Planck energy (Planck mass) would have the force of gravity be comparable to the strong force or the electromagnetic force. Such a particle would have a Compton frequency equal to Planck angular frequency which is the inverse of Planck time. The natural unit of length of such a hypothetical particle is Planck length. All of these properties are hypothetical because a Planck mass fundamental particle does not exist. It would be the smallest possible black hole.

If a wave in spacetime causes the distance between two points to change by ± Planck length, the frequency of this oscillation can be much less than Planck angular frequency ($\sim 10^{43}$ s^{-1}). Similarly, a wave in spacetime can cause an oscillation in the rate of time at a frequency much less than Planck frequency. The point is that an oscillation distortion of spacetime does not imply Planck energy scale just because the displacement of spacetime is Planck length or Planck time. In order to reach Planck energy, the frequency of this oscillation needs to be Planck angular frequency ($\sim 10^{43}$ s^{-1}). We will be discussing waves in spacetime which produce Planck length/time displacements of spacetime at frequencies in the range of 10^{20} Hz to 10^{25} Hz. This is many orders of magnitude less than Planck energy and therefore does not imply the commonly accepted definition of "Planck scale".

"Displacement of Spacetime" Explained: In the second assumption above, the term "displacement of spacetime" needs some explanation. Imagine that we define two points in space separated by distance r. It would take a time period of $t = 2r/c$ to measure the separation between these two points because this is the time required for light to make a round trip between the two points. Suppose that the space between these two points is filled with multiple frequencies of waves in spacetime. The frequencies with wavelengths much shorter than distance r (frequencies $\omega << 1/t$) would not add coherently and therefore would be minimized. However, even incoherent addition would seem to imply that occasionally the total displacement amplitude could exceed the Planck length/time limitation for a short time.

However, over the integration time of $t = 2r/c$ the higher frequency components average out so that the Planck length/time limitation is not exceeded. Furthermore, we know that virtual particle pairs such as electron/positron pairs and virtual photon pairs are continuously coming into existence and going out of existence. These will be discussed later and shown to have a wave structure. The formation of these virtual particle pairs is proposed to be the mechanism that also limits the maximum amplitude from exceeding the Planck length/time limitation.

It is important to also understand that dipole waves in spacetime travel at the speed of light but they do not freely propagate like photons or gravitational waves. Since dipole waves affect the rate of time and the proper volume, they interact with each other. Here are some other proposed properties of dipole waves in spacetime that are presented here in summary form and explained later.

1) Every part of a dipole wave in spacetime becomes the source of a new wave (called a wavelet).
2) These wavelets propagate in all directions.
3) The addition of wavelets tends to constructively interfere predominately in the forward and backward propagation directions of the previously existing wavefronts.
4) These wavelets explore an infinite number of possible trajectories to achieve an amplitude sum at any point (intensity is amplitude squared).
5) This is proposed to be the physical explanation that is being modeled by Richard Feynman's path integral. These properties will be explained later.

Impedance of Spacetime

The first step in unraveling the 10^{120} discrepancy between the quantum mechanical model and the general relativity model is to see if there is anything in general relativity that actually supports the idea of a large vacuum energy density. It is proposed that an analysis of gravitational waves indeed gives support to the quantum mechanical model of spacetime. Gravitational waves are a form of energy that propagates at the speed of light as transverse waves IN spacetime. They produce a dynamic distortion of 2 of the 4 dimensions of spacetime. The distortion converts the spherical volume into an oscillating ellipsoid. One transverse axis of the ellipsoid elongates while the orthogonal transverse axis contracts. This oscillation of the ellipsoid produces no net change in volume from the original spherical volume and there is no change in the rate of time.

Gravitational waves transfer energy and angular momentum. In 1993 the Nobel Prize was awarded to Russell Hulse and Joseph Taylor for the proof that a binary neutron star system was slowing down its rotation because it was emitting gravitational waves. The amount of slowing was exactly the amount predicted by general relativity. The emission of gravitational waves produces a retarding force on the rotating binary stars, thus producing an observable slowing of the rotation (loss of energy and angular momentum). If it was possible to reverse the direction of these gravitational waves, the gravitational waves would return energy and angular momentum to the binary neutron star system.

The reason that gravitational waves are introduced into a discussion about the energy density of spacetime is that gravitational waves are propagating in spacetime. They are analogous to sound waves propagating in an acoustic medium. The same way that the equations for sound propagation give information about the acoustic medium, so also the gravitational wave equations can give information about the properties of spacetime.

Z_s – The Impedance of Spacetime: An analysis of gravitational wave equations has been made in the book The Detection of Gravitational Waves[8] and it was found that spacetime has characteristic impedance, just like any other acoustic medium. This impedance of spacetime is given in this book as:

$Z_s = c^3/G = 4.038 \times 10^{35}$ kg/s $\qquad Z_s$ = impedance of spacetime

The reasoning that led to this designation of the impedance of spacetime can be understood by examining the general properties of waves in any form. All propagating waves involve the movement of energy. In other words, propagating waves of any kind are a form of power. There is a general equation that applies to waves of any kind. The most common form of this equation relates intensity "$\mathcal{I}$", the wave amplitude H, the wave angular frequency ω and the impedance Z of the medium carrying the wave. The intensity $\mathcal{I}$ can be expressed in units of w/m^2.

$\mathcal{I} = k\,H^2\omega^2 Z$
$\mathcal{I}$ = intensity; H = amplitude; ω = angular frequency; Z = impedance;
k = a dimensionless constant

We will first illustrate the use of this general equation using acoustic waves. The acoustic impedance is: $Z_a = \rho c_a$ where ρ is density and c_a is the speed of sound in the medium (acoustic speed). Acoustic impedance has units of kg/m^{2}s using SI (dimensional analysis units of M/L^2T). The amplitude of an acoustic wave is defined by the displacement of particles oscillating in an acoustic wave. The amplitude term in acoustic equations has units of length such as meters.

[8] Blair, D. G. (ed.): The Detection of Gravitational Waves. p 45. Cambridge University Press, Cambridge New York Port Chester (1991)

When this equation is used for gravitational waves, the amplitude term is a dimensionless ratio which in its simplest form can be expressed as $H = \Delta L/L$. This ratio is expressing a strain in spacetime which can also be thought of as the maximum slope of a graph that plots displacement versus wavelength. When the amplitude term is dimensionless strain amplitude, then for compatibility the impedance of spacetime Z_s must have dimensions of mass/time (M/T).

Even though $\mathcal{I} = k\,H^2\omega^2 Z$ is a universal wave-amplitude equation, it can only be used if amplitude H and impedance Z are expressed in units compatible with this equation. For example, electromagnetic radiation is usually expressed with amplitude in units of electric field strength and the impedance of free space Z_o in units of ohms. This way of stating wave amplitude and impedance does not have the correct units required for compatibility with the above intensity equation. As discussed in chapter 9, there are other ways of expressing these terms that make electromagnetic radiation compatible with this universal equation.

The intensity of gravitational waves can be complex because of nonlinearities and radiation patterns. However, this intensity can be expressed simply if we assume plane waves and the weak gravity limit. Using these assumptions, the gravitational wave intensity $\mathcal{I}$ is often expressed as:

$$\mathcal{I} = \left(\frac{\pi c^3}{4G}\right) \upsilon^2 H^2 \qquad \text{where: } \upsilon = \text{frequency}$$

However, this can be rearranged to yield the following equation:

$$\mathcal{I} = kH^2\omega^2(c^3/G) \qquad \text{Where:}$$

$\mathcal{I}$ = intensity of a gravitational plane wave
k = a dimensionless constant
$H = \Delta L/L$ = strain amplitude where L is measurement length and ΔL is the change in length
ω = angular frequency

It is obvious comparing this equation to the general equation $\mathcal{I} = k\ H^2\omega^2 Z$ that the two equations have the same form and that the impedance term must be: $Z = c^3/G$. I have chosen to call this the “impedance of spacetime” designated by the symbol Z_s.

$$Z_s = \frac{c^3}{G}$$

5 Wave-Amplitude Equations: Now that we are armed with the impedance of spacetime, the equation for intensity *($\mathcal{I}$)* can be converted into equations that express energy density *(U)*, energy *(E)* and power *(P)*. If we are restricted to waves propagating at the speed of light, then we can also convert the intensity equation into an expression of the force *(F)* exerted by the wave. This conversion incorporates the equation $F = P/c$ where P is power propagating at the speed of light. These will be called the "5 wave-amplitude equations". These equations also use the symbols of:

A = area (m^2), V = volume (m^3) and k = dimensionless constant near 1

5 Wave-Amplitude Equations

$\mathcal{I} = k\,H^2\,\omega^2\,Z$	$\mathcal{I}$ = intensity (w/m^2)		
$U = k\,H^2\,\omega^2\,Z/c$	U = energy density (J/m^3)	$(U = \mathcal{I}/c)$	and $U = \mathbb{P}$ = pressure
$E = k\,H^2\,\omega^2\,Z\,V/c$	E = energy (J)	$(E = \mathcal{I}V/c)$	
$P = k\,H^2\,\omega^2\,Z\,A$	P = power (J/s)	$(P = \mathcal{I}A)$	
$F = k\,H^2\,\omega^2\,Z\,A/c$	F = force (N)	$(F = \mathcal{I}A/c)$	

These 5 equations will be used numerous times in the remainder of the book. It is proposed that all energy, force and matter is derived from waves in spacetime and these 5 equations will be used to support this contention. The amplitude term H needs further explanation. We are presuming waves propagating at the speed of light and we are temporarily excluding electromagnetic waves until chapter 9. This leaves gravitational waves and dipole waves in spacetime. We need to standardize how we designate the amplitude of these waves.

For gravitational wave experiments where the wavelength is much longer than the measurement path length ($\lambda >> L$), it is acceptable to designate the strain amplitude as $H = \Delta L/L$. However, when we are dealing with an arbitrary wavelength which might be small, it is necessary to specify strain as the maximum slope of a graph that plots displacement versus wavelength. This maximum slope occurs when the displacement is zero and the strain is maximum. If we designate the maximum displacement as ΔL, and the wavelength as λ, then the maximum strain (maximum slope) is $H = \Delta L/\lambda\!\!\!^-$. where $\lambda\!\!\!^- = \lambda/2\pi$. This example presumes that we are working with a displacement of length. Gravitational waves only produce a modulation of length in such a way that there is no modulation of volume and no modulation of the rate of time. Therefore, gravitational waves are not subject to the Planck length/time limitation that applies to dipole waves. As previously explained, dipole waves have a maximum spatial displacement amplitude of $\Delta L = L_p$ and a maximum temporal amplitude of $\Delta T = T_p$. Therefore, when the maximum strain amplitude H_{max} of dipole waves is:

$$H_{max} = L_p/\lambda\!\!\!^- = \omega/\omega_p = \sqrt{\hbar G\omega^2/c^5}$$

Impedance of Spacetime from the Quantum Mechanical Model: Now that we are equipped with the 5 wave-amplitude equations, the dipole wave hypothesis and $H_{max} = L_p/\lambda\!\!\!^-$, it is possible to analyze zero point energy from a new perspective. If zero point energy is really dipole wave fluctuations in the medium of spacetime, then it should be possible to do a calculation which supports this idea. For review, the quantum mechanical model of spacetime has spacetime filled with zero point energy (quantum oscillators) with energy of E = ½ $\hbar\omega$. If we are ignoring numerical factors near 1, therefore we can consider each quantum oscillator as occupying a volume $V = \lambda\!\!\!^{-3}$. This means that the energy density of the quantum mechanical model is $U = \hbar\omega/\lambda\!\!\!^{-3} = \hbar\omega^4/c^3$. Now we are ready to calculate the impedance of spacetime obtained from the quantum mechanical model using the previously obtained equation for energy density $U = H^2\omega^2 Z/c$. Rearranging terms we have:

$Z = Uc/H^2\omega^2$
Set: $U = \hbar\omega^4/c^3$ and $H = H_{max} = \sqrt{\hbar G\omega^2/c^5}$
$Z = c^3/G = Z_s$

Link between QM and GR Models of Spacetime: This is a fantastic outcome! We took the energy density of zero point energy and combined that with the strain amplitude of a dipole wave in spacetime. When we solved for impedance we obtained c^3/G. This is the same impedance of spacetime that gravitational waves experience as they propagate through spacetime. To me, this implies that the characteristics of spacetime obtained from general relativity agree with the quantum mechanical model of spacetime filled with zero point energy and exhibiting energy density of 10^{113} J/m^3. How can this be? The general relativity model incorporates cosmological observation and sets the energy density of the universe at about 10^{-9} J/m^3.

Actually this is an erroneous comparison. The quantum mechanical model of spacetime is giving the homogeneous internal energy density of spacetime itself. When gravitational waves propagate through spacetime, they are interacting with this internal structure of spacetime and the gravitational waves experience impedance of $Z_s = c^3/G$. The energy density of 10^{-9} J/m^3 obtained by cosmological observation is not seeing the internal structure of spacetime with its tremendous energy density of dipole waves. Instead, the cosmological observations are just looking at the energy density of the hadrons, bosons and "dark energy" (discussed later). This is not the same thing as the internal structure of spacetime. Gravitational waves can propagate through spacetime that contains no hadrons or bosons and still experience $Z_s = c^3/G$. Assuming that the total energy density of the universe is 10^{-9} J/m^3 is like looking only at the foam on the surface of the ocean and ignoring all the water that makes up the ocean.

The first part of reconciling the difference between the general relativity and quantum mechanical models of spacetime is to view the quantum mechanical model as describing the internal structure of spacetime. Meanwhile, the general relativity model is describing the macroscopic characteristics of spacetime and the interactions with matter.

If spacetime can propagate waves such as gravitational waves (or dipole waves), it implies that spacetime must have elasticity. This elasticity requires the ability to store and return energy as the wave propagates. The medium itself must have energy density. The quantum mechanical model of space is filled with a sea of energetic fluctuations (dipole waves). If these are visualized as energetic waves in spacetime, then a new wave can be visualized as compressing and expanding these preexisting waves. If this new wave causes the preexisting waves to slightly change their frequency and dimensions as they are being compressed and expanded, then this picture provides the necessary elasticity and energy storage to spacetime.

This might sound like a circular argument since each wave contributes to the elasticity required by all other waves. What about the "first" wave? This subject will be discussed further in the two cosmology chapters 13 and 14. However, it will be proposed that there was no first wave. Spacetime came into existence already filled with these vacuum fluctuations. Energetic waves are simply a fundamental property of spacetime. In fact, spacetime does not have waves; spacetime IS the sea of vacuum fluctuations (waves) described by the quantum mechanical model. Spacetime never was the quiet and smooth medium assumed by general relativity. Therefore there never was a time when a first wave was introduced into a quiet spacetime. This wave structure with its Planck length/time limitation can be ignored on the macroscopic scale but spacetime has a quantum mechanical basis.

The task is not to find a mechanism that causes cancelation of this tremendous energy density. This energy density is really present in spacetime and is necessary to give spacetime the properties described by general relativity. Instead the focus needs to turn to finding the reason that this high energy density is not more obvious and why it does not itself generate gravity. Is there something about the energy in vacuum fluctuations that makes it different than the energy in matter and photons? This question will be answered later.

Thoughts on the Impedance of Spacetime: It should be emphasized that the impedance of spacetime is one of the few truly fundamental properties of spacetime. For example, later it will be shown that it is possible to make a system of units that use only the properties of spacetime. One of the three properties of spacetime used for this system of units is Z_s, the impedance of spacetime. In Planck units, the impedance of spacetime is equal to 1 ($\underline{Z}_s = 1$). Also, the impedance of spacetime has the following connection to other Planck terms:

$Z_s = m_p \omega_p = F_p / c = p_p / L_p$
where: m_p = Planck mass, ω_p = Planck frequency; F_p = Planck force, p_p = Planck momentum

The impedance of spacetime is intimately connected to all the Planck terms. These Planck terms represent the limiting values of mass, force, length, momentum, etc. The impedance of spacetime is the maximum possible value of impedance. In order for gravitational waves to propagate at the speed of light in the medium of spacetime, the required impedance is Z_s.

In chapter 3 we saw how a change in the gravitational gamma Γ affected the units of physics. It should be noted that the impedance of spacetime Z_s is one of the few terms that is unaffected by a change in Γ. There is an analysis (not presented here) that concludes that Z_s must be independent of Γ in order for all the laws of physics to be covariant when there is a change in gravitational potential.

Energy Density Equals Pressure: Energy density U is fundamentally equivalent to pressure $\mathbb{P}$ when we are dealing with energy propagating at the speed of light. Even though the units look different (J/m^3 versus N/m^2), in dimensional analysis notation the dimensions of both energy density and pressure are the same: M/LT^2 (mass/length time^2). For example, Black body radiation inside a uniform temperature closed container has radiation pressure being exerted on the walls and has a radiation energy density filling the container. The relationship between energy density and pressure for black body radiation (electromagnetic radiation) is $U = 3\mathbb{P}$. The factor of 3 in a container filled with blackbody radiation is traceable to 3 spatial dimensions. A laser with collimated electromagnetic radiation reflecting between 2 mirrors would eliminate the factor of 3 and have $U = \mathbb{P}$. We are ignoring numerical factors near 1 in these conceptual equations therefore we will equate $U = \mathbb{P}$. The relationship between energy density and pressure is important in cosmology because radiation pressure inside a star prevents the star from undergoing a gravitational collapse. For example, the center of the sun is at a temperature of roughly 15 million degrees Kelvin. At this temperature, the photon energy density is about 3 x 10^{13} J/m^3 and the photon pressure is about 10^{13} N/m^2.

The relationship between pressure and energy density in a gas or liquid is more complex. The simplest example of the energy storage of the pressure component in a fluid can be illustrated by the following. Imagine two helium atoms colliding in a vacuum. This collision is viewed from the frame of reference where the atoms are initially propagating at equal speed in opposite directions. The kinetic energy of each atom can be associated with a typical temperature using the Boltzmann constant. When the atoms collide, the speed momentarily drops to zero in this frame of reference and the temperature of each atom also momentarily drops to zero. The kinetic energy (temperature) is temporarily converted to internal energy in each atom resulting in a distortion of the electron cloud of each helium atom. In a high pressure gas there are many such collisions per second. The energy associated with the pressure of the gas can be traced to the fact that atoms in the gas spend part of the time with a distorted electron cloud that has higher energy than an isolated atom with no distortion. A high pressure monatomic gas has 3 energy contributions to its total energy density; 1) the internal energy ($E = mc^2$) of the individual atoms, 2) the kinetic energy of the temperature and 3) the pressure component resulting in a distorted electron cloud.

Now we will look at the much simpler case of confined light. Even though each photon has energy of $E = \hbar\omega$, still the total energy density of the confined light is $U = 3\mathbb{P}$ for chaotic 3 dimensional propagation such as confined black body radiation. It is proposed that the equivalence between energy density and pressure applies in all cases because the units are the same (M/LT^2) and the physical interpretation of these units is the same. There are a few cases in physics where two dissimilar definitions can have the same units when expressed as length, time and mass. For example, torque and energy both have units of ML^2/T^2. However, it is clear that torque is force applied through a radial length r without motion (no work). Energy is force applied through a distance $[(ML/T^2)L]$. The units of energy have to be interpreted as requiring motion through a distance (work). There is never an example where a unit of torque is equal to a unit of energy because the physical interpretation of the units is fundamentally different. In the case of energy density and pressure, the physical interpretation is the same. It is proposed that at the most fundamental level, energy density ALWAYS implies pressure.

It is proposed that even the energy density of a proton or electron implies pressure. It is not possible to casually ignore the energy density of a proton and assume that since there is no obvious container restraining the implied pressure that the equivalence between energy density and pressure has somehow been broken. The standard model assumes that there is no internal structure and no volume to fundamental particles. Even string theory has one dimensional strings with no volume. Therefore, both of these require infinite energy density which implies infinite pressure. No conceptually understandable explanation is demanded.

This book proposes a quantum mechanical model of spacetime where the energy density of dipole waves in spacetime is 10^{113} J/m^3 and the implied pressure is 10^{113} N/m^2. Therefore the picture that emerges is that the quantum mechanical model of spacetime not only has a tremendous energy density, but it also is capable of exerting any pressure up to Planck pressure of about 10^{113} N/m^3. If the pressure is unequal on opposite sides of an object, then this unequal pressure would be considered a force. Furthermore, this force could be considered either an attractive or repulsive force depending on the direction of the object "causing" the mysterious force. Later in this chapter it will be shown that the maximum pressure that spacetime can exert for a particular size object is the limiting factor for the size (radius) of a black hole. Also, all fundamental particles will be shown to possess energy density and pressure that is stabilized by an interaction with the energy density and pressure of the dipole waves in spacetime.

Interactive Bulk Modulus of Spacetime K_s: If spacetime is visualized as the acoustic medium which permits the propagation of gravitational waves, then this acoustic medium should have a bulk modulus in addition to having impedance. Next we will calculate the "interactive bulk modulus of spacetime" designated with the symbol K_s. The term "interactive" is used here because it will be shown that spacetime has an unusual type of bulk modulus that is wavelength/frequency dependent. This bulk modulus only reveals itself when there is an interaction with a wave in spacetime.

The bulk modulus of an acoustic medium can be thought of as the stiffness of the material. It has the dimensions of pressure. The bulk modulus of a fluid is $K \equiv \frac{\Delta\mathbb{P}}{\Delta V/V}$ which is the change in volume/total volume in response to a change in pressure $\Delta\mathbb{P}$. In discussions of gravitational waves it is often said that the reason that gravitational waves are so hard to detect is the fact that spacetime is so stiff. Now we can quantify the stiffness of spacetime in response to a wave with angular frequency ω and reduced wavelength $ƛ$.

We will start by making an analogy to a fluid contained in a cylinder with cross sectional area A_o and initial length L_o. This fluid is compressed by a piston also with area A_o. A force F exerted on the piston causes the length L_o of the fluid column to compress by ΔL. We will use force F and ΔL to obtain the elastic potential energy E_{el} and the elastic potential energy density U_{el} given to the fluid (ignoring numerical factor k). The change in volume is designated ΔV, therefore we have:

$\Delta V/V = A_o\Delta L/A_oL_o = \Delta L/L_o$

$$K = \frac{\Delta\mathbb{P}}{\Delta V/V} = \frac{F/A_o}{\Delta L/L_o} = \frac{FL_o}{A_o\Delta L}$$

$F = KA_o(\Delta L/L_o)$

$$E_{el} = \int F dL = \int \frac{K A_o \Delta L}{L_o} dL = \frac{K A_o \Delta L^2}{2L_o}$$ where E_{el} = elastic potential energy (drop ½)

$$U_{el} = E_{el}/V = E_{el}/A_oL_o = K\left(\frac{\Delta L}{L_o}\right)^2$$ where U_{el} = energy density of elastic potential energy

Now we need to switch to a wave doing the compression rather than a piston. It will be shown later that fundamental particles easily pass through the sea of dipole waves in spacetime without meeting any resistance. Only waves which dynamically distort spacetime are interacting with spacetime in a way that can sense the energy density in a volume of spacetime. However, to make a calculation we will assume an impervious cylinder that is a half wavelength resonant cavity. This length of the cavity can also be expressed as $L_o = ½\,\lambda = kƛ$ and we are ignoring k. This means that $\Delta V/V = \Delta L/ƛ$ and $U_{el} = K(\Delta L/ƛ)^2$. We are going to equate the elastic energy density U_{el} to the energy density of a wave in spacetime. If we have a wave of energy $\hbar\omega$ confined to a volume of $kƛ^3$ (ignore k), this energy density will be designated $U_\omega = \hbar\omega/ƛ^3 = \hbar c/ƛ^4$. This energy density can also be obtained from one of the 5 wave-amplitude equations: $U_\omega = H^2\omega^2 Z_s/c$.

$$U_\omega = \frac{H^2\omega^2 Z_s}{c} = \left(\frac{\Delta L}{ƛ}\right)^2\left(\frac{c}{ƛ}\right)^2\left(\frac{c^3}{G}\right)\left(\frac{1}{c}\right) = \left(\frac{\Delta L}{ƛ}\right)^2\left(\frac{F_p}{ƛ^2}\right)$$ U_ω = energy density of $\omega\hbar/ƛ^3$

$$\left(\frac{\Delta L}{ƛ}\right)^2\left(\frac{F_p}{ƛ^2}\right) = K_s\left(\frac{\Delta L}{ƛ}\right)^2$$ (set $U_\omega = U_{el}$)

$K_s = \frac{F_p}{\lambda\!\!\!^{-}{}^2}$ $\qquad$ K_s = dynamic bulk modulus of spacetime

The name "interactive bulk modulus of spacetime" is intended to imply that waves (interactive compression and expansion) are required for spacetime to exhibit a bulk modulus. The bulk modulus of spacetime is unlike the bulk modulus of a normal liquid such as water. For example, a constant pressure on water produces a constant compression ($\Delta V/V$ is constant). With spacetime the bulk modulus is dependent on frequency (wavelength). If the frequency is zero, then the bulk modulus also is equal to zero. This is understandable when it is realized that the vacuum fluctuations (waves) require dynamic compression resulting from the passage of a wave in spacetime to reveal their presence. The maximum possible value of the bulk modulus of spacetime occurs when $\lambda\!\!\!^{-} = L_p$. Then the interactive bulk modulus is equal to Planck pressure: $K_s = \mathbb{P}_p = c^7/\hbar G^2$.

Interactive Energy Density U_i of Spacetime: We previously said that we can learn about the properties of an acoustic medium by examining the acoustic properties of the medium. Gravitational waves are waves propagating in the acoustic medium of spacetime. Therefore, we will extend the impedance of spacetime Z_s and the bulk modulus of spacetime K_s to see if we can obtain any further insights into how waves in spacetime interact with the energy density of spacetime. Specifically, do waves in spacetime of different wavelength/frequency experience different energy density?

In acoustic wave propagation there is the equation $K_a = c_a^2\rho$ incorporating the acoustic bulk modulus (K_a), the acoustic speed of sound (c_a), and the density ρ of the acoustic medium. For spacetime it is possible to extract energy density by setting $K_a = K_s$, $c_a = c$ and $\rho = U_i/c^2$ where U_i is interactive energy density of spacetime. While the total energy density of all frequencies of the dipole waves in spacetime is Planck energy density, that energy density is only experienced by waves with Planck angular frequency. Lower frequency waves interact with the spectrum of frequencies differently. This can be calculated as follows:

$K_s = c^2\rho = U_i$

$U_i = F_p/\lambda\!\!\!^{-}{}^2 = (c^2/G)\,\omega^2$

Similarity of K_s and U_i: The equation $K_s = U_i = F_p/\lambda\!\!\!^{-}{}^2$ needs to be explained. This is one of the rare cases where two concepts can be mathematically equal but not be conceptually equivalent. Recall that the bulk modulus of a material is defined as: $K \equiv \frac{\Delta\mathbb{P}}{\Delta V/V}$. Energy density is equivalent to pressure but neither energy density nor pressure contains the ratio $\Delta V/V$ in their definition. Therefore, the concepts of U_i and K_s are fundamentally different even though they are both equal to F_p/λ^2. What this equivalency is telling us is that there is a limiting pressure (limiting energy density) that achieves $\Delta V/V = 1$. That maximum possible pressure is $\mathbb{P}_{max} = F_p/\lambda\!\!\!^{-}{}^2$ (Planck force over area $\lambda\!\!\!^{-}{}^2$). It will be shown below that $F_p/\lambda\!\!\!^{-}{}^2$ is also the energy density of a black hole with radius equal to $ƛ$. Therefore, this black hole condition also achieves $\Delta V/V = 1$. It is quite reasonable that the condition that achieves a black hole also achieves $K_s = U_i$. This can even be considered as conformation of the accuracy of these equations.

Importance of High Frequency Vacuum Fluctuations: A gravitational wave or dipole wave in spacetime is compressing all harmonic oscillators (all other waves) within its volume of influence. However, the efficiency of compression depends on the frequency mismatch. The elasticity of spacetime depends on the frequency range being probed. A wave in spacetime interacts most efficiently with vacuum fluctuations in the same frequency range which have about the same energy density, pressure contribution and elasticity. However, this does not imply that high frequency oscillations in spacetime are unimportant for relatively low frequency waves. The energy density of the oscillators in spacetime increases proportional to ω^4. Therefore, even with a bulk modulus mismatch, the high frequency fluctuations are still important in determining the total interactive energy density of spacetime experienced by relatively low frequency waves in spacetime. The tremendous increase in density at high frequencies (proportional to ω^4) far outweighs the reduction in coupling due to the frequency mismatch (proportional to $1/\omega^2$). The result is the $(\omega/\omega_p)^2$ scaling relative to Planck energy density: $U_i = (\omega/\omega_p)^2 U_p$. For comparison, a single harmonic oscillator (zero point energy) at angular frequency ω has energy density of only $U = (\omega/\omega_p)^4 U_p$. The difference between $(\omega/\omega_p)^2$ and $(\omega/\omega_p)^4$ for a wave with a muon's Compton frequency ($\omega_c \approx 10^{-20}$) is about a factor of 10^{40}. The point is that Planck frequency harmonic oscillators (dipole waves in spacetime) make an important contribution to the properties of spacetime at all frequencies.

Energy Density of a Black Hole: The interactive energy density $U_i = F_p/ƛ^2$ is a very large energy density. How does this energy density compare to the energy density of a black hole (symbol U_{bh})? We will designate the black hole's energy as E_{bh} and its classical Schwarzschild radius as R_s. Ignoring numerical factors near 1 we have:

$$U_{\mathrm{bh}} = \frac{E_{bh}}{R_s^3} = \left(\frac{R_s c^4}{G}\right)\left(\frac{1}{R_s^3}\right) = \frac{F_p}{R_s^2}$$

Therefore, since $U_i = F_p/ƛ^2$ and $U_{bh} = F_p/R_s^2$ it can be seen that if $ƛ = R_s$ then $U_i = U_{bh}$. This gives an insight into both black holes and the interactive energy density.

Radius of Black Holes Determined by Vacuum Pressure: We now have enough information to begin making a connection between the characteristics of black holes and the quantum mechanical model of spacetime. Suppose that we imagine a black hole that is predominately made of circulating photons. These photons would be considered "confined light" and therefore exhibit the inertia discussed in chapter 1. They also are energy propagating at the speed of light and therefore the equivalency between energy density and pressure clearly holds. What provides the opposing pressure to confine these photons? General relativity avoids this question by merely saying that we are dealing with "curved spacetime". However, even curved spacetime must have an underlying physical mechanism that contains (opposes) the pressure generated by the photons. One of the objectives of this book is to conceptually explain the underlying causality that results in the effect we call curved spacetime.

First, we will imagine two reflecting hemispherical shells confining photons at energy density of about 3 J/m^3. This photon energy density striking a reflecting surface generates pressure of 1 N/m^2. To hold together the two hemispherical shells would take two opposing forces of 1 Newton times the cross sectional area of the hemispheres. Next we will imagine increasing the photon energy density to the point that it meets the energy density of a black hole with a radius equal to the radius of the hemispherical shells. Ignoring gravity, the force required to hold the black hole size spherical shells together is always equal to Planck force (times a constant near 1) no matter what the radius of the spherical shells (radius of the black hole). When we include the force of gravity, the conclusion is that spacetime is supplying pressure that is equivalent to supplying Planck force to the hemispherical shell.

The smallest possible black hole consisting of photons would be a single photon with Plank energy in a volume Planck length in radius. A confined photon of this energy density would generate Planck pressure (~10^{113}N/m^2). To confine this energetic photon to the restricted volume of a black hole, it is necessary for spacetime to be able to exert an opposing pressure of ~10^{113}N/m^2. Since gravity accomplishes the task of confining black holes, it is possible to gain an insight into the implied properties of spacetime by looking at the size of a black hole that is formed to contain a particular energy density.

We previously found that $U_{bh} = F_p/R_s^2$ and $U_i = F_p/\lambda\!\!\!^{-2}$. A reduced wavelength $\lambda\!\!\!^-$ propagating in spacetime is interacting with the same energy density as the energy density of a black hole with $R_s = \lambda\!\!\!^-$. The point of this is to give another example of how black holes from general relativity support the quantum mechanical model of spacetime with its large energy density/pressure. Black holes made of photons are exerting a pressure that required the pressure of the quantum mechanical model of spacetime to stabilize. Later it will be shown that even a black hole made of fermions still has energy density that exerts pressure that must be offset by a pressure exerted by the vacuum energy/pressure of spacetime. The size of a black hole is determined by the maximum pressure that spacetime can exert over a spherical volume.

Insight into the Speed of Light: The speed of light is usually accepted as a constant of nature and no attempt is given to try to understand what the characteristics of spacetime must be in order for there to be a specific speed of light. In fact, if a photon is visualized like a quantized energy particle that travels through space, then the speed of light does not appear to be derived from the properties of spacetime.

We are visualizing spacetime as an elastic medium with vacuum fluctuations at all frequencies up to Planck angular frequency. Any given frequency has strain amplitude of $H = L_p/ƛ = \omega/\omega_p$ and energy density of $U = \hbar\omega/ƛ^3 = \hbar\omega^4/c^3$. We can convert one of the 5 wave-amplitude equations into:

Propagation speed $= \dfrac{H^2\omega^2 Z_s}{U}$ set $H^2 = (L_p/ƛ)^2 = \hbar G\omega^2/c^5$; $Z_s = c^3/G$; and $U = \dfrac{\hbar\omega^4}{c^3}$

Propagation speed $= c$

This can be viewed as just a trivial rearrangement of terms. However, the equation: propagation speed $= c$ is intended to convey the idea that the speed for wave propagation is "c" in a medium that has the energy density, impedance and amplitude characteristics of spacetime. In chapters 10 and 11 we will examine the properties of a photon propagating in the quantum mechanical model of spacetime.

Vacuum Energy and the Einstein Field Equation: There is also a similarity to the Einstein field equation which can be considered a statement that energy density equals pressure. Ignoring the cosmological constant, the Einstein field equation can be written as:

$T_{\mu\upsilon} = \left(\dfrac{1}{8\pi}\right)\left(\dfrac{c^4}{G}\right) G_{\mu\upsilon}$ set $\left(\dfrac{c^4}{G}\right) = F_p$ and $\left(\dfrac{1}{8\pi}\right) = k$

$T_{\mu\upsilon} = kF_pG_{\mu\upsilon}$

The left side of this equation has $T_{\mu\upsilon}$ which is the stress energy tensor with units of energy/length^3 which is energy density. The right side of this equation has Planck force and $G_{\mu\upsilon}$ which is the Einstein tensor that expresses curvature with units of: 1/length^2. Therefore, the right side of this equation is force/area = pressure. Therefore from the dimensions a valid interpretation of this equation is that the field equation is an expression of: energy density $= k$ pressure. The proportionality factor is equal to Planck force times a numerical factor near 1. In the limit of maximum curvature, Einstein's field equation says that Planck force is the maximum possible force in the universe. For example, two equal size black holes exert Planck force on each other at distance r_s. We normally do not associate gravity with a pressure but later in this book gravity will be related to vacuum energy/pressure. For now, we will merely point out that if gravity is associated with pressure, then the maximum pressure that the universe can exert is Planck force F_p from the quantum mechanical model of spacetime.

Force

If the universe is only spacetime, and if energy is a wave in spacetime (dynamic spacetime), then force must also be the result of a dynamic distortion of spacetime. The following assumption can be made:

Third Assumption: **There is only one fundamental force: $F_r = P_r/c$. This is a repulsive force that occurs when waves in spacetime, traveling at the speed of light, are deflected.**

This single fundamental force exerted by the deflection of waves in spacetime will be called the "relativistic force" F_r.

F_r = relativistic force (force exerted by the emission, absorption or deflection of waves in spacetime propagating at the speed of light)
P_r = relativistic power (power contained in waves in spacetime that are being deflected)

The relativistic force is the only force delivered by dipole waves in spacetime. This energy always propagates at the speed of light, even when it seems to be confined to a limited volume. The limited volume is the result of speed of light propagation in a closed loop and interacting with the surrounding vacuum energy (explained later). I propose that the relativistic force is the only truly fundamental force in the universe. All other forces of nature are just different manifestations of this force. The relativistic force is derived from the only energy in the universe (dipole waves in spacetime).

It is a common assumption among physicists that the forces of nature were all united at the high energy conditions that existed shortly after the Big Bang. It is true that a hypothetical particle with Planck mass would have a gravitational force roughly comparable to the electromagnetic force or even comparable to the strong force at short distances. According to the commonly held view, the forces of nature separated when the universe expanded and the energy density decreased. The implication is that today the forces of nature are fundamentally different. Furthermore, gravity is not included in the standard model and general relativity does not consider gravity to be a force.

Therefore, the above assumption is a radical departure from conventional thought. It is proposed that all forces, (the strong force, the electromagnetic force, the weak force and the gravitational force), are the result of the deflection of waves in spacetime traveling at the speed of light. The case will be made that even today the four forces of nature (including gravity) are still closely related.

The force $F = P/c$ is well known as the force associated with photon pressure where P is the power of a beam of light. For example, the emission or absorption of 3×10^8 watts of light produces a force of 1 Newton. The word "deflection" is used to cover any change in propagation. For example, even the absorption of a photon by an electron in an atom is characterized here as an interaction between waves in spacetime that involves a deflection. In later chapters it will be shown that the electromagnetic force, the strong nuclear force and even the gravitational force are all the result of dipole waves in spacetime interacting and being deflected.

Attractive Forces: The above assumption is surprising because it claims that there is only one fundamental force and because it claims that this single fundamental force is only repulsive. The obvious question is: How can attractive forces such as gravity, the strong force or the electromagnetic force be the result of a single force that is only repulsive? The detailed answer to this question requires additional information covered in subsequent chapters. However, it is possible to give a brief introductory explanation here.

It was previously explained that vacuum fluctuations have energy density equal to Planck energy density. From the equivalence of energy density and pressure, it follows that vacuum fluctuations are capable of exerting a maximum pressure equal to Planck pressure $\approx 10^{113}$ N/m^2. Later it will be shown that the proposed spacetime based model of fundamental particles has a specific energy density and this requires that vacuum energy/pressure exert an offsetting pressure to achieve stability. For example, the pressure on an isolated electron is about 10^{23} N/m^2. Stated another way, an isolated electron experiences a balanced repulsive force exerted on all sides. If the electron comes near a proton and experiences what we consider to be a force of attraction, it will be shown that this is actually an unbalanced vacuum pressure exerted by vacuum energy/pressure. In this model there are no exchange particles. All action at a distance is ultimately traceable to a localized imbalance in vacuum pressure. There are also no attractive forces. There is only an unbalanced repulsive force (unbalanced pressure) exerted on fundamental particles by the dipole waves that are vacuum fluctuations. The net force appears to be an attractive force between the particles. This introductory explanation lacks many essential details that will be provided later.

Exchange Particles: The standard model uses exchange particles to transfer force. For example, the electromagnetic force is supposedly the result of the exchange of virtual photons between charged point particles. These virtual photons travel at the speed of light, so the electrostatic force is commonly explained as resulting from the emission or absorption of energy traveling at the speed of light. Therefore, the power (P) of virtual photons required to generate a given force is also: $F = P/c$. Similarly, gravitons are believed by many scientists to be the exchange particle that conveys the gravitational force. While the spacetime based model of the universe does not require exchange particles, the point is that gravitons supposedly also travel at the speed of light and the force they generate would also be $F = P/c$. For example, a person weighing 70 kg is supposedly being pulled towards the earth by about 200 billion watts of gravitons and this is being resisted by about 200 billion watts of virtual photons striking the bottom of a person's shoes to keep the person from sinking into the Earth. It is proposed here that gravitons and virtual photons are replaced with an equally large power of interacting waves in spacetime.

Gluons have been ignored so far, but they are also viewed as having an explanation associated with waves in spacetime (discussed later). The weak force has already been united with the electromagnetic force to form the electroweak force. Therefore, in the discussion to follow, I will concentrate on determining the relationship between the strong force, the electromagnetic force and the gravitational force. However, a brief examination of the weak force will be made later.

Note that I have used the terms "the strong force" and "the gravitational force". Both of these terms are currently out of favor among physicists. At one time "the strong force" was commonly used to describe the force that bound protons and neutrons together in the nucleus of an atom. Since the discovery of quarks, it was necessary to name the force that binds quarks together and the term "the strong interaction" is now commonly used. With this change in terminology, the force that binds protons and neutrons is now "the residual strong interaction". I need a simple name for the strongest of all forces. I choose to resurrect the term "the strong force" and redefine this as the resultant force from an interaction between quarks (wave model) and vacuum energy (wave model) that binds quarks together.

Newton considered gravity to be a force, but general relativity considers gravity to be the result of the geometry of spacetime. The equations of general relativity are commonly interpreted as describing curved spacetime. However, the concept of curved spacetime does not lead to a conceptually understandable explanation of how a force is generated when a mass is held stationary in a gravitational field. It will be shown that gravity is a real force that is closely related to both the electromagnetic force and the strong force. Therefore, the term "the gravitational force" will be used even prior to offering this proof.

Fields: If the universe is only spacetime, then the following assumption can be made:

Corollary Assumption: **There is only one truly fundamental field. This single field is the dipole wave vacuum fluctuations of spacetime.**

The presently accepted physics model incorporates numerous different fields. The concept of an electric field and a magnetic field was combined into a single electromagnetic field by Maxwell. However, this is considered separate from a gravitational field or the field of virtual particle pairs that are continuously coming into existence and going out of existence. In general, the 4 forces are usually associated with separate fields. Zero point energy also has the properties of a field. This background is given because the proposal presented here is that all these fields are just different distortions of vacuum fluctuations which have energy density of about 10^{113} J/m^3. These fluctuations are dipole waves in spacetime that are exerting a pressure. This pressure can produce a force between objects up to a maximum of Planck force ($F_p = c^4/G \approx 10^{44}$ N). In later chapters additional details will be given to show how distortions of vacuum fluctuations produce a gravitational field or an electromagnetic field.

Summary – Properties of Spacetime: In upcoming chapters we are going to attempt to construct the universe (particles, forces and photons) using only the properties of spacetime. Besides the standard properties of spacetime described by general relativity, it is useful to summarize the additional properties of spacetime that we have added to our tool bag. These additions are:

1) We have concluded that spacetime has a quantifiable impedance ($Z_s = m_p\omega_p = c^3/G$), bulk modulus ($K_s = F_p/\lambda\!\!\!^{-2}$) and interactive energy density ($U_i = F_p/\lambda\!\!\!^{-2}$).
2) The quantum mechanical model of spacetime has a sea of high frequency, small amplitude vacuum fluctuations at Planck energy density $\sim 10^{113}$ J/m^3. This model is adopted because even the impedance of spacetime obtained from general relativity supports this model.
3) Dipole waves are allowed to exist in spacetime but they are subject to the Planck length/time limitation previously discussed. Vacuum fluctuations and zero point energy are actually dipole waves in spacetime.
4) We are armed with the 5 wave-amplitude equations obtained by combining a general wave equation with the relativistic force equation.
5) We presume that the only truly fundamental force is the relativistic force ($F_R = P/c$) which is the repulsive force exerted when energy traveling at the speed of light is deflected. The dipole waves in spacetime are always moving at the speed of light even when they are confined to a limited volume.
6) From the equivalence of energy density and pressure, it follows that the large energy density of vacuum fluctuations (dipole waves) is exerting an equally large vacuum pressure.
7) Distortions of these dipole wave vacuum fluctuations are responsible for all fields

"Elementary particles represent a percentage-wise almost completely negligible change in the locally violent conditions that characterize the vacuum…In other words, elementary particles do not form a really basic starting point for describing nature."

John Archibald Wheeler

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Chapter 5

Spacetime Particle Model

"Think of a particle as built out of the geometry of space; think of a particle as a geometrodynamic excitation."
John Archibald Wheeler

Early Wave-Particle Model: In 1926, Erwin Schrodinger originally proposed the possibility that particles could be made entirely out of waves. However, in an exchange of letters, Henrik Lorentz criticized the idea. Lorentz wrote,

> "A wave packet can never stay together and remain confined to a small volume in the long run. Even without dispersion, any wave packet would spread more and more in the transverse direction, while dispersion pulls it apart in the direction of propagation. Because of this unavoidable blurring, a wave packet does not seem to me to be very suitable for representing things to which we want to ascribe a rather permanent individual existence."

Schrodinger's idea of a wave-particle was a group of different frequency waves that, when added together, formed a Gaussian shaped oscillating wave confined to a small volume (Fourier transformation). Schrodinger eventually agreed with Lorentz that the waves that formed such a "particle" would disperse. However, this initial failure should not be interpreted as condemning all possible wave explanations for particles. For example, optical solitons are compact pulses of laser light (waves) that propagate in nonlinear optical materials without spreading. They exhibit particle-like properties and will be discussed later.

In this chapter a model of a fundamental particle will be proposed made entirely out of a dipole wave in spacetime. Even though this model gives a structure and physical size to an isolated fundamental particle, the reader is asked to reserve judgment about this model until it can be fully explained. Even though the spacetime based model of a fundamental particle has waves with physical size, this model will be shown to be consistent with experiments that indicate no detectable size in collision experiments. Also the spacetime based model explains how an electron can increase its size and form a cloud-like distribution under the boundary conditions of a bound electron in an atom.

Brief Summary of the Cosmological Model: We will start with a brief description of the cosmological model proposed to be compatible with the starting assumption. The cosmological model is covered in detail in chapters 13 and 14. If the universe is only spacetime today, it must have always been only spacetime. The highest energy density that spacetime can support is Planck energy density (~ 10^{113} J/m^3). One point of possible confusion is that this is also the current energy density of the vacuum energy in the universe. However, there are some key differences involving spin and the rate of time that distinguish the conditions at the start of the Big Bang from the conditions that exist today in vacuum energy. These differences are explained in chapter 13, but one easy to understand difference is that vacuum energy in the current universe lacks quantized spin. Vacuum energy can be said to have a temperature of absolute zero because it lacks any quantized units and temperature is defined as energy per quantized unit. The same energy density at the start of the Big Bang was in the form of 100% quantized spin units. The energy per quantized unit was equal to Planck energy and therefore the temperature at the start of the Big Bang was equal to Planck temperature.

Even though 10^{113} J/m^3 is an incredibly large number, it is not a singularity which would be infinite energy density. For spacetime to reach Planck energy density (U_p) spacetime must have dipole waves at the highest possible frequency (ω_p = Planck frequency) and the largest possible amplitude ($H = 1$).

$U = H^2\omega^2 Z/c$ set: $H = 1$, $\omega = \omega_p = \sqrt{c^5/\hbar G} \approx 1.9 \times 10^{42}$ s^{-1} $Z = Z_s = c^3/G$

$$U = \frac{c^7}{\hbar G^2} \approx 4.6 \times 10^{113} \text{ J/m}^3 = \text{Planck energy density}$$

These waves are still subject to the Planck length/time limitation but at this frequency a displacement of Planck length and Planck time achieves Planck energy density U_p. Spacetime at this highest possible energy density and with maximum quantized spin will be called "Planck spacetime".

In order for this starting condition to be capable of evolving into the present universe, one additional characteristic of Planck spacetime is required. The dipole waves that form Planck spacetime must be divided into quantized units with each unit possessing angular momentum of $\hbar$. Therefore 100 % of the energy in Planck spacetime possessed quantized angular momentum. If we jump forward in time, today only about 1 part in 10^{122} of the total energy in the universe (including vacuum energy) possesses quantized angular momentum of $\hbar$ or ½ $\hbar$. Furthermore, this fraction is continuously decreasing because of the cosmic redshift and another characteristic described later. All the fundamental particles and forces that we can detect are the 1 part in 10^{122} that possesses quantized angular momentum. The vastly larger energy in the universe is the sea of vacuum fluctuations (dipole waves in spacetime) that does not possess angular momentum. The only hint we have that this vast energy density exists is the quantum mechanical effects such as the Lamb shift, Casimir effect, vacuum polarization, the uncertainty principle, etc. However, it will be shown that this sea of vacuum fluctuations is essential for the existence of fundamental particles and forces.

Vacuum Energy Has Superfluid Properties: If we are going to be developing a model of fundamental particles incorporating waves in spacetime, it is important to understand the properties of the medium supporting the wave. In the last chapter we enumerated many properties of spacetime. The point was made that the properties of vacuum fluctuations are an integral part of the properties of spacetime. However, one property of vacuum energy was intentionally saved for this chapter because it is particularly important in the explanation of fundamental particles formed out of waves in spacetime.

It is proposed that vacuum energy has the property that it does not possess angular momentum. Any angular momentum present in the midst of the sea of vacuum energy is isolated into units that possess quantized angular momentum. These quantized angular momentum units have different properties than vacuum energy.

This concept is easiest to explain by making an analogy to superfluid liquid helium or a Bose-Einstein condensate. When the helium isotope ^{4}He is cooled to about 2° K, it changes its properties and partly becomes a superfluid. Cooling the liquid further increases the percentage of the helium atoms that are in the superfluid state. Cooling some other atoms to a temperature very close to absolute zero changes their properties and a large fraction of these atoms can occupy the lowest quantum state and exhibit superfluid properties. This is a Bose-Einstein condensate. Since superfluid liquid helium is a special case of a Bose-Einstein condensate, they will be discussed together.

When a group of atoms occupy a single quantum state, the group must exhibit quantized spin on a macroscopic scale. The quarks and electrons that form atoms individually are fermions. However, a Bose-Einstein condensate or superfluid ^{4}He exhibits quantized spin on a macroscopic scale. The group of fundamental particles can possess either zero spin or an integer multiple of spin units related to $\hbar$. If we have a group of atoms in a Bose-Einstein condensate and we introduce angular momentum ("stir" the condensate), then we can form "quantized vortices" that possess quantized angular momentum within the larger volume of Bose-Einstein condensate that does not possess macroscopic angular momentum. Therefore a quantum vortex is a group of atoms that has a different angular momentum quantum state (different spin) than the larger group of surrounding atoms that forms the superfluid ^{4}He or Bose-Einstein condensate. This effect was first discovered with superfluid liquid helium[1]. Dramatic pictures are also available of multiple quantum vortices in a Bose-Einstein condensate[2,3].

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[1] E.J. Yarmchuk, M.J. Gordon and R.E. Packard, *Observation of stationary vortex arrays in rotating superfluid helium*, Phys. Rev. Lett. 43, 214-217 (1979)

[2] K. W. Madison, F. Chevy, W. Wohlleben and J. Dalibard, *Vortex lattices in a stirred Bose-Einstein condensate* cond-mat/0004037[e-print arXiv].

[3] Ionut Danaila, *Three-dimensional vortex structure of a fast rotating Bose-Einstein condensate with harmonic-plus-quartic confinement*, http://arxiv.org/pdf/cond-mat/0503122.pdf

It is proposed that the quantum fluctuations of spacetime are a Lorenz invariant "fluid" that is the most ideal superfluid possible. Unlike the fundamental particles (fermions) that form a Bose-Einstein condensate, the vacuum fluctuations do not possess any quantized angular momentum. However, vacuum fluctuations are similar to a superfluid or Bose-Einstein condensate because it isolates angular momentum into quantized units. These quantized angular momentum units that exist within vacuum energy are proposed to be the fermions and bosons of our universe. The same way that the quantized vortices cannot exist without the surrounding superfluid, so also the fermions and bosons cannot exist without being surrounded by a sea of vacuum energy.

The total angular momentum present in the quantum fluctuations of spacetime at the start of the Big Bang probably added up to zero. However, even though counter rotating angular momentum can cancel, still there should be offsetting effects that should statistically preserve the quantized angular momentum units from the Big Bang to today (calculated in chapter 13). Dipole waves in spacetime that possess angular momentum would not be the same as the dipole waves that form vacuum fluctuations. A unit that possesses quantized angular momentum loses its ideal superfluid properties because it can interact with another unit of energy that possesses quantized angular momentum (for example, exchange angular momentum).

Spacetime Eddy in a Sea of Vacuum Energy: It is proposed that what we consider to be the fundamental particles today (quarks and leptons) are the spacetime equivalent of the vortices that carry quantized angular momentum in a superfluid. However, the quantized angular momentum entities are better visualized as chaotic eddies that exists in the vacuum fluctuations of spacetime. We can only directly interact with the dipole waves in spacetime that possess quantized angular momentum. We are unaware of the vast amount of superfluid vacuum energy that surrounds us because it only indirectly has any influence on us.

In the spacetime based model of the universe, fundamental particles are dipole waves in spacetime that possess quantized angular momentum. They are living in a sea of superfluid vacuum fluctuations that cannot possess angular momentum. Fundamental particles cannot exist without the support provided by this sea of superfluid vacuum fluctuations.

Rotar: The simplest form of quantized angular momentum that can exist in a sea of dipole waves in spacetime would be a rotating dipole wave that forms a closed loop that is one wavelength in circumference. A dipole wave in spacetime is always propagating at the speed of light, even if it forms a closed loop. This rotating dipole wave in spacetime is still subject to the Planck length/time limitation, so it can be thought of as being at the limit of causality. Its rotation is chaotic rather than being in a single plane. It has a definable angular momentum, but all rotation directions are permitted with different probabilities of observation. (The exact opposite of the expectation direction has zero probability). Therefore, the proposed model of an isolated fundamental particle is a dipole wave in spacetime that forms a rotating closed loop that is one wavelength in circumference.

This obviously is a drastic departure from the standard definition of the word "particle". The standard model of a fundamental particle is a mass that has no discernible physical size, but somehow exhibits wave properties, angular momentum and inertia. It is an axiom of quantum mechanics that the ψ function has no physical interpretation. This vagueness will be replaced with a tangible physical model that explains many of the properties exhibited by fundamental particles. A new name is required to distinguish between the standard concept of a fundamental particle and the proposed model of a rotating dipole wave in spacetime. The new name will be: "**rotar**". It is with great reluctance that a new word is coined, but this is necessary for clarity and brevity in the remainder of this book.

The name rotar refers specifically to the spacetime dipole model of a fundamental particle that exhibits rest mass. This model, and its variations, is described in detail later. Objects without rest mass, such as a photon, have a different model and are not covered by the term "rotar". There will be a spacetime model of a photon, but that will be introduced later. The word "particle" will be used whenever the common definition of a particle is appropriate or when it is not necessary to specifically refer to the spacetime particle model. For example, the name "particle accelerator" does not need to be changed. Even the term "fundamental particle" will occasionally be used in the remainder of this book when the emphasis is on distinguishing a quark or lepton from composite objects such as hadrons or molecules.

Trial and Error: It is proposed that the Big Bang started with spacetime being in the most energetic form possible in the sense that all of the energy was "observable" because all the dipole waves in spacetime initially possessed quantized angular momentum. Today, almost all the energy in the universe is in the form of vacuum fluctuations which do not possess angular momentum. These vacuum fluctuations are not "observable" except through quantum mechanical interactions such as virtual particle formation and annihilation. It will be shown in the chapters on cosmology that it is possible to extrapolate backwards from the current universe to the condition that existed when the universe was in its most primitive form at an age of one unit of Planck time ($\sim 5 \times 10^{-44}$ s). This extrapolation will indicate that the density of quantized spin in the universe today is the amount that would be expected if there was approximately no loss of quantized spin units. The lower density of quantized spin units today is due to the expansion of the proper volume of the universe. This statement should not be confused with the today's energy per quantized spin unit. Today almost all the quantized spin in the universe is in the form of cosmic microwave background (CMB) photons and neutrinos. The spin contained in other leptons and quarks is less than one part in 10^8 compared to CMB photons and neutrinos.

The angular momentum present in today's rotars was present at the Big Bang. However, this angular momentum is always trying to find the most stable form. The early universe was radiation dominated but energetic photons can combine to form matter/antimatter pairs. However, there is a slight preference for matter (about one part in a billion). As the early universe expanded (transformed), the chaotic dipole waves in spacetime explored every allowed combination of frequency and amplitude in an effort to find a suitable form to hold the unwanted angular momentum. By trial and error, relatively long lived spacetime resonances were found that both held quantized angular momentum and also were compatible with the properties of the vacuum energy dipole waves in spacetime. These spacetime resonances are proposed to be the fundamental particles (fundamental rotars). It will be shown later that the fundamental rotars are resonances that have frequencies between about 10^{20} and 10^{25} Hz.

In the proposed early stages of the Big Bang, the most energetic spacetime particles (rotars) formed first. For example, tauons (tau leptons) formed before muons. These were partially stable resonances. They survived for perhaps 10^{11} cycles, but not indefinitely. They then decayed into other energetic rotars and photons. The radiation dominated universe was undergoing a large redshift per second. Energy was being removed from photons and transformed into vacuum energy. This lowered the temperature of the observable portion of the universe that possesses angular momentum (photons, neutrinos and rotars). Eventually, other fundamental spacetime resonances (rotars) were formed at lower frequencies (lower energy). Eventually, truly stable resonances formed and these were electrons and the up and down quarks that found stability by forming protons and neutrons.

Wave-Particle Duality: Before launching into a more detailed description and analysis of a rotar, it is interesting to initially stand back and look at the philosophical difference in perspective required to imagine a particle made entirely of dipole waves in spacetime waves. At first, the idea of a particle made out of waves in spacetime seems to be intuitively unappealing. The essence of a particle is something that acts as a unit. Waves, on the other hand, are imagined to be infinitely divisible, perhaps like a sound wave. When a particle undergoes a collision, it responds as a single unit in a collision. This property seems incompatible with a rotar made entirely of waves. The term "wave-particle duality" was coined to "explain" the contradictory properties of both particles and photons.

Below, I will postulate a new property of nature called "unity". This property is closely related to entanglement. It permits a dipole wave possessing quantized angular momentum to communicate internally faster than the speed of light and respond to a perturbation as a single unit. This property would impart a "particle like" property to a quantized dipole wave in spacetime. However, the quantized wave would not exhibit classical particle properties. "Finding" the particle would become a probabilistic event because we are really dealing with interacting with a wave carrying quantized angular momentum that is distributed over a finite volume. A point particle cannot exhibit angular momentum or cannot explore all possible paths between two events in spacetime. On the other hand, a quantized wave in spacetime can exhibit both angular momentum and give a physical interpretation to the path integral of QED. There is actually a great deal of appeal to fundamental particles being made of quantized waves in spacetime, provided that the model is plausible.

An objection to a rotar model made entirely of waves is that our experience with light seems to imply that waves do not interact with each other. Light does have a very weak gravitational interaction, but overall light waves exhibit almost no interaction. The waves in spacetime that are proposed to be the building blocks of all matter and forces must be able to interact with each other.

Any wave that exhibits nonlinearity will interact to some degree with a similar wave. For example, sound waves have a slight nonlinearity. There is a temperature difference between the compression and rarefaction parts of a sound wave. This slight temperature difference produces a slight periodic difference in the speed of sound. This slight nonlinearity in a single sound wave means that two superimposed sound waves do interact. However, at commonly encountered sound intensities, the interaction between two sound waves is very small.

Gravitational waves also have a slight interaction because general relativity shows that gravitational waves are nonlinear. One of the appeals of dipole waves in spacetime is that they exhibit the required ability to interact with each other. In fact, dipole waves interact so strongly that they would cause a violation of the conservation of momentum without the quantum mechanical Planck length/time limitation previously discussed. The interactions between dipole waves in spacetime will be shown to be responsible for all the forces including gravity.

Spacetime is the stiffest possible medium. The incredibly large impedance of spacetime ($Z_s = c^3/G \approx 4 \times 10^{35}$ kg/s) permits a wave with small displacement to have the very high energy density for a given frequency. When we have frequencies in excess of 10^{20} Hz, then waves in spacetime are capable of achieving the energy density of fundamental particles. When we permit the frequency to reach Planck frequency, we can achieve the energy density required at the start of the Big Bang (Planck energy density). Also, a universe made only of spacetime and perturbations of spacetime has an appealing simplicity.

Particle Design Criteria: Everything that has previously been said in this book has set the stage for the task of attempting to design and analyze a plausible model of a fundamental rotar. In designing a rotar from dipole waves in spacetime, there is one factor that will be temporarily ignored. This is the experimental evidence that seems to indicate that fundamental particles are points with no physical size. This will be analyzed later.

It should be expected that the first model of fundamental particles will be overly simplified. For example, this first generation rotar model will make no distinction between leptons and quarks. Subsequent generations of the rotar model should make such a distinction and exhibit other refinements. The hope is that the first generation rotar model will pass enough plausibility tests that others will be encouraged to improve on this model.

There are 6 considerations that will be brought together in an attempt to design a fundamental particle. These are:

1) The universe is only spacetime. Energetic spacetime is spacetime that contains waves in spacetime. The waves can be dipole waves (with the Planck length/time limitation), quadrupole waves (for example, gravitational waves) or higher order waves. Of these, only dipole waves in spacetime have the proper characteristics to be the building blocks of rotars.
2) The rotar model should exhibit inertia. As shown in chapter 1, this requires energy traveling at the speed of light, but confined to a limited volume in a way that the momentum vectors generally cancel.
3) The rotar model should exhibit angular momentum. This will be interpreted as implying a circulation (rotation) of the dipole waves in spacetime. Furthermore, there should be a logical reason why fundamental rotars with different energy all possess the same angular momentum.
4) The rotar model should exhibit de Broglie waves when moving relative to an observer. This implies bidirectional wave motion, at least in the "external volume". The frequency of the confined dipole waves in spacetime can be calculated by analogy to the de Broglie waves generated by confined light described in chapter 1.
5) The rotar model should exhibit action at a distance without resorting to mysterious exchange particles. Both gravity and an electric field should logically follow from the rotar design. To accomplish this, part of the rotar's dipole wave in spacetime must extend into what we regard as empty space surrounding the rotar.
6) The rotar model should logically explain how it is possible for particles to explore all possible paths between two events in spacetime (path integral of QED).

Note to Reader: *The rest of this chapter presents the spacetime-based model of a fundamental particle. In these 11 pages the emphasis will be on describing the particle model and there will be no attempt to justify this model. This spacetime-based particle model will include unfamiliar concepts that may be difficult to initially visualize. Chapters 6, 8 and 10 are devoted to testing this particle model. For example, chapter 6 will subject the particle model to tests of its angular momentum, inertia, energy and the generation of forces (including gravity). These tests will also help to explain the model further.*

Particle Model

Fourth Starting Assumption: **A fundamental particle is a dipole wave in spacetime that forms a rotating spacetime dipole, one wavelength in circumference. Inertia is a natural property of this particle design.**

A rotating dipole in spacetime can be mentally thought of as a dipole wave in spacetime that has been formed into a closed loop, one wavelength in circumference. Recall that a dipole wave in spacetime oscillates both the rate of time and proper volume. For example, one portion of the wave, which we will name the spatial maximum, expands proper volume and slows the rate of time. The opposite portion of the wave, which we will name the spatial minimum has a reduction of proper volume and an increased rate of time. If a dipole wave in spacetime possesses quantized angular momentum, it forms a closed loop that is one wavelength in circumference. What was the spatial maximum and minimum in a plane wave have now become the two opposite polarity lobes of the rotating dipole wave. The wave is still traveling at the speed of light; it is just traveling at the speed of light around a closed loop. Such a wave is confined energy traveling at the speed of light. While there is angular momentum, the net translational momentum of this quantized wave is zero ($p = 0$ because of opposing vectors). Therefore, just like confined light or confined gravitational waves, a dipole wave rotating at the speed of light satisfies the condition required for it to exhibit rest mass and inertia.

This rotating dipole must be pictured as an isolated rotating dipole wave existing in a sea of vacuum energy/pressure that consists of other non-rotating dipole waves in spacetime. This vacuum energy/pressure is capable of exerting a far greater pressure than is required to confine the energy density of a rotar. For now the important point is that a rotar (rotating spacetime dipole) can achieve stability by interacting with the sea of vacuum energy that surrounds the rotar. The quantized rotating disturbance can effortlessly move through the superfluid vacuum energy.

Illustrations of a Rotar: Figures 5-1 and 5-2 are two different ways of depicting the rotating dipole portion of the rotar model. The spacetime dipole depicted in Figure 5-1 shows two diffuse lobes representing strained volumes of spacetime that are rotating in the sea of vacuum energy. These lobes are designated “dipole lobe A” and “dipole lobe B”. Each lobe exhibits both a slight spatial and a temporal distortion of spacetime. For example, lobe A can be considered the lobe that exhibits a proper volume slightly larger than the Euclidian norm (the spatial maximum lobe) and a rate of time that is slightly slower than the local norm. Lobe B has the opposite characteristics (smaller proper volume and faster rate of time). These lobes are always moving at the speed of light, so it is only possible to infer their effect on time or space by wave amplitudes. Also, the rotar model extends beyond the volume shown, but that portion is not illustrated here.

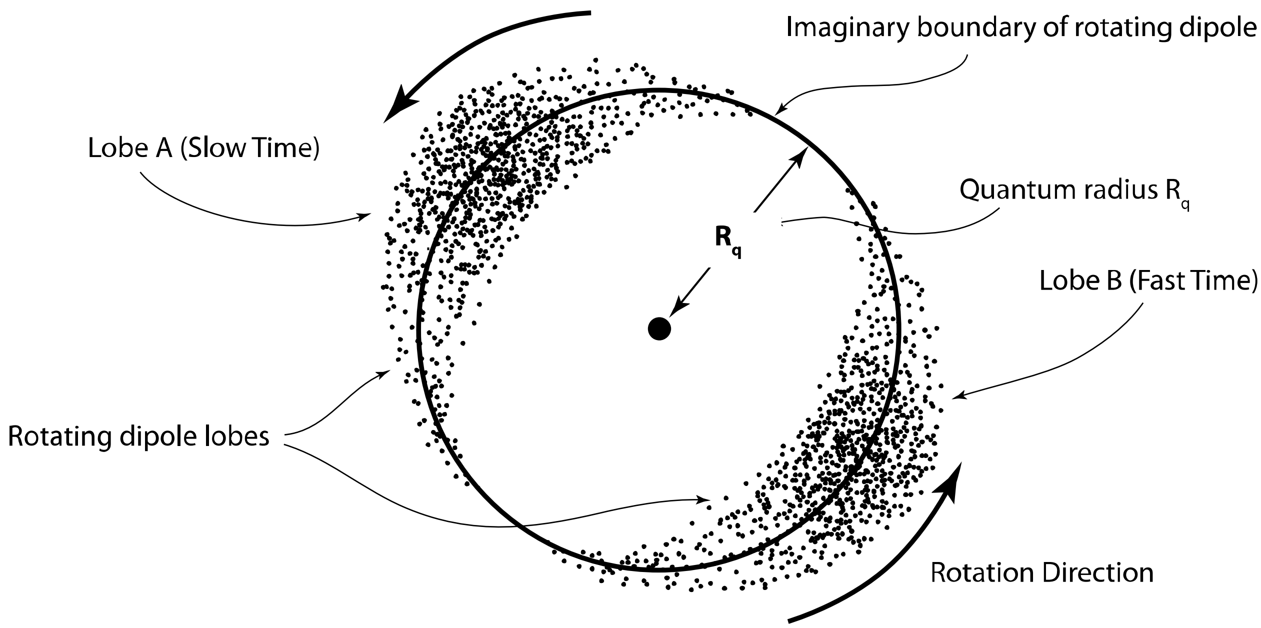

FIGURE 5-1 Depiction of the Rotar Model Emphasizing the Rotating Lobes
This is a rotating spacetime dipole that is one wavelength in circumference.

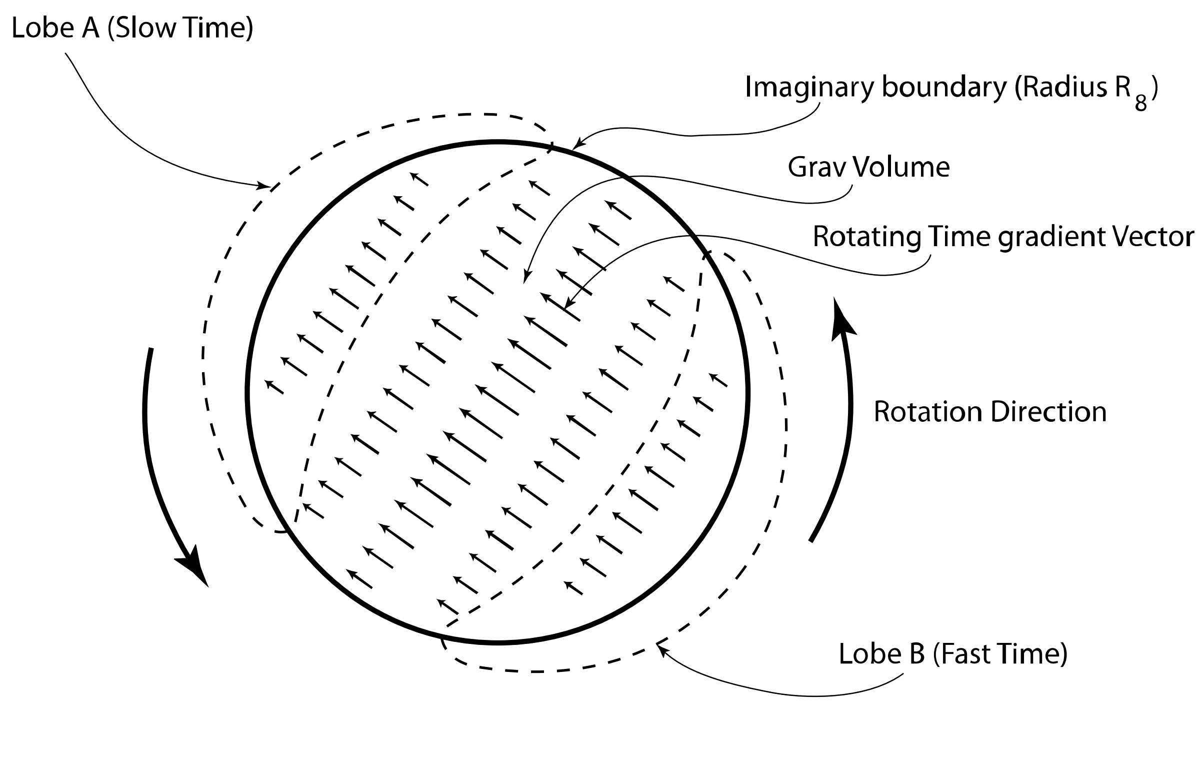

FIGURE 5-2 Depiction of the Rotar Model Emphasizing the Rotating Time Gradient Called a "Grav Field"

Quantum Radius and Quantum Volume: This cross sectional view in Figure 5-1 shows a circle with radius designated R_q. This radius will be called the rotar's "quantum radius". The circle and radius R_q should not be considered as physical entities. Instead, they should be considered as convenient mathematical references for a rotar. This is similar to the way that the center of mass is a convenient mathematical concept for mechanical analysis.

Since the dipole lobes are quantum mechanical entities, they cannot be accurately described by pictures. While figure 5-1 depicts a rotation in a single plane, the intended representation is a semi-chaotic rotation that has an expectation direction of rotation, but also other planes of rotation occur with a probabilistic distribution. This distribution is the same as quantum mechanical spin characteristics of a particle. Because of the semi-chaotic rotation characteristics, the circle depicted in Figure 5-1 should be considered the cross section of an imaginary sphere. The volume of this imaginary sphere will be designated the "quantum volume V_q". While this volume should be $(4/3)\pi R_q^3$, often we are dropping numerical factors near 1 in this plausibility study, so the quantum volume will be considered $V_q \approx R_q^3$.

An additional insight into figure 5-1 can be obtained by making a comparison to the TEM_{01}* Laguerre-Gauss mode of a laser beam which is also known as the "doughnut" mode. While a laser beam is propagating at the speed of light and the rotar being modeled is generally stationary, there are 4 points of similarity. 1) The spatial and temporal fluctuation of spacetime being depicted has a similar intensity doughnut distribution in cross section. There is zero intensity at the center. 2) The center contains all phases so that there is a phase singularity at the center where there is zero intensity. 3) The TEM_{01}* mode exhibits quantized orbital angular momentum. 4) The wave goes through an angular rotation where the rotation rate equals the photon's angular frequency.

In figure 5-1 there is also a circle designated "imaginary boundary of the rotating dipole". This circle with radius equal to the quantum radius R_q will be called the "quantum circle". Later we will imagine what would happen if it was possible to measure the rate of time at a point on this circle or measure the distance between two points on this circle. The rotation of the lobes affects both the rate of time and the distance between points on this circle.

Rotating Rate of Time Gradient: The presence of these lobes also implies that there is a gradient in the rate of time and a gradient in proper volume between these lobes (and even outside these lobes). If lobe A has a rate of time that is slower than the local norm and lobe B has a rate of time that is faster than the local norm, then this implies that the rotar model also contains a volume of space with a gradient in the rate of time that is rotating with the lobes. Any gradient in the rate of time produces acceleration. In chapter 2 we showed that the acceleration of gravity was directly related to the gradient in the rate of time:

$$g = c^2\frac{d\beta}{dr} = -\frac{c^2 d\left(\frac{d\tau}{dt}\right)}{dr}$$

For example, a 1 m/s^2 acceleration is produced by a rate of time gradient of: 1.11 x 10^{-17} seconds/second per meter. The rate of time gradient in the rotar model therefore produces a volume of spacetime that exhibits acceleration similar to gravity but there are also important differences explained below.

Figure 5-2 is intended to illustrate the rotating rate of time gradient present in the rotar model. In figure 5-2 the lobes A and B have been replaced with a dashed outline showing their approximate location. Instead of illustrating the lobes, figure 5-2 shows the rate of time gradient that exists between the lobes. (Only the rate of time gradient inside the quantum volume is shown). The arrows show the direction (vector) of the rate of time gradient and the length of the arrows is a crude representation of the amount of rate of time gradient. The direction of the rate of time gradient rotates with the lobes, so Figure 5-2 should be considered as depicting a moment in time.

It is also possible to make a laser mode analogy to figure 5-2. This is similar to a TEM_{00} Hermite-Gauss mode with circularly polarized light. The rotating electric field of the circularly polarized light is analogous to the rotating gradient in the rate of time depicted in figure 5-2. Also the intensity of the TEM_{00} mode is maximum at the center and this is analogous to the maximum intensity of the rate of time gradient at the center being depicted in figure 5-2. One place that this analogy breaks down is that adding together a TEM_{00} mode and a TEM_{01}* mode would produce interference effects in laser beams while the phenomenon being depicted in figures 5-1 and 5-2 not only produce no interference but they are naturally compatible. One follows from the other.

Rotating "Grav" Field: A new name is required to describe this rotating acceleration field caused by the rotating rate of time gradient illustrated in figure 5-2. The name "**grav field**" will be used to describe this rotating rate of time field. It will be shown later that this is a first order effect capable of exerting a force comparable to the maximum force of a rotar. However this force vector is rapidly rotating therefore we are not aware of its effect. The gravity produced by a rotar is a vastly weaker force. However, the gravity vector is not rotating and therefore it is additive. This "grav field" filling the center of the quantum volume will be shown to have an energy density comparable to the energy density of the rotating dipole wave which is concentrated closer to the circumference of the quantum volume. Therefore, the two different types of energetic spacetime approximately fill the entire quantum volume with an approximately uniform total energy density.

Lobe A as described above produces an effect in spacetime that is similar to the effect on spacetime produced by ordinary mass (minute slowing in the rate of time and minute increase in volume). Lobe B, on the other hand, produces an effect that is similar to the effect of a hypothetical anti-gravity mass. It produces a minute increase in the rate of time relative to the local norm and a minute decrease in volume. In lobe B, the minute increase in the rate of time never reaches the rate of time that would occur in a hypothetical empty universe. This will be discussed later, but it will be proposed that the entire universe has a background gravitational gamma Γ that results in the entire universe having a rate of time that is slower than a hypothetical empty universe. It is therefore possible for lobe B to have a rate of time that is faster than the surrounding spacetime without having a rate of time faster than a hypothetical empty universe.

Compton Frequency: We will return to figures later, but first we want to calculate the rotational frequency of the rotating dipole. If we presume that a rotar is a confined wave traveling at the speed of light, it is necessary to assign a frequency to this wave. Is it possible to obtain an implied frequency from a particle's de Broglie wave characteristics? In chapter #1 we showed that confined light exhibits many properties of a particle. These include the appearance of the optical equivalent of de Broglie waves when the confined light is moving relative to an observer. If we were only able to detect the optical de Broglie waves present in a moving laser, it would be possible to calculate the frequency of the light in the moving laser. Similarly, we can attempt to calculate a rotar's frequency from its de Broglie waves. We know a particle's de Broglie wavelength ($\lambda_d = h/mv$) and the de Broglie wave's phase velocity ($w_d = c^2/v$). From these we obtain the following angular frequency ω.

$$\upsilon_d = \frac{w_d}{\lambda_d} = \left(\frac{c^2}{v}\right)\left(\frac{mv}{h}\right) = \frac{mc^2}{h} \qquad \upsilon = \text{frequency}$$

$$\omega = 2\pi\upsilon_d = \frac{2\pi mc^2}{h} = \frac{mc^2}{\hbar} = \omega_c$$

$$\omega = \omega_c \qquad \omega_c = \text{Compton angular frequency} = \frac{mc^2}{\hbar} = \frac{c}{R_q} = \frac{E_i}{\hbar}$$

This calculation says that a rotar's angular frequency is equal to a rotar's Compton angular frequency ω_c. We will presume that this is a rotar's fundamental frequency of rotation. While the de Broglie wavelength and phase velocity depend on relative velocity, the velocity terms cancel in the above equation yielding a fundamental frequency (Compton frequency) that is independent of relative motion. The reasoning in this calculation can be conceptually understood by analogy to the example in chapter 1 of the bidirectional waves in the moving laser.

A rotar's Compton wavelength will be designated λ_c. The connection between a rotar's Compton wavelength and de Broglie wavelength is very simple.

$\lambda_c \approx \lambda_d\,(v/c)$ approximation valid for $v << c$
$\lambda_c \approx \lambda_d \gamma$ approximation valid for $\gamma >> 1$

The simplicity of these equations show the intimate relationship between a rotar's de Broglie wavelength and Compton wavelength. For another example, imagine a generic "particle" that might be a composite particle such as an atom or molecule. This "particle" is at rest in our frame of reference. Suppose that this particle emits a photon of wavelength λ_γ. This photon has momentum $p = h/\lambda_\gamma$. Therefore the emission of this photon imparts the same magnitude of momentum to the emitting particle but in the opposite vector direction (recoil). Now, the particle is moving relative to our frame of reference. What is the de Broglie wavelength of the recoiling particle in our frame of reference?

$\lambda_d = h/p$ set $p = h/\lambda_\gamma$
$\lambda_d = \lambda_\gamma$

Therefore, we obtain the very interesting result that the de Broglie wavelength of the recoiling particle equals the wavelength of the emitted photon. In Appendix A of chapter 1 it was proven that a confined photon with a specific energy exhibits the same inertia as a fundamental particle with the same energy. Another way of saying this is that a particle with de Broglie wavelength λ_d exhibits the same inertia as a confined photon with the same wavelength. Furthermore, in chapter 1 we saw the similarity between de Broglie waves with wavelength λ_d and the propagating interference patterns with modulation wavelength λ_m. Imparting momentum $p = h/\lambda_\gamma$ to either a fundamental particle with Compton wavelength λ_c or a confined photon with the same wavelength will produce the result: $\lambda_d = \lambda_m = \lambda_\gamma$. Therefore, it is proposed that this offers additional support to the contention that fundamental particles are composed of a confined wave in spacetime with a wavelength equal to the particle's Compton wavelength λ_c.

In the remainder of this book we will often use an electron in numerous examples. An electron has the following Compton frequency, Compton angular frequency and Compton wavelength:

Electron's Compton frequency $\nu_c = 1.24 \times 10^{20}$ Hz
Electron's Compton angular frequency $\omega_c = 2\pi\,\nu_c = 7.76 \times 10^{20}$ s^{-1}
Electron's Compton wavelength $\lambda_c = 2.43 \times 10^{-12}$ m
Electron's reduced Compton wavelength $\lambda\!\!\!^{-}_c = 3.86 \times 10^{-13}$ m ($\lambda\!\!\!^{-}_c = c/\omega_c$)

Quantum Radius: Once we know the frequency of rotation, we can calculate the quantum radius R_q of the rotating dipole assuming speed of light motion. The "quantum circle" in Figure 5-1 is an imaginary circle with a circumference one Compton wavelength. The radius of the circle one Compton wavelength in circumference is the "quantum radius R_q".

$R_q = c/\omega_c = \hbar/mc = \lambda_c/2\pi = \lambda\!\!\!^{-}_c$
where R_q = quantum radius, λ_c = Compton wavelength $\lambda\!\!\!^{-}_c$ = reduced Compton wavelength

What I call the "quantum radius" has sometimes been referred to as the "Compton radius". However, the term "Compton radius" is also used to describe a charged particle's classical radius, for example, an electron's classical radius (~ 2.82 x 10^{-15} m). Therefore, to avoid this confusion, I will use the term "quantum radius" R_q to describe $\hbar/mc$. For example, the quantum radius of an electron is R_q = 3.86 x 10^{-13} meters.

In quantum mechanics, this distance R_q, is the logical division where a particle's quantum effects become dominant. For example, a fundamental particle of mass m can move discontinuously over a distance R_q. A particle can go out of existence, or come into existence, for a time equal to R_q/c. Essentially, the distance R_q is a rotar's natural unit of length and $1/\omega_c$ is a rotar's natural unit of time.

Analysis of the Lobes: Suppose that it was possible to freeze the motion of the rotating dipole and examine the difference between the two lobes. The slow time lobe (lobe A) can be thought of as having a proper volume that exceeds the anticipated Euclidian volume as previously explained. The fast time lobe (lobe B) can be thought of as having less proper volume than the anticipated Euclidian volume (the spatial minimum lobe). This connection between volume and the rate of time is well established for the effects of gravity. However, gravity is a static effect on spacetime. This effect on space produced by a rotar's dipole wave in spacetime results in the distance between two points on the quantum circle changing slightly as the dipole rotates. Similarly, if it was possible to freeze the rotation we would find a different rate of time between the two lobes. Since the lobes are always moving at the speed of light, the effect is that the rate of time fluctuates at a point on the quantum circle (radius = R_q) and the distance between two points on the quantum circle also fluctuates.

All quantized dipole waves have maximum spatial displacement amplitude equal to ± Planck length (± L_p) as the quantum dipole rotates. To illustrate this concept, imagine two points located on the quantum circle of Figure 5-1 separated by a circumferential distance equal to R_q (separated by one radian). As the lobes rotate they modulate volume and result in the separation distance between these two points increasing and decreasing by Planck length (± L_p). Figure 5-3 is a graph of the spatial effect produced by the rotating spacetime dipole. In figure 5-3 the Y axis is the spatial displacement produced by the rotating dipole between these two points (± L_p). The X axis is length in units of $\lambda\!\!\!^-_c$ which is the same as R_q since ($R_q = \lambda\!\!\!^-_c$). It should be noted that the Y axis is about a factor of 10^{23} smaller scale than the X axis if we presume that $\lambda\!\!\!^-_c$ is an electron's reduced Compton wavelength ($\lambda\!\!\!^-_c \approx$ 3.86 x 10^{-13} m and $L_p \approx$ 1.6 x 10^{-35} m).

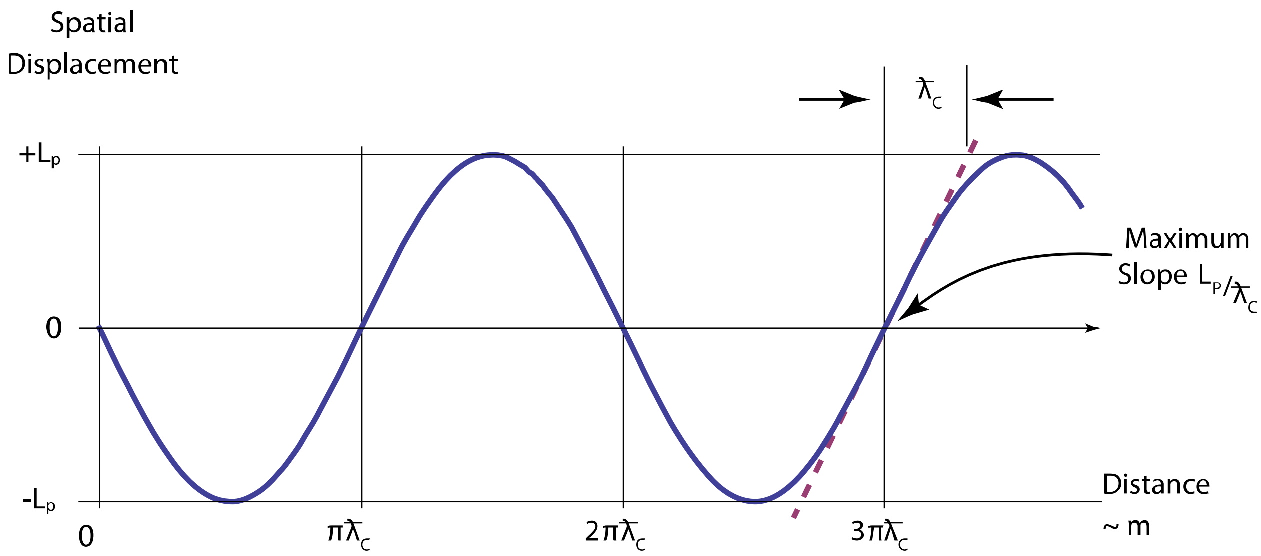

FIGURE 5-3

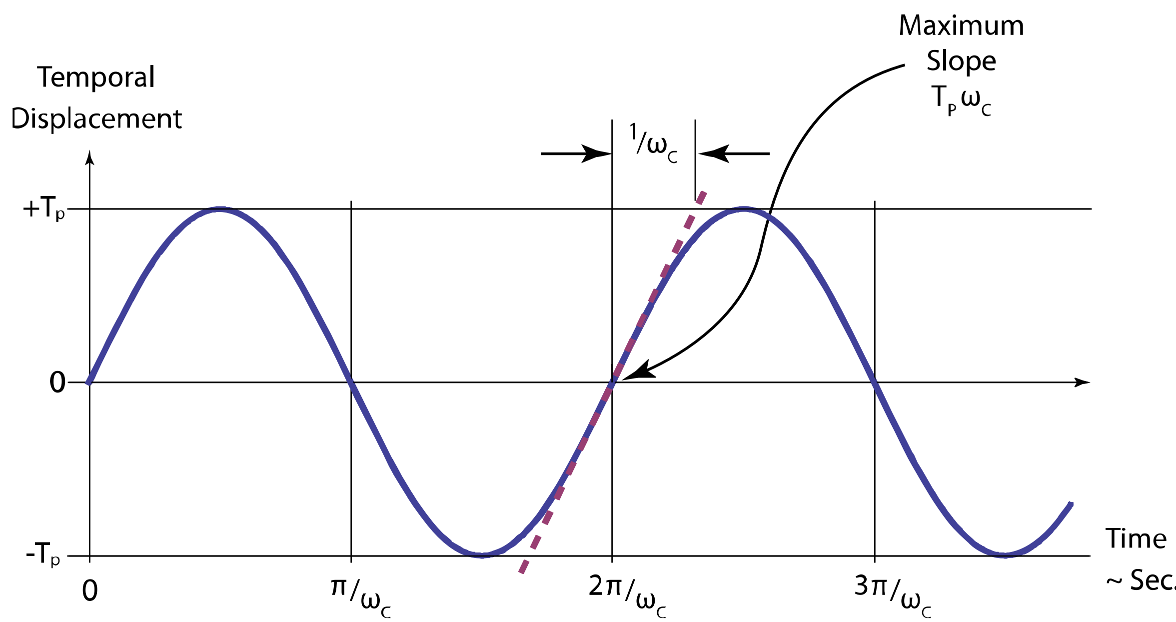

FIGURE 5-4

Figure 5-4 is a graph of the temporal effect of the rotating spacetime dipole. It was previously stated that in Figure 5-1 we can consider lobe "A" as exhibiting a rate of time slower than the local norm and lobe "B" as exhibiting a rate of time faster than the local norm. To illustrate this concept further, we will imagine a thought experiment where we place a hypothetical perfect clock at a point on the circumference previously designated the "quantum circle" in Figure 5-1.

Previously we imagined freezing the rotation of the dipole. Now in figure 5-4 we imagine having the dipole rotate and we are monitoring the time at only one point on the imaginary quantum circle and comparing this to a "coordinate clock" at another location in flat spacetime. The clock monitoring a point on the edge of the dipole will be called the "dipole clock".

As lobes A and B rotate past the dipole clock location, the dipole clock would speed up and slow down relative to the coordinate clock that is unaffected by the rotating dipole. Both clocks are started at the same moment. In flat spacetime, we would expect both clocks to perfectly track each other. Figure 5-4 plots the temporal displacement of spacetime produced by the rotating dipole wave (Y axis) versus time as expressed in units of $1/\omega$ (X axis). For example, an electron has angular frequency of $\omega_c \approx 7.76 \times 10^{20}$ s^{-1}. Therefore, for an electron $1/\omega_c \approx 1.29 \times 10^{-19}$ s. As can be seen in figure 5-4 the dipole clock speeds up and slows down relative to the coordinate clock. The maximum time difference between the two clocks is plus or minus Planck time T_p ($\pm \sim 5 \times 10^{-44}$ s). This maximum time difference is a quantum mechanical limit for a displacement of spacetime that is undetectable. This oscillation of the rate of time is what has been called "dynamic Planck time T_p". Figure 5-4 only shows what happens during a short time period ($\sim 10^{-20}$ s) after starting the dipole and coordinate clocks. The time difference over a longer time will be discussed in a later chapter.

Strain Amplitude – H_β: The strain amplitude of the wave depicted in figures 5-3 and 5-4 is just the maximum slope of these waves. The dashed line in figure 5-3 represents the maximum slope which occurs when the sine wave crosses zero. This maximum slope can be a dimensionless number if the X and Y axis have the same units which cancel when expressing slope. For example, in figure 5-3 both the X and Y axis have units of length. The maximum displacement is one unit of Planck length ($L_p \approx 1.6 \times 10^{-35}$ m). The X axis is length units expressed as multiples of $\lambda\!\!\!^{-}_c$ which is equal to R_q. For an electron $\lambda\!\!\!^{-}_c = R_q = 3.86 \times 10^{-13}$ m. The maximum slope occurs at Y = 0. The maximum slope in figure 5-3 is $L_p/\lambda\!\!\!^{-}_c$. This dimensionless maximum slope will be designated the "strain amplitude" and designated with the symbol H_β. Therefore, one way of expressing a rotar's strain amplitude is with the ratio of lengths:

$H_\beta = L_p/\lambda\!\!\!^{-}_c = L_p/R_q$ strain amplitude expressed with length ratio

Figure 5-4 is similar to figure 5-3 except that 5-4 is characterizing the effect on the rate of time. The Y axis of this figure depicts the difference between the dipole clock and the coordinate clock shortly after we start both clocks. This difference between clocks can reach $\pm$ Planck time ($\pm T_p$). The X axis of figure 5-4 is in units of time expressed as $1/\omega_c$ which for an electron is $1/\omega_c \approx 1.29 \times 10^{-19}$ s. The strain amplitude H_β of the dipole wave can also be expressed using time related symbols:

$H_\beta = \omega_c/\omega_p = T_p\omega_c$ strain amplitude expressed using frequency and time

Therefore the dipole waves strain amplitude can be expressed either as a strain of space ($L_p/\lambda\!\!\!^{-}_c = L_p/R_q$) or as a strain in the rate of time ($\omega_c/\omega_p = T_p\omega_c$). For an electron $R_q \approx 3.86 \times 10^{-13}$ m and $\omega_c \approx 7.76 \times 10^{20}$ s^{-1}. Therefore, an electron's dimensionless strain amplitude is: $H_\beta \approx 4.18 \times 10^{-23}$. (This will be discussed in more detail in the next chapter.) Other rotars have different strain amplitudes because they have different Compton angular frequencies (and corresponding different values of R_q and $\lambda\!\!\!^{-}_c$). Note that the sine waves in figures 5-3 and 5-4 are shifted by π radians (180°). This is because the lobe with maximum proper volume corresponds to the lobe with the minimum rate of time and vice versa.

Conceptual Examples of Wave Amplitude: The rotar model is based on the sea of vacuum fluctuations that form spacetime being dynamically strained. It is important to have a mental picture of the incredibly small displacements of time and space required for this model. For example, for an electron $H_\beta \approx 4.18 \times 10^{-23}$ which is the ratio of L_p/R_q or $T_p\omega_c$. This spatial strain of spacetime causes the orbits of the two lobes to exhibit differences in circumference and radius comparable to Planck length. This is really equivalent to having one of the lobes exceed the electron's quantum radius by Planck length and the other lobe is less than the quantum radius by Planck length. This means that the lobes are not exactly symmetrical. Actually, the very concept of a dipole implies that there must be two different (opposite) properties that are interacting. With electromagnetic radiation, a dipole oscillator has a positive and negative electrical charge. Similarly, a spacetime dipole has two lobes which produce an opposite type of spatial distortion (big and small) of the properties of spacetime or the opposite type of temporal distortion (fast and slow) of the properties of spacetime.

Planck length is so small that it is hard to imagine the minute distortion of spacetime required to make an electron according to the proposed model. We will use the following example to illustrate this incredibly small difference between the two lobes. Suppose we compare an electron's quantum radius to the radius of Jupiter's orbit. Stretching space by Planck length over a distance equal to an electron's quantum radius produces a strain of about 4.2×10^{-23}. ($1.6 \times 10^{-35}/3.9 \times 10^{-13} \approx 4 \times 10^{-23}$). Stretching Jupiter's orbital radius (7.8×10^{11} m) by 3.3×10^{-11} m would produce a comparable strain in space. To put this in perspective, the Bohr radius of a hydrogen atom is $\sim 5.3 \times 10^{-11}$ m. Now imagine a sphere the size of Jupiter's orbit, except that one hemisphere has strained spacetime such that the radius exceeds the prescribed radius by a distance roughly equal to the radius of a hydrogen atom. The other hemisphere is less than the prescribed amount by the radius of a hydrogen atom (a 4×10^{-23} volume difference). Of course, the transition between the two lobes is not an abrupt step. This simplified example is meant to illustrate the minute distortion of spacetime involved in the spacetime-based model of a fundamental particle.

Thus far, this example describes a static strain. To give an idea of dynamic strain in spacetime, imagine the spherical volume of spacetime the size of Jupiter's orbit with the distortion of spacetime rotating at the speed of light. This rotating slight strain of spacetime would be an example of dynamic spacetime. The analogy breaks down because the rotation frequency of an electron exceeds 10^{20} Hz and speed of light around the circumference of Jupiter's orbit would take roughly 4 hours. Since this frequency term is squared, the higher frequency of the electron produces the effect that is roughly 10^{48} times larger than the same strain amplitude circulating at the speed of light around Jupiter's orbit.

Continuing with the example, suppose that we were to compare the rate of time between the two lobes of an electron. Suppose that it was possible to stop the rotation and insert a perfectly accurate clock into the fast lobe of an electron (at distance R_q) and insert a second perfect clock into the slow lobe. The rate of time difference is so small that it would take about 50,000 times longer than the age of the universe before the two clocks differed in time by one second. This ratio in the rate of time is also about 4 x 10^{-23}. Once again, this describes a fixed difference in the rate of time.

There is another way of looking at the difference in the rate of time. An elevation change of 0.4 micron (4 x 10^{-7} m) in the earth's gravity produces about the same change in the rate of time that occurs between the two lobes of an electron. While this example also seems like an insignificant difference in the rate of time, the electron produces this change in the rate of time over a much shorter distance than the earth's gravitational field. This means that an electron has a much larger gradient in the rate of time than the earth's gravitational field. This will be quantified later, but the result is that the center of the rotar model quantum volume contains a rotating acceleration field previously named a "grav field". It has similarities to gravity, but is not the same as gravity.

In chapter 6 we will analyze this spacetime-based model of fundamental particles to see if the model plausibly yields the correct energy, angular momentum, gravity, etc. However, the above examples begin to give a feel for how particles can appear to be nebulous entities which result in their counter intuitive quantum mechanical properties. Rotars made from small amplitude waves in spacetime can be difficult to locate exactly. Furthermore, a property will be proposed later that permits quantized waves in spacetime to respond to a perturbation as a single unit. This gives "particle-like" properties to a quantized wave in spacetime and gives rise to the famous wave-particle properties in nature.

Solitons: Why do a few combinations of frequency and amplitude produce resonances that result in fundamental particles and all other frequencies and amplitudes not produce fundamental particles? There must be a combination of properties of spacetime which achieve stability by canceling loss at the few frequencies that form fundamental particles. There appears to be a similarity between the conditions that form a stable rotar and the conditions that form a stable optical soliton. An optical soliton is formed when a very short pulse of laser light is focused into a transparent material that exhibits a set of complementary optical characteristics. One of these characteristics is the optical Kerr effect. As previously mentioned, this is a nonlinear effect in all transparent materials where the speed of light is dependent on intensity. This nonlinear effect is also wavelength dependent. In some optical materials the dispersion of the optical Kerr effect can be offset against the optical dispersion of the transparent material. These two properties can interact in a way that confines rather than disperses the energy in the pulse of laser light. The dispersion is a loss mechanism for a pulse of laser light. The combination of the two different types of dispersion plus the intensity dependence together can create a stability condition. A pulse of laser light forms a propagating wave that fulfills this stability condition and this combination of effects shape the pulse of light into an "optical soliton". The term "soliton" is a self-reinforcing wave that maintains its shape as it propagates. The first identified solitons were water waves propagating in a channel. Optical solitons can exhibit many particle-like properties. For example, two optical solitons propagating near each other can attract or repel each other depending on the relative phase of the light. A wonderful video is available at the following website showing particle-like interactions of optical solitons[4].

The characteristics of spacetime appear to form a similar loss cancellation for the 3 charged leptons. These are fundamental particles with rest mass that can exist in isolation. The stability of any rotars depends on the existence of vacuum energy, but there must be a few frequencies and conditions where the stabilization is optimum. This is equivalent to a pulse of light satisfying the soliton condition in a transparent material. The analogy to optical solitons can be extended if a fundamental particle is visualized as propagating along the geodesic at the speed of light.

It was previously stated that each fundamental rotar has a unique dimensionless number that describes its wave amplitude H_β, frequency, mass, quantum radius (inverse), energy, circulating power ($P_c^{1/2}$) and even its gravitational magnitude ($\beta_q^{1/2}$). For the electron: $H_\beta = 4.18 \times 10^{-23}$; for the muon: $H_\beta = 8.66 \times 10^{-21}$; and for the tauon: $H_\beta = 1.46 \times 10^{-19}$. Each of these numbers somehow matches a stability condition for spacetime. There are an infinite number of other numbers that do not describe fundamental rotars. The difference between the few numbers that describe fundamental rotars and the infinite number of other numbers that do not describe rotars is that these few numbers describe conditions in spacetime where there is cancelation of waves in the external volume of rotars. The high loss frequencies that do not cancel, never survived the early stages of the Big Bang when all combinations of frequencies and amplitudes were being tested. The few stable frequencies that satisfied the soliton condition condensed out of the energetic spacetime that existed at the early stages of the Big Bang and formed the fundamental rotars.

[4] http://www.sfu.ca/~renns/lbullets.html

Chapter 6

Analysis of the Particle Model and Derivation of Gravity

In chapter 5 the spacetime-based model of a fundamental particle was presented without any analysis to see if it can satisfy the known characteristics of fundamental particles. This chapter will be devoted to testing the rotar model of fundamental particles for plausibility. We will first analyze whether this model will appear to be a point particle in collision experiments. Then we will see if the particle model produces the required energy, angular momentum, and forces including the correct gravity. Finally the implied inertia of the particle model will be discussed.

Particle Size Problem: Perhaps the biggest objection to the hypothesis proposed in chapter 5 is that experiments seem to indicate that fundamental particles are points with no physical size. Now we will examine whether the rotar model is compatible with the experiments that seem to indicate a point particle.

In one sense, a rotar is only an angular momentum disturbance in spacetime. For an electron, the strain produced on spacetime is only about 4×10^{-23}. Spatially, this is a strain of spacetime comparable to stretching Jupiter's orbit by the radius of a hydrogen atom. Temporally this is comparable to retarding the rate of time by one second over 50,000 times the age of the universe. It is only the incredibly large impedance of spacetime (c^3/G) and the high oscillation frequency that gives this small strain of spacetime a detectable physical presence. Even then, the oscillations are not detectable as waves because the maximum displacement of spacetime is only Planck length and Planck time.

When we do detect the presence of an electron, it exhibits properties that are not explainable from classical physics. For example, "finding" an electron (interacting with a wave with quantized angular momentum) is a probabilistic event. An electron can seem to jump from one location to another without traversing the space between these two points. This is because the rotating dipole in spacetime that is an isolated electron is distributed over a relatively large volume with a radius in the range of 4×10^{-13} m. Indeed, this is the uncertainty volume over which these counter intuitive interactions can occur. The angular momentum of an electron is quantized therefore this distributed distortion of spacetime seems to interact at a point. The quantized angular momentum property is enforced by the vacuum energy fluctuations which are in a superfluid state as previously discussed. The list of counter-intuitive properties of an electron is long, but the non-classical property of interest here is the fact that an electron seems to have no physical size in a collision experiment.

Even though the rotar model gives a physical size to fundamental particles, it is not the classical "billiard ball" type of physical size. For example, a "collision" between an electron and a positron (rotar model) often results in these two rotating dipole waves merely passing through each other with the only interaction being a slight scattering from the original trajectories. When an electron and positron annihilate each other in an interaction that forms positronium (not a high speed collision), about 10^{-10} seconds is required for this annihilation (photon emission) to take place. In a collision at near light speed the overlap time is less than 10^{-20} seconds in the frame of reference where the total momentum is zero. When the collision energy is less than the about 1 GeV, then the scattering cross-section of an electron-positron collision decreases as the collision energy increases. At higher collision energy where new fundamental particles can be formed the interaction cross-section becomes complex with the formation of new particles.

In a collision between two electrons the electrostatic repulsion can be visualized as momentarily bringing the two colliding electrons to a halt. What happens to the kinetic energy at the moment of closest approach? With the rotar model the kinetic energy of each electron is momentarily converted into internal energy of the two electrons. This increase in energy means that the frequency increases, the wavelength decreases, the circumference decreases, and the quantum radius decreases. These changes keep the angular momentum constant because the decrease in radius offsets the increase in mass/energy. The quantum radius R_q scales with the rotar's internal energy E_i as: $R_q = \hbar c/E_i$. At the moment of "closest approach" the two rotars are actually partially overlapping. They also have the smaller radius and higher frequency appropriate for their higher energy condition.

How does this radius compare with the particle size resolution limit in a collision experiment? This resolution limit is set by the uncertainty principle $\Delta x\,\Delta p = \hbar/2$. We have been ignoring dimensionless constants like ½, so we will use $\Delta x\,\Delta p = \hbar$ and then include a single all-inclusive constant k. In a collision between two electrons, we have an uncertainty about the momentum transferred at the moment of closest approach. Is the collision head on or a glancing collision? All we really know is the maximum momentum available, so the uncertainty becomes $\Delta p = mv$. For a collision between electrons with ultra-relativistic velocity ($v \approx c$), the special relativity gamma is $\gamma \approx E_k/mc^2$ where E_k is the relativistic kinetic energy. Also, when γ is large, the momentum is: $p \approx \gamma mc$. With this information we can solve for Δx.

$$\Delta x = \frac{\hbar}{\Delta p} = \frac{\hbar}{\gamma mc} = k\left(\frac{\hbar}{mc}\right)\left(\frac{mc^2}{E_k}\right) \qquad \text{dimensionless constant k included}$$

$$\Delta x = k\,\frac{\hbar c}{E_k}$$

Therefore, in a collision between ultra-relativistic rotars, the kinetic energy is momentarily added to the rotar's internal energy ($E = mc^2$ energy) for a total energy of $E + E_k \approx E_k$. This means that the quantum radius momentarily shrinks to $R_q \approx \hbar c/E_k$ which matches the uncertainty resolution limit of the experiment $\Delta x = \hbar c/E_k$. It is no coincidence or lucky result that the resolution of the experiment matches the momentary size of a rotar. If fundamental particles really are rotars with a probabilistic interaction radius, then this size <u>must</u> match the uncertainty in the interaction.

The combination of the overlap and the reduction in R_q results in an expectation separation distance that is less than the Δx uncertainty resolution of the experiment that attempts to measure the size of the rotar (particle). This is analogous to the uncertainty principle saying that an experiment cannot simultaneously measure the position and momentum of a particle to better than ½ħ. Similarly, an experiment cannot measure the size of a fundamental particle because the measurement process introduces energy that momentarily decreases the size of the particle to below the measurement resolution ($R_q = \hbar c/E_i < \Delta x$). Therefore, the rotar model gives a plausible explanation of why fundamental particles always appear to be point particles in experiments that attempt to measure their size.

The current upper limit for the size of an electron is set by an experiment using two electrons accelerated to a kinetic energy of about 50 GeV. When the rotar model of an electron undergoes a collision, the 50 GeV kinetic energy is temporarily converted to the electron's internal energy. This momentarily increases the electron's internal energy (dipole wave energy) by a factor of 100,000 and reduces the quantum radius by a factor of 100,000. An isolated electron has a quantum radius of about 4 x 10^{-13} m. However when 50 GeV of kinetic energy is converted to an electron's internal energy at the moment of closest approach, this reduces R_q by a factor of 100,000 to about 4 x 10^{-18} m. Combined with the ability to partially overlap quantum volumes, the electron always has an instantaneous size smaller than the Δx resolution limit of the experiment. A 50 GeV electron undergoing a collision temporarily becomes much smaller than a proton (~10^{-15} m) and can be used as a probe of the internal structure of a proton.

The rotar model of an electron also has an advantage over the point particle model of an electron when it comes to explaining the behavior of an electron in an atom. An electron bound in an atom appears to be bigger than the isolated rotar size. For example, an electron bound in a hydrogen atom has a different boundary condition than an isolated electron. This creates a different stability condition that results in the dipole wave energy of the electron distributed around the nucleolus of an atom in a way that enlarges the apparent size and explains the cloud-like quality of an electron bound in an atom.

Equations Demand Size: One of the strengths of the spacetime model of fundamental particles is that it gives a plausible explanation of how the fundamental particle (rotar) can have a physical size equal to the reduced Compton wavelength (equal to R_q) and yet also always appear to be a point particle in collision experiments. One of the "mysteries" of quantum mechanics has been that the equations of quantum mechanics yield an unreasonable answer of infinity when they incorporate the assumption that fundamental particles are point particles. These equations are screaming that this is a wrong starting assumption. Yet the equations are ignored because the physical interpretation of experiments is that the fundamental particles must be point particles.

However, this is a failure of the physical interpretation of the experiments, not a failure of the equations. The process of renormalization used to eliminate the infinity is actually adjusting the starting assumption to give a physical volume to fundamental particles. Physicists believe that experiments are the ultimate referee of a theory. Usually experiments are easy to interpret correctly. However, the physical interpretation of collision experiments always makes the erroneous assumption that the colliding particles do not change any of their characteristics compared to the same particles not undergoing a collision. In particular, the assumption is that the physical size of a fundamental particle remains constant, even if the collision is ultra-relativistic. However, where is the kinetic energy stored at the instant when both particles are stopped? It is proposed that the collision experiments are giving the correct answer for this instant but this collision moment cannot be extrapolated to deduce the size of isolated particles. This is like a self-fulfilling prophecy. If you assume point particles, then you can interpret the experimental results to support this model.

Stability Mechanism: How exactly does the spacetime dipole achieve stability? What prevents the waves from simply propagating in a straight line rather than forming a rotating dipole? This question will be addressed later, but an introductory explanation will be given here. Chapter 5 started by recounting Erwin Schrodinger's attempted to give a wave based explanation to fundamental particles. Schrodinger eventually abandoned this explanation because he was unable to explain what prevented his "wave packet" from dissipating.

The proposed rotar model has a single frequency dipole wave in spacetime that forms a rotating closed loop. This dipole wave is still propagating at the speed of light. This model achieves a large energy density that will be calculated later. However, it also implies a large pressure required to confine this energy. In fact, any concentration of energy density fundamentally implies pressure. Therefore, this proposed rotar model requires some means to counteract the pressure associated with the energy density. This is accomplished by an interaction with the vacuum energy dipole waves in spacetime that exist everywhere in spacetime. This vacuum energy possesses a vastly larger energy density than any rotar. Therefore the vacuum energy exists at a vastly larger pressure than is required to stabilize the rotar. There are only a few quarks and leptons in the standard model. These represent only a few Compton frequencies that have achieved at least partial stability interacting with the surrounding vacuum energy dipole waves in spacetime. This explanation will be expanded later.

Rotar Energy Test: Now we are going to subject the rotar model and the concept of dipole waves in spacetime to a critical test. We will use one of the 5 wave-amplitude equations and attempt to calculate the energy of any rotar. We are not attempting to calculate the energy of specific particles. Instead, we are checking to see if the concept of dipole waves in spacetime that are confined to a specific volume can produce the equivalent mass/energy for a rotar. For this plausibility test to be successful, inserting a rotar's amplitude, frequency and volume into the wave-amplitude equation must produce the correct energy for a rotar (ignoring dimensionless constants near 1). The equation to be used is:

$E = k H^2 \omega^2 Z V/c$ wave-amplitude equation expressing energy E in a volume V

We know that the angular frequency ω equals the Compton frequency: $\omega = \omega_c = c/R_q = mc^2/\hbar$. We will also set the amplitude as: $H_\beta = L_p/R_q = T_p\omega_c$. Where H_β = strain amplitude in the quantum volume of a rotar. This amplitude was obtained in the last chapter using the starting assumption about the maximum displacement of spacetime allowed by quantum mechanics for dipole waves in spacetime.

The volume term V should be equal to the volume of the rotar's quantum volume: $V = kR_q^3$. It is true that we are not addressing the question about how uniformly this volume is filled, but this is just a plausibility test and we are using the constant k which permits us to be vague about this point. Finally, the impedance term Z is set equal to the previously obtained impedance of spacetime: $Z_s = c^3/G$. We will lump all dimensionless constants into a single constant k.

$E = k H^2 \omega^2 Z V/c$ set $H = H_\beta = L_p/R_q$ $\omega = \omega_c = c/R_q$ and $Z = Z_s = c^3/G$

$$E = k\left(\frac{L_p}{R_q}\right)^2\left(\frac{c}{R_q}\right)^2\left(\frac{c^3}{G}\right)\left(\frac{R_q^3}{c}\right) = k\frac{L_p^2c^4}{GR_q} = k\left(\frac{\hbar G}{c^3}\right)\left(\frac{c^4}{G}\right)\left(\frac{mc}{\hbar}\right)$$

$E = k\,mc^2$

This important plausibility test is successful. The rotar model establishes the famous relationship between energy and mass (inertia). We have shown that an amplitude of $H_\beta = L_p/R_q$, a frequency of ω_c and a volume of kR_q^3, together produce the correct energy of $E = mc^2$ (times a possible constant). The mass in this equation should be thought of as the inertia exhibited by confined energy circulating at the speed of light. The calculation that was just made represents a bridge between the familiar concept of particles exhibiting mass and the unfamiliar concept of confined waves in spacetime that exhibit energy and inertia.

We are presuming that $k = 1$. We actually have a little bit of flexibility in this regard. Previously we gave an example where the displacement amplitude was defined as the normal $\pm$ amplitude of a sine wave. It would also be possible to define the amplitude as the RMS amplitude or the peak to peak amplitude. These three ways of defining amplitude all apply to the same wave. Furthermore, there may be another way of defining amplitude. I am going to presume that some definition of amplitude will permit $k = 1$.

It should be emphasized that the quantum radius R_q is a convenient mathematical representation of a rotar model, but the rotar does not abruptly stop at a distance of R_q. The rotar model is more complex than this and part of the quantum wave that forms the rotar extends beyond the quantum radius. For example, it will be shown later that the rotar's electric field and gravity are the result of the rotar's wave structure that extends far beyond the quantum radius. However, the energy in the electric and gravitational fields beyond R_q contains less than 1% of the rotar's total energy. The use of R_q can be thought of as a convenient mathematical tool to easily represent the entire rotar in simple calculations.

Angular Momentum Test: The next test of the model is to see if the model has approximately the correct angular momentum. We will build on the energy calculation and test to see if the angular momentum $\mathcal{L}$ of this rotar model has the same angular momentum for all fundamental particles regardless of mass/energy and furthermore whether this angular momentum is equal to $\hbar$ when numerical factors near 1 are ignored.

$\mathcal{L} = pr$ set: $p =$ momentum $= E/c = mc$ and $r = R_q = \hbar/mc$;
$\mathcal{L} = mc(\hbar/mc) = \hbar$

Mass cancels and all mass/energy has the same angular momentum. It is actually possible to rationalize an answer closer to ½ $\hbar$ by the following reasoning. Another way of calculating angular momentum is to use $\mathcal{L} = \mathbb{I}\omega$ where $\mathbb{I}$ is the moment of inertia. If we only had energy traveling at the speed of light around a circle (a hoop) of radius R_q, (for example, light in a waveguide) then we should use the moment of inertia of a hoop ($\mathbb{I} = mr^2$). However, the dipole wave is diffuse and as shown in figure 5-2, there is also a "grav field" filling the center of the quantum volume.

In chapter 8 it will be shown that the energy density contained in the strongest part of the rotating grav field is exactly the same as the energy density contained in the strongest part of the rotating dipole wave. In fact, the grav field is a fundamental part of the dipole wave and energy is just being transferred between these two states. This means that the energy density is relatively evenly distributed across the quantum volume and the moment of inertia of a rotar is most closely approximately by the moment of inertia for a disk: ($\mathbb{I} = \tfrac{1}{2} mr^2$).

$\mathcal{L} = \mathbb{I}\omega$ set: $\mathbb{I} = \tfrac{1}{2} mr^2 = \tfrac{1}{2} mR_q^2$ $\omega = c/R_q$ $R_q = \hbar/mc$

$\mathcal{L} = (\tfrac{1}{2} mR_q^2)\left(\frac{c}{R_q}\right) = (\tfrac{1}{2} mc)\left(\frac{\hbar}{mc}\right)$ note that mass cancels

$\mathcal{L} = \tfrac{1}{2}\hbar$

This is a much more complicated problem that can only be solved accurately with a more advanced model and a rigorous analysis. However, this is a successful plausibility test. The proposed model inherently incorporates angular momentum into the structure of a rotar. Furthermore, the proposed model explains why particles of different mass/energy all have the same angular momentum. A rotar with a relatively large mass/energy has a relatively small quantum radius. The combination always produces the same angular momentum.

The standard model assumes that all fundamental particles are virtually point particles. For example, string theory has a one dimensional vibrating string that is roughly Planck length long. This can be considered a point particle. However, the concept of a point particle is incompatible with a conceptual understanding of how fundamental particles can exhibit any angular momentum. Therefore, students are told that fundamental particles possess "intrinsic angular momentum". If there is any objection, it is answered with a statement that the student must move beyond classical physics where concepts were conceptually understandable and embrace quantum mechanics with its many counter intuitive concepts. The real problem appears to be that the teacher was giving the student the wrong model of a fundamental particle. The spacetime based model makes quantum mechanics conceptually understandable.

Molecules also possess quantized angular momentum, but in the case of molecules it is easy to prove that this quantized angular momentum results from the physical rotation of the molecule. There are other examples of quantized angular momentum involving the rotation of physical objects such as the quantized vortices that form in superfluid liquid helium. The point is that the angular momentum is physical. There is no need to invoke the abstract concept of an object possessing "intrinsic angular momentum" in these cases. Something external is enforcing this quantization of angular momentum. The spacetime based model proposed here attributes this enforcement to all matter (fundamental particles, molecules, etc.) being immersed in a sea of superfluid vacuum energy. This spacetime based model also gives a conceptually understandable explanation of how a fundamental particle such as an electron can possess angular momentum. The electron is a rotating disturbance in spacetime with a physical size that gives conceptually understandable angular momentum. The concept that a point particle can possess angular momentum is an admission that the model being used is inadequate.

Dipole Moment: Not only does the proposed rotar model give the same angular momentum to all rotars, the rotar model also specifies that all rotars have the same dipole moment d_m. The dipole moment of a rotar is the dipole amplitude times the quantum radius. We will calculate the value of the dipole moment shared by all rotars.

$$d_m = H_\beta R_q = \sqrt{\frac{Gm^2}{\hbar c}} \left(\frac{\hbar}{mc}\right) = \sqrt{\frac{\hbar G}{c^3}}$$ d_m = dipole moment H_β - see explanation below

$$d_m = L_p$$ L_p = dynamic Planck length

A dipole made of two electrically charged particles has a dipole moment with units of Coulomb meters. However, a spacetime dipole has a dipole moment with units of just meters because H_β is a dimensionless number. Rotars with a large mass have a large value of H_β, but this is offset by a small quantum radius R_q. Therefore, all rotars have the same dipole moment of dynamic Planck length L_p.

Quantum Amplitude Equalities: The strain amplitude H_β of the spacetime wave inside the quantum volume of a rotar is an important dimensionless number for a rotar that has been designated with the symbol H_β. This symbol was chosen because it is amplitude that affects the rate of time and proper volume with similarities to gravitational magnitude β. The above calculation used the substitution that $H_\beta = L_p/R_q$, but there are several other ways of expressing this strain amplitude.

$$H_\beta = L_p/R_q = T_p\omega_c = \sqrt{Gm^2/\hbar c} = m/m_p = E_i/E_p = \omega_c/\omega_p = \sqrt{R_s/R_q} = \sqrt{P_c/P_p}$$

E_i = internal energy of a rotar (mc^2 energy)
R_s = classical Schwarzschild radius $\quad R_s = Gm/c^2$
P_c = circulating power $\quad P_c = E_i\,\omega_c = \omega_c^2\hbar$ (explained later)
The symbols m_p, ω_p, E_p, and P_p are Planck mass, Planck energy and Planck power. They are defined further in the table below.

To help convey the significance of this string of equalities, I will use an electron for a numerical example. The mass of an electron is: $m_e = 9.1094 \times 10^{-31}$ kg

Electron's Characteristics

$R_q = \hbar/mc = c/\omega_c = 3.8616 \times 10^{-13}$ m	quantum radius
$\omega_c = mc^2/\hbar = c/R_q = 7.7634 \times 10^{20}$ s^{-1}	Compton angular frequency
$E_i = mc^2 = \hbar\omega_c = 8.1871 \times 10^{-14}$ J	internal energy
$P_c = E_i\,\omega_c = \omega_c^2\hbar = 6.356 \times 10^{7}$ w	circulating power (explained below)

$H_\beta = \sqrt{Gm^2/\hbar c}$	$= 4.185 \times 10^{-23}$	quantum amplitude
$L_p/R_q = 1.616 \times 10^{-35}/3.8616 \times 10^{-13}$	$= 4.185 \times 10^{-23}$	quantum radius
$\omega_c T_p = \omega_c/\omega_p = 7.76 \times 10^{20}/1.855 \times 10^{43}$	$= 4.185 \times 10^{-23}$	Compton frequency
$m/m_p = 9.109 \times 10^{-31}/2.176 \times 10^{-8}$	$= 4.185 \times 10^{-23}$	mass
$E_i/E_p = 8.187 \times 10^{-14}/1.956 \times 10^{9}$	$= 4.185 \times 10^{-23}$	energy
$\sqrt{R_s/R_q} = (6.76 \times 10^{-58}/3.86 \times 10^{-13})^{1/2}$	$= 4.185 \times 10^{-23}$	Schwarzschild radius
$\sqrt{P_c/P_p} = (6.36 \times 10^{7}/3.63 \times 10^{52})^{1/2}$	$= 4.185 \times 10^{-23}$	circulating power
$(U_q/U_p)^{1/4} = (1.42 \times 10^{24}/4.64 \times 10^{113})^{1/4}$	$= 4.185 \times 10^{-23}$	energy density
$(A_q/A_p)^{1/2} = (9.74 \times 10^{6}/5.58 \times 10^{51})^{1/2}$	$= 4.185 \times 10^{-23}$	grav acceleration

$(g_q/A_p)^{1/3} = (4.08 \times 10^{-16}/5.58 \times 10^{51})^{1/3} \quad = 4.185 \times 10^{-23}$ gravitational acceleration at R_q

It is amazing that the dimensionless number H_β that represents the strain amplitude of a rotar is related to so many rotar properties. These include the rotar's mass, energy, Compton frequency, Schwarzschild radius, quantum radius and circulating power (defined below). These properties can also be expressed in Planck units. Symbols written in bold and underlined such as $\underline{\boldsymbol{m}}$ and $\underline{\boldsymbol{R}}_q$ will represent values expressed in dimensionless Planck units. For example $\underline{\boldsymbol{m}} = m/m_p$. Using this designation, H_β has the following equalities:

$H_\beta = \underline{\boldsymbol{m}} = \underline{\boldsymbol{\omega}}_c = \underline{\boldsymbol{E}}_i = 1/\underline{\boldsymbol{R}}_q = \underline{\boldsymbol{P}}_c^{1/2} = \underline{\boldsymbol{A}}_q^{1/2} = \underline{\boldsymbol{U}}_q^{1/4}$ dimensionless rotar constant in Planck units

Each fundamental rotar has a single dimensionless number that expresses all of a rotar's unique properties. Angular momentum and charge are shared properties. For example, an electron, muon and tauon all have the same angular momentum and charge. The unique values of quantum strain amplitude H_β for an electron, muon and the tauon are:

$H_\beta = 4.18 \times 10^{-23}$ electron's amplitude, Planck frequency, mass, energy and inverse size
$H_\beta = 8.66 \times 10^{-21}$ muon's amplitude, Planck frequency, mass, energy and inverse size
$H_\beta = 1.46 \times 10^{-19}$ tauon's amplitude, Planck frequency, mass, energy and inverse size

Maximum Amplitude Rotar: Out of curiosity, let's calculate the mass of the rotar that has the maximum possible amplitude which is a quantum amplitude of $H_\beta = 1$.

$H_\beta = \sqrt{Gm^2/\hbar c}$ substitute $H_\beta = 1$ and square both sides
$1 = Gm^2/\hbar c$
$m = \sqrt{\hbar c/G} = m_p$ $H_\beta = 1$ when the mass equals the Planck mass (m_p).

Therefore, the proposed rotar model has Planck mass as the natural basis. However, $H_\beta = 1$ not only represents a rotar with Planck mass, but because of the above equalities, $H_\beta = 1$ also represents a rotar with Planck angular frequency ω_p, and a rotar with a quantum radius equal to Planck length l_p. Going even further, a rotar with $H_\beta = 1$ also has a circulating power equaling Planck power P_p, an internal energy equal to Planck energy E_p, and an energy density equal to Planck energy density U_p. If there were such a thing as a "Planck rotar", this proposed rotar model would have the Planck rotar as the natural basis. Here is a table of Planck conversions.

Planck Conversions

l_p = Planck length	$l_p = ct_p = \sqrt{\hbar G/c^3}$	1.616×10^{-35} m
m_p = Planck mass	$m_p = \sqrt{\hbar c/G}$	2.176×10^{-8} kg
t_p = Planck time	$t_p = l_p/c = \sqrt{\hbar G/c^5}$	5.391×10^{-44} s
q_p = Planck charge	$q_p = \sqrt{4\pi\varepsilon_o\hbar c}$	1.876×10^{-18} Coulomb
E_p = Planck energy	$E_p = m_p c^2 = \sqrt{\hbar c^5/G}$	1.956×10^{9} J
ω_p = Planck angular frequency	$\omega_p = 1/t_p = \sqrt{c^5/\hbar G}$	1.855×10^{43} s^{-1}
F_p = Planck force	$F_p = E_p/l_p = c^4/G$	1.210×10^{44} N
P_p = Planck power	$P_p = E_p/t_p = c^5/G$	3.628×10^{52} w
U_p = Planck energy density	$U_p = E_p/l_p^3 = c^7/\hbar G^2$	4.636×10^{113} J/m^3
$\mathbb{P}_p$ = Planck pressure	$\mathbb{P}_p = F_p/l_p^2 = c^7/\hbar G^2$	4.636×10^{113} N/m^2 (= U_p)
ρ_p = Planck density	$\rho_p = m_p/l_p^3 = c^5/\hbar G^2$	5.155×10^{96} kg/m^3
A_p = Planck acceleration	$A_p = c/t_p = \sqrt{c^7/\hbar G}$	5.575×10^{51} m/s^2
V_p = Planck voltage	$V_p = E_p/q_p = \sqrt{c^4/4\pi\varepsilon_o G}$	1.043×10^{27} V
Z_p = Planck impedance	$Z_p = \hbar/q_p^2 = 1/4\pi\varepsilon_o c$	29.98 Ω

Planck units are the natural units to use for a model of the universe based on the properties of spacetime. For example, Planck length is the minimum unit of length in spacetime. Planck time is the minimum unit of time and Planck energy is the maximum energy that spacetime can incorporate into a single dipole wave with quantized angular momentum. When a unit of time, length, energy, etc. is expressed in dimensionless Planck units, it represents the ratio of the particular quantity to the maximum or minimum that spacetime can support. Special attention will be given into the significance of Planck force: $F_p = c^4/G \approx 1.2 \times 10^{44}$ Newton. One of the many insights obtained from Einstein's field equation is that the universe has a limit to the maximum possible force that can be exerted and this limiting force is equal to Planck force[1],[2]. (This ignores a numerical factor near 1.) The equations of general relativity deviate from Newtonian gravitational physics in strong gravity partly because of the existence of a maximum possible force which introduces nonlinearity. Therefore, general relativity and quantum mechanics agree on the significance of Planck force. It is often said that Planck units are the "natural" units of the universe. This is particularly true if the universe is only spacetime and we are attempting to construct all matter, forces and cosmology out of

[1] T. Jacobson, "Thermodynamics of Spacetime: The Einstein Equation of State." Phys.Rev. Lett. ***75***, 1260 (1995)
[2] G. W. Gibbons, "The Maximum Tension Principle in General Relativity." Found. Phys. ***32***, 1891 (2002) http://arxiv.org/pdf/hep-th/0210109.pdf

spacetime. We would expect that expressing various concepts relating to particles and forces in Planck units would lead to simplifications and give important insights.

Circulating Power: A rotar's internal energy is confined energy made of dipole waves in spacetime that are moving at the speed of light. Therefore, there is a specific amount of circulating power in any rotar. The circulating power (P_c) in an isolated rotar is the rotar's internal energy E_i times the rotar's Compton angular frequency ω_c. This is the momentary power that would leave the rotar's quantum volume if the circulating wave (rotating dipole) dissipated by all points in the wave traveling in straight lines. The wave would expand beyond the quantum radius in a time equal to $1/\omega_c$.

$P_c = E_i\,\omega_c = \omega_c^2\hbar = m^2c^4/\hbar = E_i^2/\hbar$ $\quad$ P_c = circulating power

An isolated electron's circulating power is about 63.56 million watts. $(8.2 \times 10^{-14}\ \text{J})^2/\hbar$ This high circulating power can be understood when it is realized that the electron's internal energy (8.2×10^{-14} J) is multiplied by the electron's Compton angular frequency ($7.8 \times 10^{20}\ \text{s}^{-1}$). The concept of circulating power will be important when we consider forces. For future reference, we will calculate the value of circulating power in Planck units by dividing conventional power by Planck power ($P_p = c^5/G$).

$\underline{\mathbf{P}}_c = P_c/P_p = (m^2c^4/\hbar)(G/c^5) = Gm^2/\hbar c$ $\quad$ $\underline{\mathbf{P}}_c$ = circulating power in Planck units

Characteristics of an Electron: It is very useful to have a single table of the rotar characteristics and standard characteristics of an electron to test concepts. Therefore, the following table is provided here and in chapter 15 which is a compilation of equations and definitions.

Constants of an Electron

$H_\beta = 4.1854 \times 10^{-23}$ = electron's strain amplitude
$R_q = 3.8616 \times 10^{-13}$ m = electron's quantum radius
$\omega_c = 7.7634 \times 10^{20}\ \text{s}^{-1}$ = electron's Compton angular frequency
$\upsilon_c = 1.2356 \times 10^{20}$ Hz = electron's Compton frequency
$P_c = 6.356 \times 10^7$ w = electron's circulating power
$F_m = 0.21201$ N = electron's maximum force at distance of R_q
$R_s = 6.7635 \times 10^{-58}$ m = electron's classical Schwarzschild radius
$U = E_i/R_q^3 = 1.422 \times 10^{24}\ \text{J/m}^3$ = electron's energy density (cubic)
$U = (3/4\pi)E_i/R_q^3 = 3.397 \times 10^{23}\ \text{J/m}^3$ = electron's energy density (spherical)
$V = R_q^3 = 5.7584 \times 10^{-38}\ \text{m}^3$ = electron's quantum volume (cubic)
$A_g = 9.7413 \times 10^6\ \text{m/s}^2$ = electron's grav acceleration at center of quantum volume
$m_e = 9.1094 \times 10^{-31}$ kg = electron's mass

E_i = 8.1871 x 10^{-14} J = electron's energy
e = 1.6022 x 10^{-19} Coulomb = electron's charge

Forces

We are next going to examine the strong force, the electromagnetic force and the gravitational force between two of the same rotars. The only force exerted by dipole waves in spacetime is the relativistic force ($F_r = P_r/c$). Therefore, we would expect that the force between particles should be a simple function of the rotar's circulating power. Initially, we will examine the forces exerted under the simplest condition for the rotar model of fundamental particles. The forces will be calculated between two of the same rotars separated by the rotar's natural unit of length – separated by R_q. In later chapters we will examine other distances, but the spacetime based rotar model presented thus far only is able to define the characteristics at a distance equal to the rotar's quantum radius R_q. It is reasonable that if the spacetime based model is correct, then the simplest separation distance would be R_q, the rotar's natural unit of length. Recall that the quantum radius is also equal to the fundamental particle's reduced Compton wavelength ($R_q = \lambda\!\!\!^{-}_c$). Calculations at arbitrary distance involve an additional consideration of how waves in the external volume of a rotar fall off with distance. Initially limiting the separation distance just to R_q (the quantum radius) involves the fewest assumptions. We know the strain amplitude of a rotar at this distance is: $H = H_\beta = T_p\omega_c = L_p/R_q$. Therefore, this fundamental test condition will be used exclusively for the remainder of this chapter.

Theoretical Maximum Force: We will begin this examination of forces by asking a simple question. Is there a theoretical maximum force that a fundamental rotar with a known energy can generate at a particular distance? This question considers only the energy of a rotar and the distance. Other characteristics of the rotar will determine whether the rotar can actually interact and achieve anything close to the theoretical maximum force. At this early stage of development of forces we are dealing with the relativistic force in its simplest form. Since the relativistic force is only repulsive, it follows that a simplified model of the theoretical maximum force will describe a repulsive force. Later the model will be expanded and eventually yield the strong force which is an attracting force with asymptotic freedom characteristics. For now we are merely logically following the narrow path associated with the starting assumption.

The standard model describes the strong force (the strong interaction) as the exchange of gluons between quarks. There are subtleties in this exchange that are explained by invoking color charge and quantum chromodynamics (QCD). We are starting from first principles and so far know nothing about gluons, etc. We only know the simplified rotar model presented so far. We have a dipole wave in spacetime that possesses quantized angular momentum and a specific amount of energy. The dipole wave is propagating at the speed of light in a closed loop one wavelength in circumference. This concept defines a specific rotational frequency and a specific amount of circulating power.

Maximum Force from Circulating Power: We will first use the concept of circulating power P_c of a fundamental rotar. Previously; it was found that the rotar model implies that every rotar can be considered to have a circulating power equal to:

$P_c = E_i\omega_c = \omega_c^2\hbar = \hbar c^2/R_q^2$ P_c = circulating power of a rotar inside R_q

Previously we concluded that the starting assumption (the universe is only spacetime) implied that there is only one truly fundamental force – the relativistic force $F_r = P_r/c$. The strongest force that a fundamental rotar can exert at distance R_q will occur if all of a rotar's circulating power is deflected (set $P_r = P_c$). This presumes two of the same rotars, each with internal energy of E_i. Only quarks are actually capable of exerting something close to this maximum force, but it is still possible to calculate the theoretical maximum force that any rotar can generate if all the rotar's circulating power is deflected. This is equivalent to saying that some rotars cannot deflect all the circulating power at a separation distance of R_q, but it is possible to calculate the maximum force that would be generated if all the circulating power was deflected. We take the relativistic force equation $F_r = P_r/c$ and set $F_r = F_m$ and $P_r = P_c = \hbar c^2/R_q^2$.

$F_m = P_c/c = \hbar c/R_q^2 = m^2c^3/\hbar = E_i^2/\hbar c = H_\beta^2 F_p$ F_m = rotar's maximum force at distance R_q

Later we will compare this value of the maximum possible force at R_q to the electrostatic force at this distance to see if it is reasonable. However, first I want to explain a qualification on the physical interpretation of this maximum force $F_m = E_i^2/\hbar c$. This equation represents the maximum force that can be exerted if two of the same rotars are held stationary at a distance equal to their quantum radius R_q. If two rotars are colliding at relativistic velocity, then a greater force can be generated because kinetic energy is converted to increase the rotar's internal energy E_i at the instant of collision. This momentarily increases the internal energy E_i of the colliding rotars which also momentarily increases F_m, ω_c and P_c. This increase in energy also decreases the rotar's quantum radius R_q.

For example, an electron with relativistic velocity equal to 50 GeV can temporarily convert this kinetic energy into internal energy in a collision raising the electron's internal energy from ~ 0.5 MeV to 50 GeV, a factor of about 100,000. This would momentarily decrease the electron's quantum radius by a factor of 10^5 from 3.86×10^{-13} m to 3.86×10^{-18} m. This would also increase both the circulating power and the maximum force by a factor of 10^{10}. Therefore, an electron undergoing a collision can exhibit a force greater than the theoretical maximum force calculated for an isolated electron (no collision). Trying to remove a quark from a hadron also changes the internal energy of the quark and can affect the binding force. This will be discussed later.

Maximum Force from the Wave-Amplitude Equation: We will also calculate the maximum force using the wave-amplitude equation: $F = H^2\omega^2 ZA/c$. We have previously used a similar equation to calculate the energy in a rotar. For that calculation we made the following substitutions: $H = H_\beta = L_p/R_q$; $\omega = \omega_c = c/R_q$; and $V = kR_q^3$. This time we have an area term A. Since the presumption is that we have two of the same rotars separated by R_q, this means that the interaction area would be a constant times R_q^2. ($A = kR_q^2$). There are many other numerical factors close to 1 that have been previously ignored, so we will also ignore this constant.

$F = H^2\omega^2 ZA/c$ set: $H = H_\beta = L_p/R_q$; $\omega = \omega_c = c/R_q$; $Z = Z_s = c^3/G$; $A = R_q^2$

$$F_m = \left(\frac{L_p}{R_q}\right)^2 \left(\frac{c}{R_q}\right)^2 \left(\frac{c^3}{G}\right)\left(\frac{R_q^2}{c}\right) \qquad \text{set: } L_p^2 = \hbar G/c^3;$$

$$F_m = \frac{\hbar c}{R_q^2} = \frac{E_i^2}{\hbar c} = \frac{\hbar\omega_c^2}{c} = \frac{m^2c^3}{\hbar} = H_\beta^2 F_p$$

In a later chapter, two competing versions of the maximum force will be shown to make up the more complex strong force between quarks. The condition known as asymptotic freedom will be analyzed and shown to result from competing maximum forces which reach equilibrium. However, a slight displacement from this equilibrium separation distance results in a net restoring force which increases with displacement and can almost reach the maximum force.

Coulomb Force: To evaluate the maximum force it is necessary to compare it to the Coulomb force (electromagnetic force) that would exist between two electrically charged rotars at the separation distance of $r = R_q$. There are actually two possible values of charge q that are interesting and we will evaluate both of them. One obvious choice is to use elementary charge e. However, the other interesting value is Planck charge $q_p = \sqrt{4\pi\varepsilon_o\hbar c} = e/\sqrt{\alpha} \approx 1.88 \times 10^{-18}$ Coulomb which is about 11.7 times larger than elementary charge e. Planck charge is actually the best choice of a unit of charge when we are comparing forces because Planck charge avoids dealing with the fine structure constant $\alpha = e^2/4\pi\varepsilon_o\hbar c \approx {}^1/_{137}$. The fine structure constant α is known to be the coupling constant relating to the strength of the electromagnetic interaction between a particle with charge e and a photon. By choosing Planck charge we are setting this coupling constant equal to 1. By eliminating the coupling constant α, we would expect that at separation distance of $r = R_q$ the electromagnetic force should be equal to the maximum force if the particle and force models described thus far are correct. The Coulomb force equation $F = q^2/4\pi\varepsilon_o\hbar c$ will be used for this critical test. We will use the force symbol F_E to specify that we are representing the electrostatic force between two Planck charges. Therefore we will make the following substitutions into the Coulomb force equation:

$$F = \frac{q^2}{4\pi\varepsilon_o r^2} \qquad \text{set: } F = F_E, \quad r = \lambda\!\!\!^{-}_c = R_q \quad q = q_p = \sqrt{4\pi\varepsilon_o\hbar c} \quad \text{and} \quad F_m = \hbar c/R_q^2$$

$$F_E = \frac{q_p^2}{4\pi\varepsilon_o R_q^2} = \frac{\hbar c}{R_q^2} = F_m$$

Therefore, this is a spectacular success. When we use Planck charge to set the coupling constant equal to 1 and $r = R_q$, then we obtain the equation that the electrostatic force equals the maximum force $F_E = F_m$.

Any time in the rest of the book that we are representing the electrostatic force generated by particles with elementary charge e, we will use the symbol F_e. The following is the first of these calculations.

$$F = \frac{q^2}{4\pi\varepsilon_o r^2} \qquad \text{set:} \quad F = F_e \quad r = \lambda_c = R_q; \quad q = e \qquad \alpha = e^2/4\pi\varepsilon_o\hbar c \quad \text{and} \quad F_m = \hbar c/R_q^2$$

$$F_e = \frac{e^2}{4\pi\varepsilon_o R_q^2} = \frac{\alpha\hbar c}{R_q^2} = \alpha F_m$$

Therefore, even using elementary charge e we obtain a connection between the electrostatic force and the maximum force, but this electrostatic force is diminished by the fine structure constant $\alpha \approx 1/137$. The fine structure constant has never been able to be mathematically derived from first principles. It has been the source of mystery for generations of theoretical physicists. Therefore, we also will merely accept this mysterious number as a coupling constant of unknown origin.

The derivation of gravity from starting assumptions starts on the next page.

Gravity

Now for the big question: Can we develop the force of gravity from first principles using the rotar model? Thus far we have discussed the fundamental dipole wave that can exist in spacetime. If we are going to be able to explain all the forces of nature with only dipole waves in spacetime, we have to examine the possibility that under some circumstances a dipole wave in spacetime may not be perfectly sinusoidal. Once again the starting assumption that the universe is only spacetime serves as a wonderful restriction. It keeps us focused on examining only the most basic properties of spacetime.

If the universe is only spacetime, we do not have many possible explanations for gravity. In fact, the only plausible possibility is that spacetime is a nonlinear medium for dipole waves in spacetime.

Optical Kerr Effect: I see a similarity between gravity and a nonlinear optical effect called the optical Kerr effect. When light passes through any transparent material, a nonlinear effect occurs. Even for wavelengths for which the material is transparent, there is a limit to the maximum intensity (maximum electric field strength) that can propagate through the material. This limit results in nonlinearity (distortion) even for intensities that are far below this limit. The oscillating electric field of the light produces a non-oscillating nonlinear effect which changes the index of refraction of the transparent material. This nonlinear effect reduces the speed of light in the transparent material in addition to the normal reduction due to the material's index of refraction at zero intensity. An expression of the optical Kerr effect is given by the following simplified equation that ignores higher order terms.

$n_k \approx n_o + k_1\mathcal{E}_\omega^2$ simplified optical Kerr effect equation

n_k = the index of refraction which includes the optical Kerr effect contribution
n_o = the normal index of refraction at zero intensity
k_1 = a nonlinear constant that depends on the transparent material
$\mathcal{E}_\omega$ = electric field strength at frequency ω

This means that the speed of light in any transparent material has a fundamental term (n_o) and a second order term ($k_1\mathcal{E}_\omega^2$). The second order term depends on the square of the alternating electric field produced by the light.

Even sunlight passing through a window produces a slight nonlinear effect in the glass. When a high peak power pulse of laser light is focused in a transparent material, the light can reach oscillating electric field strength where the optical Kerr effect increases the index of refraction to the extent that the laser beam is further concentrated and confined to a small filament. This confinement can be so great that the beam is not allowed to diverge. This effect is easily seen in glass and other solids, but it has even been demonstrated in air.

While the analogy between the optical Kerr effect and gravity is far from perfect, the point is that homogeneous materials like glass or air exhibit a nonlinearity that scales proportional to the square of the wave amplitude ($\mathcal{E}_\omega^2$). This squaring produces an effect that is always positive. In the optical Kerr effect, the index of refraction always increases.

This nonlinearity in transparent materials is associated with the fact that any transparent material has a maximum electric field strength limitation. Exceeding this maximum electric field strength will physically damage the transparent material. The most extreme form of damage is ionization of the atoms, but molecules can be decomposed at electric field strength less than the ionization threshold. This maximum field strength introduces a nonlinearity that scales with $\mathcal{E}_\omega^2$ and higher powers of $\mathcal{E}_\omega$. However, the higher powers only become significant as the limiting intensity is approached. Spacetime is also a medium that transmits waves. Is there any evidence that spacetime is a nonlinear medium?

Gravity – A Nonlinear Effect: We need to consider the force of gravity between two of the same rotars at distance R_q. If the universe is only spacetime and if there is only one truly fundamental force (the relativistic force) then dipole waves in spacetime must also cause gravity. We are therefore looking for a mechanism whereby a rotar's circulating power can be converted into a force that has only one polarity and is vastly weaker than the other forces. There is really only one reasonable choice. Gravity must be the result of spacetime being a nonlinear medium for dipole waves in spacetime.

Fifth Starting Assumption: **Spacetime is a nonlinear medium for dipole waves in spacetime. This nonlinearity ultimately produces gravity.**

The gravitational force must be the result of this nonlinearity while the other forces are a direct (linear) function of circulating power. Dipole waves in spacetime have a theoretical maximum amplitude of $H_\beta = 1$. This means that dipole waves in spacetime should also exhibit a nonlinearity that scales with H_β^2 even when $H_\beta << 1$. The strain produced by dipole waves in spacetime must have a linear term and a nonlinear term.

Strain = $H_\beta \sin\omega t + (H_\beta \sin\omega t)^2 = H_\beta \sin\omega t - \frac{1}{2} H_\beta^2 \cos 2\omega t + \boldsymbol{\frac{1}{2} H_\beta^2}$ (bold for emphasis)

The linear term is ($H_\beta\, sin\omega t$) and the nonlinear term is $(H_\beta\, sin\omega t)^2$. There are also higher order nonlinear terms but these can be ignored because H_β is a number very close to zero and any higher powers of this are insignificant. The nonlinear term has been further expanded into a weak oscillating term ($H_\beta^2 cos2\omega t$) and a non-oscillating term that is always positive (½ H_β^2). It is proposed that the strain in spacetime produced by the non-oscillating term (H_β^2 at distance R_q) is responsible for the general relativistic curvature of spacetime which results in gravity.

An analysis in chapter 8 will show how the nonlinear term $(H_\beta\ sin\omega t)^2$ leads to both gravitational attraction as well as the gravitational effect on time and distance. In this chapter we are going to start with a simplified analysis that concentrates only on the magnitude of the force exerted by the gravity of a rotar. With this limitation we again are developing an over-simplified repulsive force with the correct magnitude of gravity. This will later be improved into an attracting force that also exhibits the spatial and temporal properties of gravity. The actual force of gravity will be shown in chapter 8 to result from a strain in spacetime that produces an unbalanced force on opposite sides of a rotar.

It is easy to demonstrate that the nonlinearity of spacetime gives the correct magnitude of the gravitational force at distance R_q using a calculation that is somewhat oversimplified. Previously we were using $H = H_\beta$ as the substitution of the wave amplitude for the maximum force and other rotar properties. To prove that gravity is caused by the nonlinearity of spacetime, we will now make the nonlinear amplitude substitution $H = H_\beta^2$ into the force equation: $F = kH^2\omega^2 ZA/c$.

$F = kH^2\omega^2 ZA/c$ for gravity set: $H = H_\beta^2 = L_p^2/R_q^2$, $\omega = \omega_c$, $Z = Z_s = c^3/G$, $A = kR_q^2$

$$F_g = H_\beta^4 \omega_c^2 Z_s A/c = \left(\frac{L_p^4}{R_q^4}\right)\left(\frac{c^2}{R_q^2}\right)\left(\frac{c^3}{G}\right)\left(\frac{R_q^2}{c}\right) = \left(\frac{\hbar^2 G^2}{c^6}\right)\left(\frac{m^2c^2}{\hbar^2}\right)\left(\frac{1}{R_q^2}\right)\left(\frac{c^4}{G}\right)$$

$F_g = \dfrac{Gm^2}{R_q^2}$ magnitude of the gravitational force between 2 particles of mass m at distance R_q

Even though this is oversimplified, I find this calculation very exciting! We obtain the Newtonian gravitational force equation starting with rotating dipole waves in spacetime. It was not necessary to make an analogy to acceleration. This particular calculation was for two of the same rotars at a separation distance of R_q, but eventually we will be able to broaden this to the more general case of any mass/energy at any distance. Furthermore, the model will be improved and result in this being an attracting force. To my knowledge, this is the first time that the gravitational force has ever been calculated from conceptually understandable first principles. There were no vague analogies to restraining a mass from following a geodesic.

This implies that gravity is really a force and not the result of the geometry of spacetime. Static curved spacetime is the result of dynamic (oscillating) curved spacetime exhibiting a nonlinear effect. In chapter 4 we described how the quantum mechanical model of spacetime possesses elasticity, impedance, energy density, etc. Introducing matter (dipole waves with quantized angular momentum) into this homogeneous medium produces distortion which has both a linear and a nonlinear component. Gravity is the nonlinear component. From the above calculation it is not hard to see that eventually we will obtain the Newtonian equation: $F = Gm_1m_2/r^2$. Even though this is a successful plausibility calculation, in chapter 8 it will be shown to be an oversimplification that gets the magnitude correct but the vector wrong. Additional steps will be introduced to obtain the complete picture. It should be recognized that for single particles the Newtonian gravitational equation can be considered exact. General relativity differs from Newtonian gravity because general relativity incorporates nonlinearities including a maximum possible force (Planck force). While this book does not carry this model to the strong gravity limit, it appears that a mature model incorporating nonlinear terms would be compatible with general relativity. In fact, chapters 8 and 10 discuss subtleties that go further than general relativity.

Review: We have just calculated a simplified version of Newton's gravitational equation from a set of starting assumptions. The steps that brought us to this point will be briefly reviewed.

The key assumptions are:

1) The universe is only spacetime.
2) Dipole waves in spacetime are permitted by quantum mechanics provided that the displacement of spacetime does not exceed the Planck length/time limitation.
3) Energy in any form is fundamentally made of dipole waves in spacetime propagating at the speed of light.
4) There is only one fundamental force: the relativistic force. This force occurs when waves in spacetime, propagating at the speed of light, are deflected.
5) Fundamental particles are dipole waves in spacetime that form a rotating dipole, one wavelength in circumference that possesses circulating power.
6) Spacetime is a nonlinear medium for dipole waves in spacetime. This nonlinearity ultimately produces gravity.

Waves in spacetime are like sound waves propagating in the medium of spacetime. Spacetime has an impedance ($Z_s = c^3/G$) and the force generated by deflecting waves in spacetime is: $F = H^2\omega^2 Z_s A/c$ where H is amplitude and A is area. Assumption #6 says that spacetime is a nonlinear medium. This nonlinear effect can be considered the source of a new nonlinear wave that has strain amplitude that is the square of the amplitude of the fundamental wave amplitude: $H_\beta^2 = H_{\beta g} = L_p^2/R_q^2$. Inserting this amplitude into the force equation above yields $F_g = Gm^2/R_q^2$ which is a simplified version of Newton's gravitational equation that assumes two of the same mass particles at distance R_q (dimensionless constants near 1 ignored).

Connection Between the Forces and Circulating Power: If the forces of nature are caused by the interaction of waves in spacetime, then there should be a simple relationship between the force and the circulating power (P_c). I previously proposed that there is only one truly fundamental force in nature – the relativistic force ($F_r = P_r/c$). This is the repulsive force exerted when relativistic power (power propagating at the speed of light) is "deflected" which includes absorbed and reflected. For this to appear to be an attracting force this interaction must include pressure (repulsive force) exerted by vacuum energy. This is discussed in chapter 8. However, in all cases a force generated by a rotar must be related to both the circulating power and the quantum radius of the rotar. Furthermore, since gravity is the result of nonlinearity, we would expect that the gravitational force would be a function of P_c^2 while the other forces would be a linear function of P_c.

We are therefore going to perform a critical test of the rotar model and the concept of a single fundamental force. There is no single rotar that exhibits all three of the following properties: elementary charge, the strong force and gravity. Quarks and the charged leptons only exhibit 2 of the 3 properties. However, it is possible to calculate the magnitude of these three forces as if they were possessed by a single pair of the same rotars separated by a distance equal to their quantum radius. We will also be assuming the hypothetical case of two particles with Planck charge in some of the following calculations.

This critical test will examine whether there is an easy to understand relationship between the magnitudes of the forces (F_m, F_E, F_e, F_g) and the circulating power P_c of the rotar causing the force. This comparison will be done using the natural Planck units of force and power (bold and underlined indicates Planck units – $\underline{\boldsymbol{F}}_m$, $\underline{\boldsymbol{F}}_E$, $\underline{\boldsymbol{F}}_e$, $\underline{\boldsymbol{F}}_g$, and $\underline{\boldsymbol{P}}_c$). Initially, all comparisons will be made at the rotar's natural unit of length, its quantum radius $R_q = c/\omega_c = \hbar/mc$.

Substitutions that will be used:

$$r = R_q = \frac{\hbar}{mc}; \quad F_m = \left(\frac{m^2c^3}{\hbar}\right); \quad F_p = \frac{c^4}{G}; \quad P_c = \left(\frac{m^2c^4}{\hbar}\right); \quad P_p = \frac{c^5}{G}; \quad \frac{q_p^2}{4\pi\varepsilon_o} = \hbar c, \quad \frac{e^2}{4\pi\varepsilon_o} = \alpha\hbar c;$$

$$\underline{\boldsymbol{F}}_g = \frac{F_g}{F_p} = \left(\frac{Gm^2}{R_q^2}\right)\left(\frac{G}{c^4}\right) = Gm^2\left(\frac{m^2c^2}{\hbar^2}\right)\left(\frac{G}{c^4}\right) = \left(\frac{G\,m^2}{\hbar c}\right)^2$$

$$\underline{\boldsymbol{F}}_m = \frac{F_m}{F_p} = \left(\frac{m^2c^3}{\hbar}\right)\left(\frac{G}{c^4}\right) = \frac{Gm^2}{\hbar c}$$

$$\underline{\boldsymbol{F}}_E = \frac{F_E}{F_p} = \left(\frac{q_p^2}{4\pi\varepsilon_o R_q^2}\right)\left(\frac{G}{c^4}\right) = (\hbar c)\left(\frac{mc}{\hbar}\right)^2\left(\frac{G}{c^4}\right) = \frac{Gm^2}{\hbar c}$$

$$\underline{\boldsymbol{F}}_e = \frac{F_e}{F_p} = \left(\frac{e^2}{4\pi\varepsilon_o R_q^2}\right)\left(\frac{G}{c^4}\right) = (\alpha\hbar c)\left(\frac{mc}{\hbar}\right)^2\left(\frac{G}{c^4}\right) = \alpha\left(\frac{Gm^2}{\hbar c}\right)$$

$$\underline{\boldsymbol{P}}_c = \frac{P_c}{P_p} = \left(\frac{m^2c^4}{\hbar}\right)\left(\frac{G}{c^5}\right) = \frac{Gm^2}{\hbar c}$$

Since all of these are related to $Gm^2/\hbar c$, we obtain simple relationships between forces and circulating power when we are dealing with two of the same rotars with charge e and separated by a distance R_q. Recall that the concept of a single relativistic force says that there should be an easy to understand relationship between force and circulating power.

$\underline{\boldsymbol{F}}_m = \underline{\boldsymbol{P}}_c$ $\underline{\boldsymbol{F}}_m$ = maximum force in Planck units (closely related to the strong force)
$\underline{\boldsymbol{F}}_E = \underline{\boldsymbol{P}}_c$ $\underline{\boldsymbol{F}}_E$ = electromagnetic force in Planck units (Planck charge q_p)
$\underline{\boldsymbol{F}}_e = \alpha\underline{\boldsymbol{P}}_c$ $\underline{\boldsymbol{F}}_e$ = electromagnetic force in Planck units (elementary charge e)
$\underline{\boldsymbol{F}}_g = \underline{\boldsymbol{P}}_c^2$ $\underline{\boldsymbol{F}}_g$ = gravitational force in Planck units

This is a spectacular success that strongly supports the spacetime based model of forces. This simplification of relationships occurs at the spacetime based model's fundamental unit of length (the reduced Compton wavelength). The maximum force deflects all of the circulating power ($\underline{\boldsymbol{F}}_m = \underline{\boldsymbol{P}}_c$). The electromagnetic force also deflects all the circulating power if we assume Planck charge $\underline{\boldsymbol{F}}_E = \underline{\boldsymbol{P}}_c$ but elementary charge e only deflects about $^1/_{137}$ of the circulating power and is therefore about 137 times weaker ($\underline{\boldsymbol{F}}_e = \alpha\underline{\boldsymbol{P}}_c$). However, forces $\underline{\boldsymbol{F}}_m$ $\underline{\boldsymbol{F}}_E$ and $\underline{\boldsymbol{F}}_e$ are similar because they all scale linearly with circulating power (scale with $\underline{\boldsymbol{P}}_c^1$). Gravity is different because it is the result of a nonlinear effect and scales proportional to $\underline{\boldsymbol{P}}_c^2$. When circulating power is expressed in Planck units it is always a dimensionless number close to zero. Therefore squaring this number produces a number even closer to zero. The weakness of gravity compared to the other forces is due to the difference between $\underline{\boldsymbol{P}}_c$ and $\underline{\boldsymbol{P}}_c^2$. The analysis of gravity will continue in chapter 8, but gravity is the result of spacetime being a nonlinear medium that scales with amplitude squared which in turn results in a $\underline{\boldsymbol{P}}_c^2$ scaling of the gravitational force.

We can also relate the rotar's Compton angular frequency $\underline{\boldsymbol{\omega}}_c$, energy density $\underline{\boldsymbol{U}}_q$ and strain amplitude H_β to the forces between two of the same rotars separated by distance R_q when terms are expressed in Planck units. Again we show the relationship to $Gm^2/\hbar c$.

$$\underline{\boldsymbol{\omega}}_c = \omega_c/\omega_p = \left(\frac{mc^2}{\hbar}\right)\sqrt{\frac{\hbar G}{c^5}} = \sqrt{\frac{Gm^2}{\hbar c}}$$

$$\underline{\boldsymbol{U}}_q = U_q/U_p = \left(\frac{m^4c^5}{\hbar^3}\right)\left(\frac{\hbar G^2}{c^7}\right) = \left(\frac{Gm^2}{\hbar c}\right)^2$$

$$H_\beta = L_p/R_q = \sqrt{\frac{\hbar G}{c^3}}\left(\frac{mc}{\hbar}\right) = \sqrt{\frac{Gm^2}{\hbar c}}$$

Combining all of these we obtain:

$$\underline{F}_g = \underline{F}_m^2 = \underline{F}_E^2 = (\underline{F}_e/\alpha)^2 = \underline{P}_c^2 = \underline{\omega}_c^4 = \underline{U}_q = H_\beta^4$$

This is one of the most important findings in this book. It is a series of equalities that can be rewritten as 28 individual equations. The simplicity of this series of equations is jaw dropping. It shows how the gravitational force is closely related to not only the maximum force and the electromagnetic force but also to a rotar's Compton angular frequency, circulating power, energy density and strain amplitude. It will be shown later that the strong force is actually the superposition of two variations of the maximum force. This superposition produces asymptotic freedom at R_q but a slight displacement from this separation produces a force close to the maximum force.

Just to help internalize these relationships, we will use two electrons separated by $R_q = 3.86 \times 10^{-13}$ meters as illustration. Readers are invited to substitute the following values of $\underline{F}_m$, $\underline{F}_e$, $\underline{F}_g$, $\underline{P}_c$, $\underline{E}_i$ and H_β into the above equations.

$\underline{F}_g = F_g/F_p = (Gm^2/R_q^2)/(c^4/G) = 3.07 \times 10^{-90}$

$\underline{F}_m = F_s/F_p = (\hbar c/R_q^2)/(c^4/G) = 1.75 \times 10^{-45}$

$\underline{F}_e = F_e/F_p = (e^2/4\pi\varepsilon_o R_q^2)/(c^4/G) = 1.28 \times 10^{-47}$

$\underline{P}_c = P_c/P_p = (\hbar c^2/R_q^2)/(c^5/G) = 1.75 \times 10^{-45}$

$\underline{\omega}_c = \omega_c/\omega_p = (mc^2/\hbar)(\hbar c^5/G)^{1/2} = 4.19 \times 10^{-23}$

$\underline{U}_q = U_q/U_p = (m^4c^5/\hbar^3)(\hbar G^2/c^7) = 3.07 \times 10^{-90}$

$H_\beta = (Gm^2/\hbar c)^{1/2} = 4.19 \times 10^{-23}$

Support for the Spacetime Based Model: The relationships enumerated in the multiple equations $\underline{F}_g = \underline{F}_m^2 = \underline{F}_E^2 = (\underline{F}_e/\alpha)^2 = \underline{P}_c^2 = \underline{\omega}_c^4 = \underline{U}_q = H_\beta^4$ make a strong statement about the accuracy of the spacetime based model of fundamental particles. The forces in this equation assumed a separation distance of $R_q = ƛ_c = c/\omega_c$. It will also be shown later that the simple force relationship between fundamental particles extends for larger separation distance when that distance is expressed in multiples of R_q. This is the natural unit of length for a spacetime based model of fundamental particles, but this distance has no significance if forces are assumed to result from the exchange of virtual photons, gluons and gravitons. **The fact that the forces have a simple relationship at the separation distance that is the natural unit of length of the spacetime based model offers strong support for the spacetime based model of fundamental particles.**

Force Equations Between Two Planck Charge Particles: One pairing of the above multiple force equations should be called out for particular attention.

$\underline{\boldsymbol{F}}_g = \underline{\boldsymbol{F}}_E{}^2$

This is an amazing relationship that needs to be stated in words for full effect. Assuming a separation distance of $r = ƛ_c = R_q$ and $q = q_p$ and Planck units, the gravitational force equals the square of the electrostatic force. A numerical example helps to internalize this equation. Suppose we assume two particles, each with the mass of an electron ($m = m_e \approx 9.1 \times 10^{-31}$ kg) but with Planck charge ($q = q_p$). Then: $\underline{\boldsymbol{F}}_E = F_E/F_p = (q_p{}^2/4\pi\varepsilon_o R_q{}^2)/(c^4/G) = 1.75 \times 10^{-45}$ and:

$3.07 \times 10^{-90} = (1.75 \times 10^{-45})^2$ (numerical example illustrates $\underline{\boldsymbol{F}}_g = \underline{\boldsymbol{F}}_E{}^2$)

The equation $\underline{\boldsymbol{F}}_g = \underline{\boldsymbol{F}}_E{}^2$ for two hypothetical Planck charge particles is a clear example that there is a fundamental connection between the gravitational force and the electrostatic force. The use of Planck charge rather than elementary charge e eliminates the coupling constant α, and effectively sets the coupling constant equal to 1. Another way of saying this is that assuming Planck charge makes the electrostatic force equal the maximum force. Planck charge is the best assumption if we want to compare the electromagnetic force to the gravitational force.

While the relationship between the forces is easiest to see when we use Planck units, there is another way to look at the relationship between the forces using force expressed using SI units of Newton. Imagine a log scale of force represented by a horizontal line. The largest force from general relativity and the constants of nature is Planck force $F_p = 1.21 \times 10^{44}$ Newton. We will place Planck force at one end of the log scale line. At the opposite end of this line (log scale of force) we will place the weakest force in this analysis which is the gravitational force $F_g = 3.72 \times 10^{-46}$ Newton (assuming electron mass). Finally we place the electromagnetic force on this scale (assuming Planck charge). For $q = q_p$, $m = m_e$ and $r = ƛ_c = R_q$ the electromagnetic force is $F_E = 0.212$ Newton. This electromagnetic force would be positioned exactly halfway between Planck force F_p and the gravitational force F_g on this log scale. The relationship of the gravitational force to the electromagnetic force is the same as the relationship of the electromagnetic force to Planck force. From $\underline{F}_g = \underline{F}_E{}^2$ we obtain:

$$F_g/F_E = F_E/F_p$$

Predictions: When James Maxwell derived the equation: $c = \sqrt{\frac{1}{\varepsilon_o \mu_o}}$, did this equation qualify to be called a prediction? Other parts of Maxwell's equations predict previously unknown physical effects, but this equation just shows a previously unknown relationship between c, ε_o and μ_o. Still, I am going to say that this equation also made a prediction because the new model being analyzed by Maxwell gave an unexpected connection and a very useful new insight. The fact that the prediction was easy to prove correct should not diminish its status as a prediction.

Similarly, the equation $\underline{\boldsymbol{F}}_g = \underline{\boldsymbol{F}}_m^2 = \underline{\boldsymbol{F}}_E^2 = (\underline{\boldsymbol{F}}_e/\alpha)^2 = \underline{\boldsymbol{P}}_c^2 = \underline{\boldsymbol{U}}_q = \underline{\boldsymbol{E}}_i^4 = H_\beta^4$ also shows previously unknown relationships that are easy to prove correct. Before this there was no equation expressing a fundamental relationship between the gravitational force and either the electromagnetic force or the strong force. This prediction came from the analysis of a new model, and supports the accuracy of the model.

Gravitational Wave Calculation: We will now move on to another plausibility test that can be performed on the proposed rotar model. Recall that dipole waves in spacetime have enough similarities to gravitational waves that we can use gravitational wave equations for analysis. However, we have to ignore dimensionless constants and interpret the results appropriately for dipole waves in spacetime.

There is an equation used to estimate gravitational wave amplitude (H_{gw}) at the low intensity limit where nonlinearities can be ignored. This equation can be applied to the proposed rotar model.

$H_{gw} \approx k\, G\, \omega^2 \mathbb{I} \varepsilon / c^4 r$ $\quad \mathbb{I}$ = moment of inertia, ε = asymmetry of a rotating object

This simplified equation, would normally be used to estimate the gravitational wave amplitude of a rotating rod or a binary star system. It contains an angular frequency term ω, the moment of inertia $(\mathbb{I})$ of the rotating object, the radius r of the rotating object, and a mass asymmetry term ε. For example, a spherically symmetric object would have no asymmetry $(\varepsilon = 0)$ and two equal point masses separated by $2r$ would have an asymmetry of $\varepsilon = 1$. We are going to assume that $\varepsilon \neq 0$ and the dimensionless asymmetry term ε will be included in the all-inclusive constant k. We will next convert the moment of inertia term to angular momentum.

$H_{gw} \approx k\, G\, \omega^2\, \mathbb{I}\, \varepsilon / c^4 r$ $\quad$ set: $\mathbb{I} = \mathcal{L}/\omega$, $\mathcal{L}$ = angular momentum, ε included in k
$H_{gw} = k\, G\, \omega \mathcal{L} / c^4 r$

The reason for converting to angular momentum is because we want to apply this equation to rotars. We know the angular momentum of particles as $\mathcal{L} = ½\, \hbar$. However, the ½ in this angular momentum is subject to interpretation as previously discussed. The constant, whatever its value, will be included in the general constant k. The rotar model implies that $\varepsilon \neq 0$ because the dipole core of a rotar is two lobes rotating at the speed of light. We will also lump the eccentricity term ε, into the general constant k. We will now calculate the hypothetical gravitational wave amplitude for a fundamental rotar.

$H_{gw} = k\, G\, \omega\, \mathcal{L} / c^4 r$ $\quad$ substitute: $\omega = \omega_c = c/R_q$; $\mathcal{L} = k\hbar$ and $r = R_q$

$$H_{gw} = k\, G \left(\frac{c}{R_q}\right)\left(\frac{\hbar}{c^4 R_q}\right)$$

$H_{gw} = k\, (\hbar G / c^3)\, / R_q^2$

$H_{gw} = k\, L_p^2/R_q^2 = kH_\beta^2$ we will ignore the constant k

This is another surprising connection. We take a gravitational wave equation used in cosmology and insert a rotar's angular momentum ½ $\hbar$ and Compton frequency ω_c. We then determine the gravitational wave amplitude (excluding constant) that would exist at a distance of R_q. We obtain the amplitude $H_{gw} = L_p^2/R_q^2 = H_\beta^2$. We previously determined that the nonlinearity of spacetime creates a non-oscillating strain amplitude equal to $H_\beta^2 = L_p^2/R_q^2$ in the quantum volume of a rotar. The same amplitude expression is obtained using an entirely different approach. Previously we employed reasoning based on the quantum mechanical properties of spacetime and also on spacetime being nonlinear. Now we obtain the same answer by inserting rotars properties (angular momentum and Compton frequency) into a gravitational wave equation from general relativity.

The above calculation is a success, but it also seems to imply a problem. Are all fundamental rotars continuously radiating away their energy as gravitational waves? It is true that if any arbitrary value of Compton frequency or quantum radius ($R_q = c/\omega_c$) is assumed, then there would probably be radiated power both for the fundamental wave and for the nonlinear wave with amplitude L_p^2/R_q^2. However, it is proposed that the fundamental rotars that do exist correspond to special frequency-amplitude combinations where a wave interaction occurs that cancels this radiated power. Even short lived fundamental rotars, such as the tauon (lifetime $\approx 3 \times 10^{-13}$ s), are long lived compared to the lifetime they would have if their circulating power was radiated. Since $P_c = E_i\omega_c$, the time required to radiate the rotar's internal energy E_i would be the inverse of the rotar's Compton frequency. For a tauon this would be: $1/\omega_c \approx 3 \times 10^{-25}$ second. The tauon's lifetime is about 10^{12} times longer than its $1/\omega_c$ time and is considered to be a "semi-stable particle".

There are an infinite number of possible frequencies, amplitudes and configurations that could hypothetically exist, but do not exist long enough to be considered fundamental rotars. The few frequencies that exist long enough to be considered fundamental rotars have some sort of wave interaction that constructively interferes to reinforce the rotating dipole rotar model and destructively interferes in a way that eliminates radiated energy. The bottom line is that the few fundamental rotars that exist belong to the small group of frequency-amplitude-configuration combinations that do not radiate either the fundamental dipole wave in spacetime or the nonlinear wave associated with gravity. Even though there is not continuous loss of energy, some of the rotar's energy does extend beyond the quantum volume. It will be shown that a particle's gravity and electric field are both the result of standing waves generated by a rotar interacting with the vacuum energy that surrounds a rotar. More will be said about this in chapter 8.

Gravitational Wave Radiation: Out of curiosity, we will calculate how long it would take for an electron to radiate away its internal energy if gravitational waves were being continuously radiated. We will assume a gravitational wave amplitude of $H_{gw} = L_p^2/R_q^2$ and a radiation area equal to the electron's quantum radius squared. We will use one of the 5 wave-amplitude equations that relate the power in a wave.

$P = H^2\,\omega^2\,Z\,A$ set $H = H_{gw} = L_p^2/R_q^2;\ \ \omega = \omega_c = c/R_q;\ \ Z = c^3/G;\ \ A = R_q^2$

$$P = \left(\frac{L_p^2}{R_q^2}\right)^2 \left(\frac{c}{R_q}\right)^2 \left(\frac{C^3}{G}\right) R_q^2 \;=\; \left(\frac{L_p}{R_q}\right)^4 \left(\frac{c^5}{G}\right) \qquad \text{set } c^5/G = P_p \text{ (Planck Power)}$$

$$P = \left(\frac{L_p}{R_q}\right)^4 P_p = H_\beta^4 P_p$$

To obtain a physical feel for the magnitude of this power, we will examine the gravitational wave power that would be radiated using the properties of an electron. We know that an electron must have a mechanism that cancels this radiated power.

$P = (4.18 \times 10^{-23})^4 \times 3.63 \times 10^{52}$ w $= 1.1 \times 10^{-37}$ w
$t = E_i/P = 8.18 \times 10^{-14}$ J$/1.1 \times 10^{-37}$ w set $E_i = 8.18 \times 10^{-14}$ J = electron's energy
$t \approx 7 \times 10^{23}$ s $\approx 2 \times 10^{16}$ years

Therefore, since the universe is 1.37×10^{10} years old, it would take more than one million times the age of the universe (2×10^{16} years) for an electron to radiate away its energy in gravitational waves. While this is a long time, it would be detectable because electrons in the early universe would have more energy (measured locally) than today's electrons. If up and down quarks radiated away power as gravitational waves, they would have radiate away all their energy in a time shorter than the age of the universe because of their much larger Compton frequency ω_c. The power radiated as gravitational waves scales with ω_c^4.

If rotars radiated energy with amplitude equivalent to the fundamental wave amplitude ($H_f = L_p/r$) with no cancelation mechanism from vacuum energy, then the picture changes completely. If an electron radiated away its energy in a wave at its Compton frequency and its fundamental amplitude, an electron would radiate about 63 million watts and it would survive for a time of only $1/\omega_c$ ($\sim 10^{-20}$ second). This is mentioned because it is proposed that the few fundamental rotars that exist have a cancelation mechanism (discussed later) that prevents this type of energy loss. Standing waves remain in the rotar's external volume after this cancelation. Standing waves have equal power flowing in opposite directions and therefore do not transfer energy. Only traveling waves are continuously transferring energy.

Inertia: Another test of the rotar model is whether it explains the inertia of fundamental particles. In chapter 1, we saw how energy traveling at the speed of light exhibits inertia and rest mass if it is confined to a specific volume (if the momentum vectors cancel in a rest frame of reference). This includes: confined light, hypothetical confined gravitational waves and confined dipole waves in spacetime. The rotar model has a dipole wave traveling at the speed of light in a closed loop. The translational momentum vectors in a stationary rotar add up to zero ($p = 0$). This satisfies the condition of energy propagating at the speed of light but confined to a specific volume. The momentum vectors add up to zero, therefore this model achieves rest mass and inertia as shown in chapter 1. Most important, the inertia of the rotar model exactly matches the inertia of an equal amount of energy propagating at the speed of light but confined to a limited volume.

Fiber Optic Loop: In chapter 1, we found that light circulating around a circular fiber optic loop satisfies the condition of $p = 0$ because all momentum vectors cancel. Therefore this circulating light exhibits inertia even though the light is not superimposed like the reflecting box example. For example, suppose that we accelerate a fiber optic loop in a direction parallel to the plane of the loop. Light in different parts of the loop receives different Doppler shifts. For example, light traveling with a vector component in the direction of the acceleration will increase in frequency and light traveling with a vector component in the opposite direction will decrease slightly in frequency. The resultant distribution of frequencies around the loop produces the same inertial forces on the fiber optic loop as the reflecting box received from accelerating confined light. Even if the loop is only one wavelength in circumference, there would still be the same inertial forces. If the loop is accelerated perpendicular to the rotational plane, the light would exhibit inertia by exerting a pressure difference on opposite sides of the fiber optic.

The rotating quantum dipole is similar to the example of light in a fiber optic loop, except that there is no physical wall confining the energy circulating at the speed of light. The interaction with the vacuum energy dipole waves in spacetime accomplishes the confinement.

Prediction: No Higgs Field: The explanation of inertia is an important part of the proposed rotar model. In fact, the starting assumption (the universe is only spacetime) ultimately implies that there is no Higgs field that gives inertia to all matter. In one sense, there is a similarity between the Higgs field and the quantum mechanical spacetime model proposed here. Both have very large energy density that lacks quantized angular momentum. The Higgs field has energy density of about 10^{46} J/m^3 while the quantum mechanical spacetime "field" has energy density of about 10^{113} J/m^3. While there is a big difference between these two numbers, in another sense they are similar because they both vastly exceed the "critical" energy density of the universe from general relativity and cosmology and they both have spin of zero.

However, there are also important differences. The rotar model of fundamental particles gives intrinsic inertia through a mechanism that ultimately depends on the speed of light being constant. This matches the inertia of the equivalent energy in confined photons. The Higgs mechanism gives inertia to fundamental particles that lack inertia through an external interaction. As discussed in chapter 1, there is no mechanism to match the inertia of an equivalent energy of confined photons. This is a previously unrecognized flaw in the Higgs mechanism.

Currently (September 2012), it was recently announced that the LHC experiments had found a new fundamental particle with energy of about 125 GeV. Since that is in the broad energy range previously predicted for the Higgs boson (between about 115 to 175 GeV) the assumption in the popular press is that this discovery is equivalent to discovering the standard model Higgs boson which gives inertia to other fundamental particles. QED has also been predicting the existence of a fundamental particle in this energy range without the requirement that it be a Higgs boson. However, colliding a proton and an anti-proton together produces a very messy result that can indicate the existence of a new particle but not be able to measure any of its properties. As Dr Tony Weidberg, from the University of Oxford said, "Even at a certainty level of five sigma you're very far from proving it's a Higgs particle at all, let alone a standard model Higgs. If the most plausible hypothesis is that it's a Standard Model Higgs, you have to ask 'what experiments can we do to test that hypothesis'. The answer is to measure as much detail as you can about this particle. It's much harder to do these detailed measurements than just see if there is something there."[3]

There are technical papers that analyze the types of particles that could produce the results observed at the LHC and yet not be the standard model Higgs boson with spin of zero. There are also discussions about building a linear accelerator capable of accelerating electrons and positrons to 250 GeV (the International Linear Accelerator). These collisions would produce a much cleaner result that could actually determine spin and some other properties of the new particle. In order for this 125 GeV particle to be the Standard Model Higgs boson and not just some previously unknown boson (perhaps spin 2), it must be proven to be a fundamental particle and not a composite like a pion that has spin of zero. Furthermore, it must give mass to other fundamental particles through the existence of a Higgs field.

As stated in chapter 1, the Higgs mechanism does not even recognize that the inertia of a fundamental particle such as an electron or muon must precisely match the inertia of an equal amount of energy of confined photons. The rotar model precisely matches this requirement because a rotar is also energy propagating at the speed of light in a confined volume resulting in zero momentum ($p = 0$) in a rest frame. Therefore, the prediction is that even though a new fundamental particle with energy of about 125 GeV has been found, this new particle does not have the properties required to form a Higgs field that gives inertia to other fundamental particles. The rotar model gives the correct inertia to match the internal energy of fundamental particles. Furthermore, the spacetime based model of the universe has spacetime filled with a vast energy with spin of zero. It is just not the Higgs field.

[3] http://www.bbc.co.uk/news/science-environment-18521327

Chapter 7

Virtual Particles, Vacuum Energy and Unity

Introduction: In the last chapter we were on a roll calculating a simplified version of the strong force, the electromagnetic force and the gravitational force between two of the same rotars at a fixed separation distance equal to the rotar's quantum radius R_q. In chapter 8 we will improve the model so that these forces exhibit attraction. We will also extend the calculation of the gravitational force to longer distances and include multiple rotars. However, before doing this it is necessary to lay some additional groundwork. This includes a description of virtual particle pairs, vacuum energy, asymptotic freedom and a proposed property called "unity" that permits quantized waves to exhibit particle-like properties.

In cosmology the terms "vacuum energy" and "dark energy" are often considered synonymous. This book makes a distinction between these two terms. Dark energy is a hypothetical concept that is required to fill the gap between the observed energy density of the universe and the theoretical "critical energy density". The apparent acceleration of the expansion of the universe seems to require a source of diffuse energy density (~ 6×10^{-10} J/m^3) distributed throughout the universe that counteracts gravity. This is completely different than the very large energy density (~ 10^{113} J/m^3) implied by the terms "vacuum energy" or "vacuum fluctuations". Dark energy and the cosmological constant should not be equated to vacuum energy and vacuum fluctuations.

Probabilistic Nature of Rotars: In chapter 5 figures 5-1 and 5-2 show the distortion of spacetime believed to be present in the quantum volume of a rotar. Figure 5-1 shows a dipole wave in spacetime that has formed into a closed loop, one wavelength in circumference. This wave is traveling at the speed of light around the closed loop. We previously calculated the angular momentum of this model. This motion is not in a single plane as depicted; instead it is a chaotic distortion of spacetime. Placing a rotar in a magnetic field can align the spin direction giving an expectation spin direction. However, even then almost all rotation directions are possible with different probabilities. The exception is the opposite spin direction to the expectation direction which has a probability of zero.

The chaotic nature of a rotar is due to the fact that the lobes are a slight distortion of energetic spacetime at the limit of causality. This small strain is below the quantum mechanical limit of detection. For an electron the spatial and temporal distortion produced by the rotating dipole wave is less than 1 part in 10^{22}. To a first approximation, the rotar model of an electron is an "empty" vacuum. The dipole lobes of an electron are so close to being homogeneous spacetime that the rate of time in the two lobes only differs by one second in 50,000 times the age of the universe. The spatial properties of the lobes are so homogeneous that the distortion is equivalent to distorting a sphere the size of Jupiter's orbit by the radius of a hydrogen atom.

The reason that the rotar model can achieve the $E = mc^2$ energy of the fundamental particles is the incredibly large impedance of spacetime and the large Compton frequency (~10^{20} to 10^{25} Hz) of the fundamental rotars. These lobes are propagating in a closed loop at the speed of light and interacting with vacuum energy so they are approximately confined to a volume. However, "finding the particle" means interacting with this incredibly weak distortion of spacetime in a way that a quantized unit of angular momentum is transferred. This is a probabilistic event that can happen over a substantial volume that scales with R_q. Furthermore, the chaotic nature of the rotar structure permits the rotating dipole wave to disappear from one quantum volume and reform in an adjacent location that was previously part of the rotar's external volume. The rotating dipole can also be visualized as a rotating rate of time gradient as depicted in figure 5-2.

Virtual Particle Pairs: The term "virtual particle" is commonly applied in two different ways. First, there are the virtual particles that according to the commonly accepted physics theory are the carriers of forces. For example, virtual photons supposedly carry the electromagnetic force. The other type of virtual particles is the virtual particle pairs that are continuously being created and annihilated in a vacuum. These virtual particle pairs are an integral part of quantum electrodynamics QED and quantum chromodynamics QCD. The incredible accuracy achieved by QED calculations is only possible by including all of the significant effects and contributions of virtual particle formation and annihilation on the problem being calculated. The spacetime based model proposed here explains forces as an interaction of dipole waves in spacetime including the dipole waves of vacuum energy. Therefore there is no need for the type of virtual particles that are supposedly the carriers of forces and they do not exist in this model. However, the virtual particle pairs that are continuously being created and annihilated are part of the spacetime based model. In developing a conceptually understandable description of the structure of these virtual particle pairs we are guided by the starting assumptions previously enumerated. In fact, the starting assumptions are so restrictive that only one description seems plausible.

A virtual particle pair is a counter rotating matter/antimatter pair. Counter rotating means that the quantized angular momentum is eliminated (zero spin). For an instant the proposed virtual particle model is strained spacetime that looks generally similar to the two dipole lobes depicted in figures 5-1 and 5-2. However, the lobes are not rotating. Such lobe pairs would form randomly out of the dipole waves that are responsible for vacuum energy. If we make an analogy to waves on water, then a virtual particle pair is a wave maximum and minimum separated by a distance comparable to twice the quantum radius (diameter = $2\,R_q$) of the rotar being simulated. Apparently spacetime has a resonance at conditions that correspond to the formation of virtual particle pairs that correspond to real matter-antimatter pairs such as electron/positron pairs or muon/antimuon pairs. Therefore these frequencies are preferred over random frequencies. These wave structures form and disappear from the dipole waves that form vacuum energy. Furthermore, all frames of reference have the same density of virtual particle pairs.

When such a shape forms, it momentarily can look like a particle/antiparticle pair such as an electron/positron pair or a muon/antimuon pair. However, this deception is quickly revealed. For example, with a real electron/positron pair, the two rotars should counter rotate 1 radian each (2 radians total) in a time of $1/\omega_c = \hbar/mc^2 \approx 1.3 \times 10^{-21}$ s. This means that a real electron/positron pair would counter rotate by a total of one radian in a time interval of $\Delta t = ½\,\hbar/mc^2 = 1/2\omega_c$. The two randomly formed lobes would dissipate into wavelets in a similar time period. This is the same lifetime given to virtual particle pairs by the uncertainty principle.

$$\Delta E\,\Delta t = ½\,\hbar$$

$$\Delta t = \frac{\hbar}{2\Delta E} = \frac{\hbar}{2mc^2} \qquad \text{set } \frac{1}{\omega_c} = \frac{\hbar}{mc^2}$$

$$\Delta t = \frac{1}{2\omega_c}$$

Therefore, the uncertainty principle is describing the time required for this model of a virtual particle pair to reveal itself and dissipate into other random dipole waves. It is proposed that all aspects of the uncertainty principle correspond to conceptually understandable effects resulting from a dipole wave in the spacetime based explanation of the universe.

Vacuum Energy Revisited

Chapter 4 laid the groundwork for a description of vacuum energy, but now that the rotar model and the relativistic force have been introduced there are a few additional insights into vacuum energy that will be mentioned.

Rotar Model Requires Vacuum Pressure: Recall in chapter 4 the point was made that energy density (U) has the same units as pressure ($\mathbb{P}$) when both are expressed in dimensional analysis terms of length, mass and time. I argue that energy density always implies pressure. This position is not held by the standard model or string theory which assumes particles can possess infinite energy density (no volume) without being concerned about the implied infinite pressure. However, it is easier to see that energy propagating at the speed of light in a limited volume (confined photons or the rotar model) always implies pressure. The energy density of a rotar's quantum volume (U_q) exerts a pressure that will be designated as $\mathbb{P}_q$. Ignoring numerical factors near 1, the energy density and pressure of this volume is:

$$U_q = \mathbb{P}_q = \frac{E_i}{R_q^3} = \frac{E_i^4}{c^3\hbar^3} = \frac{\hbar\omega_c^4}{c^3} = \frac{m^4c^5}{\hbar^3} = H_\beta{}^4 U_p = H_\beta{}^4 \mathbb{P}_p$$

It is also possible to determine both energy density and pressure using one of the 5 wave-amplitude equations: $U = \mathbb{P} = kH^2\omega^2 Z/c$. Using the substitution: $H^2 = H_\beta{}^2 = (T_p\omega_c)^2 = (\hbar G/c^5)\omega_c{}^2$ and previous substitutions we obtain the same answer as the above equation from the wave-amplitude equation:

$$U_q = \mathbb{P}_q = \frac{H_\beta^2\omega_c^2 Z_s}{c} = \left(\frac{\hbar G\omega_c^2}{c^5}\right)\omega_c^2 \left(\frac{c^3}{G}\right)\left(\frac{1}{c}\right) = \frac{\hbar\omega_c^4}{c^3} = \frac{E_i}{R_q^3}$$

For example, an electron has: E_i = 8.19 x 10^{-14} J and R_q = 3.86 x 10^{-13} m. Therefore, if $U_q = E_i/R_q{}^3$ then the rotar model of an electron has energy density of about 10^{24} J/m^3. This model would then have internal pressure of roughly 10^{24} N/m^2. Vacuum energy is required to stabilize and confine this energy density/pressure. Therefore, vacuum energy must exceed this energy density/pressure. If it takes 10^{24} N/m^2 to stabilize an electron with energy of 8 x 10^{-14} J, how much pressure does it take to stabilize the highest energy particle? The most energetic particle that has been experimentally observed is the top quark with energy of: $E_i \approx$ 3x10^{-8} J. Using $E_i{}^4/c^3\hbar^3$ the energy density of vacuum energy must exceed about 10^{45} J/m^3 and the pressure must exceed 10^{45} N/m^2. This represents a lower limit for the energy density of vacuum energy. These pressures are easily accommodated by the spacetime based model of vacuum energy.

The high energy density of vacuum energy required by the spacetime based model proposed here should not be surprising since a large vacuum energy density is also required for the formation of virtual particle pairs and many other operations of QED and QCD. In fact, even the hypothetical Higgs field (not part of the spacetime based model) also requires a very high vacuum energy density. This energy density depends on the energy of the Higgs boson but the implied energy density is roughly 10^{46} J/m^3. This is mentioned to illustrate that the concept of a Higgs field also challenges the cosmological critical energy density number.

Astronomical measurements indicate that the universe has average energy density of only about 10^{-9} J/m^3 (the "critical density"). However, this is proposed to be only the energy density of the dipole waves that possesses angular momentum such as rotars and photons. The vastly larger portion of the universe's energy (dipole waves) does not possess angular momentum and only interacts with our observable universe through quantum mechanics. This energy density is as homogeneous and isotropic as quantum mechanics allows. It does not produce the same gravitational effects as energy that possesses angular momentum.

The rotar model of a fundamental particle has a finite volume. The energy density of a fundamental particle implies a pressure that must be contained to achieve stability. Vacuum energy can exert this pressure without itself needing to be contained by a still larger pressure vessel. We do not know whether the universe is infinitely large or just vastly larger than our observable portion of the universe. In either case, the vacuum energy/pressure in our observable portion of the universe has nowhere to go. It is in equilibrium with the rest of the observable universe. One inadequacy of both the standard model and string theory is that their fundamental particles have energy but no volume. If energy density is absolutely equivalent to pressure, what mechanism contains the infinite pressure of a particle with no volume?

Rotars in Superfluid Vacuum Energy: If I wave my hand through spacetime, I am not aware of any interaction with the vast energy density of spacetime. There is no resistance; therefore it is hard to visualize spacetime as having momentum or being a very stiff elastic medium. However, it is necessary to remember that the fundamental particles that make up my hand are merely quantized eddies that can easily propagate through the sea of vacuum fluctuations without encountering any resistance or leaving a wake. There is no new compression of spacetime. It is only when we introduce a new wave in spacetime such as a gravitational wave that we are attempting to introduce a net compression and displacement of the dipole waves that fill spacetime. Spacetime has a bulk modulus but this bulk modulus only reveals itself to a wave in spacetime that is physically introducing a compression and expansion of spacetime. A unit of quantized angular momentum can freely propagate through the sea of dipole waves that forms spacetime without resistance.

However, if a rotar possessing quantized angular momentum encounters another rotar with quantized angular momentum, then this is entirely different. Even though these two rotars are also just distortions of spacetime, the quantized angular momentum permits them to exceed the homogeneous energy density of vacuum energy. This starts a chain of interactions with vacuum energy/pressure that ultimately result in the forces of nature. For example, rotars can coalesce into massive bodies ranging from hadrons to galaxies. These are islands of concentrated energy in a sea of superfluid vacuum energy that was previously homogeneous. Each rotar increases the energy density at a specific location causing a disturbance we know as curved spacetime. All other nearby rotars now experience an energy density gradient which results in a gravitational interaction between rotars (particles). The other forces are the result of similar interactions as will be explained later. Chapters 13 and 14 will discuss further why the energy density of spacetime does not form a black hole.

Spacetime: The New Ether? If the universe is only spacetime, it should not be surprising that spacetime is ultimately responsible for all of physics. The description of spacetime offered here is a combination of the energetic vacuum fluctuations described by quantum mechanics and the general relativistic description where spacetime can be curved and time is the fourth dimension. Ultimately energetic spacetime even performs the functions previously attributed to the ether. However, spacetime is much more subtle than the antiquated description of the ether. There is no detectable motion relative to spacetime because spacetime is a sea of energetic waves which are always forming new wavelets and all of this is propagating chaotically at the speed of light. Also, the ω^3 dependence of the spectral energy density means that the harmonic oscillators of spacetime are a perfect Lorentz invariant medium. Doppler shifts are offset so that no relative motion is detectable.

Fundamental particles do not drag spacetime the way that the ether was presumed to be dragged by mass. Instead, fundamental particles are quantized vortices in superfluid spacetime. These vortices freely propagate through energetic spacetime without imparting inertia or leaving a wake. In chapter 11 it will be proposed that photons are a disturbance in energetic spacetime carrying quantized angular momentum. While this has similarities to waves propagating in the ether, there also are important differences. The proper speed of light is constant everywhere because all fundamental particles and forces are made of energetic spacetime. These all scale in a way that keeps the proper speed of light constant in every location and every direction. This means that there is no detectable motion relative to spacetime.

Stability of a Particle Made of Waves

Schrodinger's Wave Packet: Previously it was mentioned that about 1926 Schrodinger attempted to explain particles as consisting only of a "wave packet". Schrodinger's wave packet had many frequencies that, when added together (Fourier transform), produced a concentrated wave. This was Schrodinger's wave based model of a particle. He was attacked for this idea by other scientists. The problem was that these many different frequencies could only temporarily add together to form a concentrated wave at a single location that acts like a particle. Another way of saying this is that Schrodinger's confluence of waves can momentarily create the energy density of a particle, but this implies a pressure. Schrodinger was unable to explain what prevented the wave packet from dissipating and he eventually abandoned this idea.

Radiated Power by Unstable Rotars: The amplitude of the rotar wave within the quantum volume (at distance R_q) has been given as $H_\beta = L_p/R_q$. A simple extrapolation of this amplitude to distances beyond R_q would result in a fundamental wave amplitude of $H_f = L_p/r$ where distance r is greater than R_q. Rotating dipoles of any type attempt to radiate away their energy. It is proposed that at the few Compton frequencies that actually form rotars, a type of resonance is formed that offsets the dipole radiation. For any fundamental rotar that actually exists there must be a wave cancelation that destroys the wave with amplitude $H_f = L_p/r$ and leaves only residual standing waves as evidence of the battle that is taking place. Without some form of cancelation in the external volume, we would expect a rotar to radiate energy into the external volume with amplitude that decreases with $1/r$ at a frequency equal to the rotar's Compton angular frequency ω_c. To calculate the hypothetical radiated power that would occur from amplitude H_f at frequency ω_c we will use one of the 5 wave-amplitude equations: $P = H^2\omega^2 ZA$. This equation contains "A" which is the radiating area. It is not necessary to assume a distance of R_q for this calculation. We can imagine a spherical shell with arbitrary radius r. Therefore, we only need to calculate the power that passes through this shell. At distance r the surface area "A" of this imaginary spherical shell with radius r is: $A = kr^2$.

$P = H^2\,\omega^2\,Z A$ set $H = H_f = L_p/r,\;\; Z = c^3/G$ and $A = kr^2$ (ignore k)

$$P = \left(\frac{L_p}{r}\right)^2 \omega_c^2 \left(\frac{c^3}{G}\right) r^2 = \left(\frac{\hbar G}{c^3}\right)\omega_c^2\left(\frac{c^3}{G}\right) = \omega_c^2\hbar = P_c$$

$P = P_c$ radiated power = rotar's circulating power $P_c = \omega_c^2\hbar = E_i\,\omega_c$

Therefore, a $1/r$ amplitude distribution means that the radiated power is equal to the rotar's full circulating power $P_c = E_i\,\omega_c$. At this radiated power, all the rotar's internal energy E_i is radiated away in a time period of only $1/\omega_c$. If an electron radiated power at this rate, it would be radiating about 63 million watts and have a lifetime of less than 10^{-20} seconds. Any structure that is radiating away its internal energy in a time period of only $1/\omega$ has absolutely no stability. In fact, it lasts as long as the uncertainty principle predicts for energy uncertainty ΔE. If a rotar survives for a time period longer than $1/\omega$, this means that there must be some mechanism for reducing the wave amplitude in the external volume from $H_f = L_p/r$.

Wave Cancelation: Here is the picture that I have for the stability of a rotar. It is not a complete picture, but it is sufficiently complete that I find it plausible when combined with the body of other information contained in this book. Imagine a rotating dipole wave in spacetime that is one wavelength in circumference. It is a single frequency, so radiation from this wave attempts to fill the universe. Power would have to be continuously supplied to this rotating dipole. In this case, the outgoing wave is acting exactly as would be expected for a single frequency wave expanding from a source. This would produce perfect monochromatic radiation, limited only by the Fourier transform of the finite emission time. Since a stable rotar is not continuously emitting energy, there must be a new source of offsetting waves.

This cancelation of waves in the external volume does not mean that all traces of wave energy have been eliminated. A very important part of the rotar model is that the destructive interference is incomplete. Standing waves (oscillations where nodes and antinodes are stationary) are left behind. These standing waves interact with vacuum energy in a way that also produces non-oscillating strains in spacetime. Two examples of these residual non-oscillating strains are electric fields (chapter 9) and curved spacetime. In particular, curved spacetime results in a static rate of time gradient and a non-Euclidian spatial distortion (discussed in chapter 8).

Traveling waves imply that power is being transferred in the direction of the wave propagation. Standing waves or a static rate of time gradient implies that no power is being transferred. Therefore, the proposed destructive interference has eliminated the power drain from the rotar, but the remaining standing waves and gradients are the evidence that a destructive interference battle is going on. Standing waves have energy, so this picture implies that a small portion of the rotar's energy is distributed outside the quantum volume. This energy is responsible for the rotar's electric and gravitational fields.

The vacuum energy waves propagating towards the core (wavelets) are returning the radiated power to the rotating dipole core. These returning waves must have the correct phase to constructively interfere with the rotating dipole. Out of the infinite possible combinations of frequency, amplitude and angular momentum, only the electron, muon and tauon have frequency/amplitude combinations to survive as isolated rotars (implies rest mass). The quarks only find stability in pairs or triplets. As previously stated, each charged lepton has a single dimensionless number that expresses all its unique characteristics in dimensionless Planck units.

Examining Alternative Particle Models: It is proposed that energy density in any form generates pressure. Any competing particle model must be able to explain where the force comes from to hold together a particle of a given energy density. For example, a proton with radius 8.8×10^{-16} m and 1.5×10^{-10} J energy implies a minimum pressure of 10^{34} N/m^2 if the energy is uniformly distributed in this volume. If some of the energy is in the form of three point particle quarks, then infinite pressure is attempting to dissipate the particle's energy. In either case an explanation must be proposed as to why the implied pressure generated by the energy density of a proton (or other particle) does not result in rapid dispersal of energy. Particles in string theory are vibrating one dimensional strings that in some cases have a length comparable to Planck length. The lack of transverse dimensions results in zero volume and infinite pressure. Advocates of string theory usually do not even permit a discussion about the structure of a string. The answer often given is that strings are postulated to be the most basic building blocks of the universe. Therefore it is not fair to inquire into the structure of a string because this implies something more fundamental. However, that response is only acceptable to people who believe in string theory. If the very existence of strings is being called into question compared to an alternative explanation, then it is fair to test both explanations as to whether they have a reasonable explanation for the containment of the energy density of fundamental particles.

Attraction and Repulsion: The conventional explanation for action at a distance is that the forces of nature are the result of the exchange of virtual particles. This explanation is conceptually understandable when it is applied to two particles which repel each other such as two electrons. It is possible to imagine virtual photons propagating between two electrons. Each virtual photon carries a small amount of momentum therefore multiple virtual photons together produce what appears to be a continuous repulsive force. However, even for repulsion there is the question: How do virtual photons find a distant point particle? Is there a homing mechanism or are there almost an infinite number of virtual photons exploring every possible location?

When the concept of virtual photon exchange is first introduced to students, the next question is usually "How does the exchange of virtual photons create attraction?" The answer usually includes mention of the uncertainty principle, Feynman diagrams, and mathematical abstractions. These answers still are unsatisfying, but the student reluctantly adopts the idea that it is necessary to move beyond classical physics with its conceptually understandable answers and accept the counter intuitive explanations of quantum mechanics. This book attempts to bring conceptually understandable ideas to quantum mechanics. The subject of action at a distance, especially attraction, is a prime example of an area that needs an improved explanation.

There is very little "wiggle room" for action at a distance if we start with the assumption that the universe is only spacetime. This restriction leads to the concept that there is only one force: the relativistic force $F_r = P_r/c$. This is the force imparted by power traveling at the speed of light. This leads to a surprising realization that the relativistic force is only repulsive.

The same way that photon pressure is only repulsive, waves in spacetime traveling at the speed of light can only produce a repulsive force. What appears to be an attracting force is actually a repulsive force exerted by the vacuum energy/pressure. Each rotar requires vacuum energy to exert a large pressure to stabilize the rotar. Previously we calculated the pressure required to stabilize a rotar is: $\mathbb{P} = m^4c^5/\hbar^3$ and applying this pressure over an area of kR_q^2 produces a force equal to the rotar's maximum force $(F_m = m^2c^3/\hbar)$ ignoring dimensionless constants near 1. If we mentally divide a rotar into two hemispheres, vacuum energy is exerting the rotar's maximum force F_m to keep those two hemispheres together. This is the same force required to deflect a rotar's circulating power $P_c/c = \mathbb{P}R_q^2 = F_m$. Even leptons which do not feel the strong force still experience a force equal to the maximum force F_m exerted by the pressure associated with vacuum energy. In chapter 8 it will be shown later that this force exerted by vacuum energy can be unbalanced and can appear to be attraction.

This maximum force was first calculated assuming that the rotar's full circulating power is deflected. The agent that is accomplishing this deflection must be an external repulsive force. Now we see that the vacuum energy is exerting this required force on the rotar. In equilibrium, the compression force exerted by vacuum energy needs to balance the outward force exerted when a rotar's circulating power is confined (deflected). Therefore, it is reasonable that the force exerted by vacuum energy needs to equal the rotar's maximum force.

Asymptotic Freedom: The strong force is an attracting force which has the property of allowing quarks bound in hadrons to freely migrate within the natural dimensions of the hadron as if there is no force acting on them. However, if there is an attempt to remove a quark from the hadron (increase the natural separation), then a force of attraction appears and resists increasing this separation distance. Furthermore, this attracting force increases with distance. An attempt to remove a quark from a hadron against this increasing force of attraction produces a new meson rather than a free quark. Once the new meson is formed the attracting force drops to near zero and the meson can be removed. Therefore the strong force has a force characteristic that seems counter intuitive.

The strong force also is responsible for binding protons and neutrons together in the nucleus of an atom. The attraction between nucleons caused by the strong force is substantially larger than the electromagnetic force generated by the protons attempting to repel each other. It is estimated that the strong force is at least 100 times greater (perhaps $1/\alpha$ times greater) than the electromagnetic force at a distance comparable to the radius of a proton ($\sim 10^{-15}$ m).

Previously in chapter 6 we calculated that the proposed wave model indicated that two quarks should repel each other with a force equal to the rotar's maximum force at a separation distance equal to R_q. However, this repulsion is only one of two forces acting on quarks when they are bound together in a hadron. The quark is also interacting with vacuum energy in a way that vacuum energy is exerting a large pressure on the quark. An isolated electron has symmetrical vacuum energy pressure exerted on the spherical quantum volume. However, a quark bound in a hadron does not have symmetrical pressure. A feature that makes protons and neutrons stable is that there is an interaction between adjacent quarks which cancels the pressure normally exerted by vacuum energy on the part of the quark that is nearest its neighbor quark. The remaining pressure applied over the remaining portion of the quark exerts a force equal to the quark's maximum force F_m (previously calculated $F_m = \mathbb{P}_q R_q^2$).

This unbalanced pressure pushes the quarks together so it appears to be a force of attraction (pseudo-attraction). Ultimately equilibrium is reached where the repulsive force between the two quarks is equal to the maximum force F_m and this also equals the vacuum energy force that pushes the quarks together. Any attempt to either increase or decrease the separation would result in a large force attempting to return the quarks to the separation where the opposing forces balance. This equilibrium is proposed to create the condition known as "asymptotic freedom".

A collision that attempts to remove a quark from a hadron increases the separation between quarks beyond the equilibrium position. The repulsive force exerted by the other rotar rapidly decreases as the separation is increased. Work is being done and it appears as if the pseudo-attraction exerted by vacuum energy/pressure remains constant as the quarks are separated. The decrease in the repulsive force exerted by the other rotar combined with a relatively constant pseudo-attraction force results in a net force that appears to increase with distance. The strong force is proposed to be the net force that results from the two opposing forces. This net force (the strong force) approaches the maximum force as the separation increases.

This subject will be discussed further in chapter 12. All that is important for a comparison of forces is that the magnitude of the strong force approaches the maximum force as quarks are separated. For example, the up and down quarks that form an isolated proton would have a maximum force of roughly 80,000 N. This maximum force is obtained from $F_m = m^2c^3/\hbar$ where the mass is approximately $^1/_3$ the proton's mass. The spacetime based model explains forces without exchange particles. Therefore actions currently ascribed to gluons are replaced by wave interactions between rotars and vacuum energy. The work done separating quarks increases the energy of the quarks (rotars) and eventually the extra energy forms a new meson.

Casimir Effect Similarity: This explanation for attraction (unbalanced pressure from vacuum energy) has some similarities to the explanation for the Casimir effect. Previously it was mentioned that the random waves in vacuum energy are creating all combinations and these include spacetime waves that appear to be zero point electromagnetic radiation. When two metal plates are brought close together, these conductive plates exclude electromagnetic waves with wavelengths larger than the gap between the metal plates. These excluded wavelengths/frequencies are still present on the opposite side of the metal plates. This slightly lowers the pressure exerted by the dipole waves in spacetime (vacuum energy) between the two plates compared to the pressure exerted on the outside of the metal plates where no waves are excluded. Practical considerations such as surface smoothness, electrical conductivity and metallic cut off frequency all serve to degrade the effect from the theoretical performance. The Casimir effect has been experimentally verified to within about 5% accuracy. Assuming an ideal electrically conductive surface, the theoretical pressure $\mathbb{P}$ generated by the Casimir effect with gap size of "r" is:

$\mathbb{P} = (k)\,\hbar c/r^4$ Casimir Pressure $\mathbb{P}$ for parallel metal plates separated by "r"

This should be compared to the pressure $\mathbb{P}$ exerted by vacuum energy on a rotar with quantum radius R_q:

$\mathbb{P} = (k)\, \hbar c / R_q^4$ $\mathbb{P}$ = pressure exerted by vacuum energy on rotar with radius R_q

It can be seen that these are the same form if gap size "r" is equated to quantum radius R_q and the constant is ignored.

The point of this is that even electrostatic attraction or the strong force has a similarity to the Casimir effect. The reasoning is that all of these attractions are the result of reducing the pressure exerted by vacuum energy on one side of an object more than the pressure exerted on the opposite side of the object.

This proposal makes attraction conceptually understandable. There is only one fundamental force and this force is only repulsive. We live in a sea of vacuum energy. It is like a fish that lives at great depth in the ocean. The fish is subject to great pressure, but the fish happily goes about its life without realizing that there is any pressure. Only if something happens to create an imbalance of pressure does the great pressure become evident. Even then, anything that lowers the pressure on one side of an object appears to be creating an attraction. The force is delivered by what appears to be a featureless environment (water for the fishes and vacuum for us). Gravitational attraction will be discussed in the next chapter.

"Unity" Hypothesis

The wave-particle duality is perhaps the most basic mystery of quantum mechanics. Both photons and particles exhibit properties that sometimes require a wave explanation and sometimes require a particle explanation. It is possible to imagine a point particle that has a percentage of its energy as a wave surrounding the point particle. However, the experiments seem to indicate that sometimes there are 100% particle properties and other times there are 100% wave properties. These are such different concepts that they seem mutually exclusive.

Today's physics puts the primary emphasis on the particle interpretation. The waves are considered to be a property of particles rather than particle-like interactions being the property of quantized waves. Not only are the leptons and quarks viewed as particles, but photons, gravitons and gluons are also considered particles. The forces of nature are considered to be carried by "exchange particles". The wave properties of all particles are recognized, but the particle properties are considered paramount.

My background is lasers and optics. In this field, the wave properties of light are considered paramount. The particle properties of photons are important, but these particle properties are secondary to the wave properties when designing optics or lasers. It is easiest to think of a photon as a quantized wave rather than a particle that possesses wave properties. In this picture, a photon is a quantized wave that is distributed over a volume when the photon is in flight. Absorption of a photon by an atom is easiest to picture as the quantized wave collapsing into the absorbing atom. From this background, there is a predisposition to quantized waves rather than particles. Having admitted my predisposition towards waves, I will start my attack on the concept that photons have particle properties by asserting the following:

There are no experiments that prove that photons have particle properties. All the experiments like the photoelectric effect and atomic photon absorption merely prove that a photon possesses quantized energy. Even Compton scattering will be shown in chapter 11 to have a wave explanation.

It is a common misconception to equate quantization with a particle. However, if spacetime is visualized as the energetic spacetime of quantum mechanics, and if these vacuum fluctuations have superfluid properties, then angular momentum must appear as quantized units. This quantized angular momentum has as a byproduct that energy possessing angular momentum also comes in quantized units. It has been proposed earlier that currently only about 1 part in 10^{120} of all the energy in the universe possesses quantized angular momentum. Energy that possesses quantized angular momentum is the only energy with which we and our instruments can interact. A photon can carry any energy up to Planck energy, but it always carries ħ of quantized angular momentum (orbital angular momentum can add multiples of ħ, but this is a special case). If we can only interact with quantized angular momentum, then everything we interact with will be forced to possess quantized energy. Waves with quantized angular momentum will appear to have particle-like properties.

We are amazed by the apparent mystery of the quantum mechanical properties of particles and photons. However, we must remember that we are only interacting with the minute part of the energy in the universe that possesses angular momentum. This minute part of the total energy of the universe must follow the rules of quantized energy transfer. These rules are enforced by the vast sea of vacuum energy in the superfluid state that surrounds us and fills the universe. For example, a molecule isolated in a vacuum can only rotate at a fundamental rotational rate or at integer multiples of this fundamental rotational rate. These quantized changes in energy are associated with quantized changes in angular momentum. This mystery of quantum mechanics becomes conceptually understandable when it is realized that the molecule really is not isolated. It lives in a sea of superfluid vacuum energy that must isolate pockets of angular momentum.

Enforcing this quantization of angular momentum requires that a unit of energy with quantized angular momentum must be able to collapse faster than the speed of light. Is there any experimental proof that faster than light action can occur? Next, we will attempt to explain how quantized waves in spacetime can exhibit particle-like properties. This explanation starts with entanglement.

Entanglement – Unity Connection: Entanglement occurs when two or more photons or particles interact in a way that their quantum states can only be described with reference to each other. Separating these entangled photons or particles does not break the quantum connection. Therefore, measuring a quantum property of one object affects the quantized state of the second entangled object. This effect happens instantly, even at a large separation distance. The existence of entanglement has been proven in many different experiments.

If entanglement provides an instantaneous response between two entangled particles or photons, is it not reasonable that there should also be a similar effect within a single dipole wave with quantized angular momentum? Chapters 11 and 14 will offer additional insights into entanglement and the super luminal communication. For now we will merely accept entanglement as an experimentally proven effect and examine the implications of its proposed close relative, unity. A purely spacetime wave model of fundamental particles must explain how a wave that is distributed over a volume can exhibit particle-like properties some of the time. If a wave is envisioned as being divisible into smaller parts like a sound wave, then it is impossible for such a wave to exhibit particle-like properties. However, a rotar is a dipole wave in spacetime that is carrying a quantized amount of angular momentum in a sea of vacuum energy that lacks angular momentum. This type of wave can change its energy in a collision, but it always must carry the assigned quantized angular momentum of $\frac{1}{2}\hbar$ or $\hbar$, for a rotar or photon respectively.

It is true that I am not giving a conceptually understandable explanation of why a superfluid cannot possess angular momentum and why any angular momentum that is present in the superfluid is broken into quantized units. This is an experimentally observed property of superfluid liquid helium and I believe that there is a theoretical explanation for the effect in liquid helium. However, I must admit that I do not have a conceptually understandable explanation for this when it is reduced to waves in spacetime. (This is a good project for someone else.) However, if we assume quantized angular momentum exists, then it is easy to see that a wave carrying quantized angular momentum must respond as a unit to a perturbation. In a collision with another quantized wave, the wave with quantized angular momentum must interact as a unit to precisely preserve the angular momentum.

The preservation of quantized angular momentum requires that the quantized wave possess faster than speed of light internal communication. This is the proposed property called "unity". The property of unity gives particle-like properties to a wave carrying quantized angular momentum.

The properties of spacetime determine the size *(½ ħ)* of the quantized angular momentum. If we accept this as a given, then the property of unity must be a component of any model of particles based only on waves. Some events such as the emission of a photon from an atom occurs over a long enough period of time that there is enough time for the quantized wave to respond without the need to invoke super luminal communication (discussed later). However, other events such as the collision of two rotars at relativistic speed requires that the rotar respond in a time period faster than required for speed of light communication across the physical size of the rotar's quantum volume. The external volume of a rotar responds differently and will be discussed later.

Nature is capable of super luminal communication as demonstrated by the many experiments that prove the existence of entanglement. The same way that it is not possible to send a message faster than the speed of light using entanglement, it also is not possible to send a message faster than the speed of light when a quantized wave responds to a perturbation as a single unit. This is merely an internal housekeeping function. The entire quantized wave (with quantized angular momentum) must respond as if it is one entangled unit.

Assume that a rotar is the dipole wave model previously described. It is not possible to interact with just 1% of a quantized dipole. It is not possible to transfer less than *ħ* of angular momentum. Either 100% of the quantum volume responds to the interaction or none of the quantum volume responds. If there is a transfer of angular momentum, it always occurs in quantized units of *ħ*. The communication within a single quantized quantum volume would be instantaneous, just like the response involving two entangled particles. In fact, the response within a single quantized wave should be *better* than when two photons or two particles are entangled.

Sixth Starting Assumption: **A wave in spacetime with quantized angular momentum responds to a perturbation as a single unit. This superluminal internal communication gives the quantized wave, particle-like properties.**

Unity is proposed to be the property responsible for the mysterious wave-particle duality present everywhere in nature. Every physical entity in the universe is made of dipole waves in spacetime. Unity permits these waves to respond with particle-like properties, but the response exhibits a probabilistic characteristics. Recall the incredibly small distortion of spacetime that forms a fundamental rotar. "Finding" a particle somewhere within a quantized dipole wave is really unity causing the quantized wave to interact with a probe (another wave) in a way that appears to exhibit particle-like properties at a single location. The particle-like properties of a quantized wave can exhibit discontinuous jumps because interacting with the quantized wave can happen at any part of the volume containing the quantized wave. The interaction and the apparent location of the interaction is a probabilistic event.

Collapse of the Wave Function: A "collapse of the wave function" in quantum mechanics is proposed to be related to the property of unity. However, this connection is complicated by the fact that often the mathematical expression of a wave function includes boundary conditions not encountered by isolated rotars. For example, a "particle in a box" or an electron bound in an atom both have restrictive boundary conditions that change the distribution of spacetime waves compared to an isolated rotar. These are more complicated conditions that will be discussed later.

In quantum mechanics, the physical interpretation of the collapse of the wave function is literally that the probabilistic wave properties of a point particle disappear (collapse) when the particle is "found". The physical interpretation of unity is that a rotar's wave properties remain after it is "found". The distributed wave of a rotar just responds to a probe (another wave) as a quantized unit.

Since the rotar is distributed over a volume, there is internal communication within the rotar that occurs faster than the speed of light. Therefore, the rotar responds to a perturbation as if it was concentrated at a single location. Unity allows fundamental rotars to respond to a relativistic collision by momentarily shrinking the radius of the rotating dipole as a single cohesive entity. This reduction in quantum radius happens faster than the speed of light, so it is impossible to detect a fundamental particle's size using inferences from collisions. In a collision, the angular momentum remains constant, but the frequency and energy increase as the radius decreases. The quantized wave appears to be a point concentration of mass/energy that discontinuously changes location. There is just no literal collapse of waves into a point particle.

The characteristic of unity is the final piece of the puzzle required for fundamental rotars to appear to be point particles. In experiments that attempt to measure the size of the fundamental rotars, the resolution of the experiment depends on the energy of the collision. Imagine two rotars colliding at relativistic velocity. In the interaction, the kinetic energy is temporarily converted to internal energy of the two rotars. In order to preserve the angular momentum of the rotar, it is necessary for the rotar to reduce its quantum radius from the size characteristic of an isolated rotar to the size appropriate for a rotar that has absorbed extra energy. This temporary size reduction gives the energetic rotar a quantum radius comparable to the resolution limit of the collision experiment. Not only does the rotar reduce the size of R_q in a collision, but this reduction happens faster than the speed of light. The entire energy in the quantum volume reacts as a unit, so the inertia appears to originate from a point. The location of that point is probabilistic, so it can appear that a rotar moves in discontinuous jumps. Later we will address the question of the small amount of a rotar's energy that is external to the quantum volume and responds differently.

Partial Explanation of Unity: The following partial explanation of unity is offered for rotars that exhibit rest mass. Unity within photons will be discussed later. It is hoped that others can improve on this partial explanation.

All rotars with rest mass are proposed to be quantized waves circulating at the speed of light in a confined volume. Even though the circulation happens in a limited volume, the fact remains that these waves do not experience time or distance. There is a fundamental difference between the way we perceive the universe (3 spatial dimensions plus time) and the way quantized waves traveling at the speed of light perceive the universe. They live in a zero dimensional universe. Dipole waves in spacetime consider the universe to be a single point.

It should not be surprising that we find many alien characteristics when we transfer from the 4 dimensional macroscopic perspective into the zero dimensional quantum perspective. Within a quantized wave circulating at the speed of light there is no time and no distance. This gives rise to both the proposed property of unity and to entanglement. Since the rotar perceives that there are no spatial dimensions, an interaction with the rotar cannot take place with only a small portion of the rotar. It is all or nothing.

In this book I have attempted to make quantum mechanical operations conceptually understandable. The above explanation of unity and entanglement is really only a partial explanation. In chapter 11 a model of two entangled photons will make entanglement more understandable. In the cosmology chapters 13 and 14 a new picture of the universe will be offered which will further improve the explanation of unity and entanglement.

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Chapter 8

Analysis of Gravitational Attraction

In chapter 6, the reader was asked to temporarily consider all forces to be repulsive. This was a simplification which allowed the calculations in chapter 6 to proceed without addressing the more complicated subject of attraction. In chapter 7, vacuum energy/pressure was introduced as an essential consideration in the generation of all forces, but especially forces that produce attraction. In this chapter we are going to attempt to give a conceptually understandable explanation for the force of attraction exerted by gravity when a body is held stationary relative to another body.

Physical Interpretation of General Relativity: Einstein's general relativity has passed numerous experimental and mathematical tests. This mathematical success has convinced most physicists to accept the physical interpretation usually associated with these equations. However, the most obvious problem with the physical interpretation is examined in the following quotes. The first is from B. Haisch of the California Institute of Physics and Astrophysics.

> "The mathematical formulation of general relativity represents spacetime as curved due to the presence of matter…. Geometrodynamics merely tells you what geodesic a freely moving object will follow. But if you constrain an object to follow some different path (or not to move at all), geometrodynamics does not tell you how or why a force arises…. Logically you wind up having to assume that a force arises because when you deviate from a geodesic you are accelerating, but that is exactly what you are trying to explain in the first place: Why does a force arise when you accelerate? … This merely takes you in a logical full circle."

Talking about curved spacetime, the book *Pushing Gravity* (M. R. Edwards) states:

> "Logically, a small particle at rest on a curved manifold would have no reason to end its rest unless a force acted on it. However successful this geometric interpretation may be as a mathematical model, it lacks physics and a causal mechanism."

General relativity does not explain why mass/energy curves spacetime or why there is a force when an object is prevented from falling freely in a gravitational field. If restraining an object from following a geodesic is the equivalent of acceleration, then apparently the gravitational force is intimately tied to the pseudo force generated when a mass is accelerated. In the standard model, particles possess no intrinsic inertia. They gain inertia from an interaction with the Higgs field. Is the Higgs field also necessary to generate a gravitational force when a particle without intrinsic inertia is prevented from following the geodesic? Is the Higgs field always accelerating towards a mass in an endless flow that attempts to sweep along a stationary particle? The standard model does not include gravity. Is gravity a force?

The point of these questions is to show that there are logical problems with the physical model normally associated with general relativity. The equations of general relativity accurately describe gravity on a macroscopic scale. However, these equations are silent as to the physical interpretation, especially at a scale (spatial or temporal) where quantum mechanics takes over.

Gravitational Nonlinearity Examined: Previously we reasoned that spacetime must be a nonlinear medium for waves in spacetime and gravity is the result of this nonlinearity. At distance R_q from a rotar we calculated the gravitational force using one of the 5 wave-amplitude equations $F = H^2\omega^2 ZA/c$. In this calculation we substituted $H = H_\beta{}^2 = (L_p/R_q)^2 = (T_p\omega_c)^2$. Also the angular frequency ω is equal to the rotar's Compton frequency $\omega = \omega_c$. At distance R_q of two of the same rotars we obtained $F = Gm^2/R_q{}^2$. This is the correct magnitude of the gravitational force between two rotars of mass m, but there are two problems. First: the equation $F = H^2\omega^2 ZA/c$ is for a traveling wave striking a surface. This traveling wave implies the radiation of power that is not happening. Second: a wave in spacetime traveling at the speed of light generates a repulsive force if it interacts in a way that the wave is deflected or absorbed. Gravity is obviously an attractive force. We have the magnitude of the force correct, but the model must be refined so that there is no loss of power and so that the force is an attraction.

There are several steps involved, and it is probably desirable to begin with a brief review. Recall that there are two types of amplitude terms for waves in spacetime: displacement amplitude and strain amplitude. The maximum displacement of spacetime allowed by quantum mechanics is a spatial displacement of Planck length or a temporal displacement of Planck time. Since these are oscillation amplitudes, we sometimes use the term "dynamic Planck length L_p" or "dynamic Planck time T_p". As previously explained, these distortions of spacetime produce a strain in spacetime. The strain is a dimensionless number equivalent to $\Delta l/l$ or $\Delta t/t$. In this case $\Delta l/l = L_p/R_q$ and $\Delta t/t = T_p\omega_c$.

In chapter 5 we imagined a hypothetical perfect clock placed at a point on the "quantum circle" of a rotar as illustrated in figure 5-1. This is the imaginary circle with radius equal to the quantum radius R_q. This clock (hereafter called the "dipole clock" with time τ_d) was compared to the time on another clock that we called the "coordinate clock" (with time t_c). This coordinate clock is measuring the rate of time if there was no spacetime dipole present. It is also possible to think of the coordinate clock as located far enough from the rotating dipole that it does not feel any significant time fluctuations. Figure 5-3 shows the difference in the indicated time $\Delta t = \tau_d - t_c$. The dipole clock speeds up and slows down relative to the coordinate clock and the maximum difference is dynamic Planck time T_p. Therefore T_p is the temporal displacement amplitude. There is also spatial displacement amplitude that is equal to dynamic Planck length L_p. The strain of spacetime produced by these displacements of spacetime is depicted in figure 5-4. Within the quantum volume, the strain of spacetime is designated by the strain amplitude $H_\beta = T_p\omega_c = L_p/R_q$. This is equivalent to the maximum slope of the sine wave which occurs at the zero crossing points in figure 5-3.

Nonlinear Effects: The above review now has brought us to the point where we can ask an interesting question: Does the dipole clock always return to perfect synchronization with the coordinate clock at the completion of each cycle? In other words, does the dipole clock show a net loss of time compared to the coordinate clock? If spacetime has no nonlinearity then the clocks would remain substantially synchronized. However, if there is nonlinearity, the dipole clock would slowly lose time.

As previously explained, the strain of spacetime (instantaneous slope in figure 5-3) has a linear component and a nonlinear component. The proposed spacetime strain equation for a point on the edge of the rotating dipole is:

Strain = $H_\beta \sin\omega t + (H_\beta \sin\omega t)^2 \ldots$ (higher order terms ignored)

The linear component is "$H_\beta \sin\omega t$" and the nonlinear component is $(H_\beta \sin\omega t)^2$. There would also be higher order terms where H_β is raised to higher powers, but these would be so small that they would be undetectable and will be ignored. This nonlinear component can be expanded:

$$(H_\beta \sin\omega t)^2 = H_\beta^2 \sin^2\omega t = ½\, H_\beta^2 - ½\, H_\beta^2 \cos 2\omega t$$

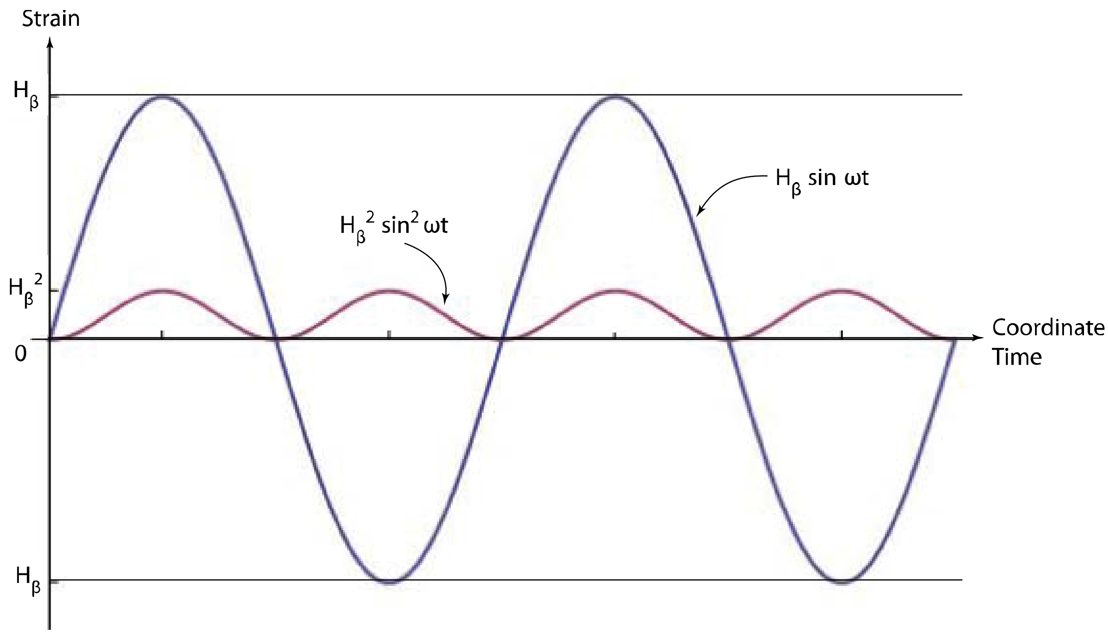

FIGURE 8-1

Figure 8-1 plots the linear component $(H_\beta \sin\omega t)$ and the nonlinear component $(H_\beta \sin\omega t)^2$ separately. It can be seen that the nonlinear component is a smaller amplitude because $H_\beta < 1$ and squaring this produces a smaller number. Also the nonlinear component is at twice the frequency of the linear component. Most importantly, the nonlinear component is always positive. Making an electrical analogy, this can be thought of as if the nonlinear wave has an AC component and a DC component. It is obvious that when the linear and nonlinear waves are added together, the sum will produce an unsymmetrical wave that is biased in the positive direction.

It was necessary to use some artistic license in order to illustrate these concepts in figure 8-1. For fundamental rotars the value of H_β is roughly in the range of 10^{-20}. This means that $H_\beta^2 \approx 10^{-40}$ and therefore H_β is approximately 10^{20} times larger than H_β^2. It would be impossible to see the plot of $H_\beta^2 \sin^2\omega t$ without artificially increasing this relative amplitude. Therefore, the assumed value in this figure is $H_\beta = 0.2$. In this case the difference between H_β and H_β^2 is only a factor of 5 rather than a factor of roughly 10^{20}. Therefore, for fundamental rotars it is necessary to mentally decrease the amplitude of the nonlinear wave by roughly a factor of roughly 10^{20}.

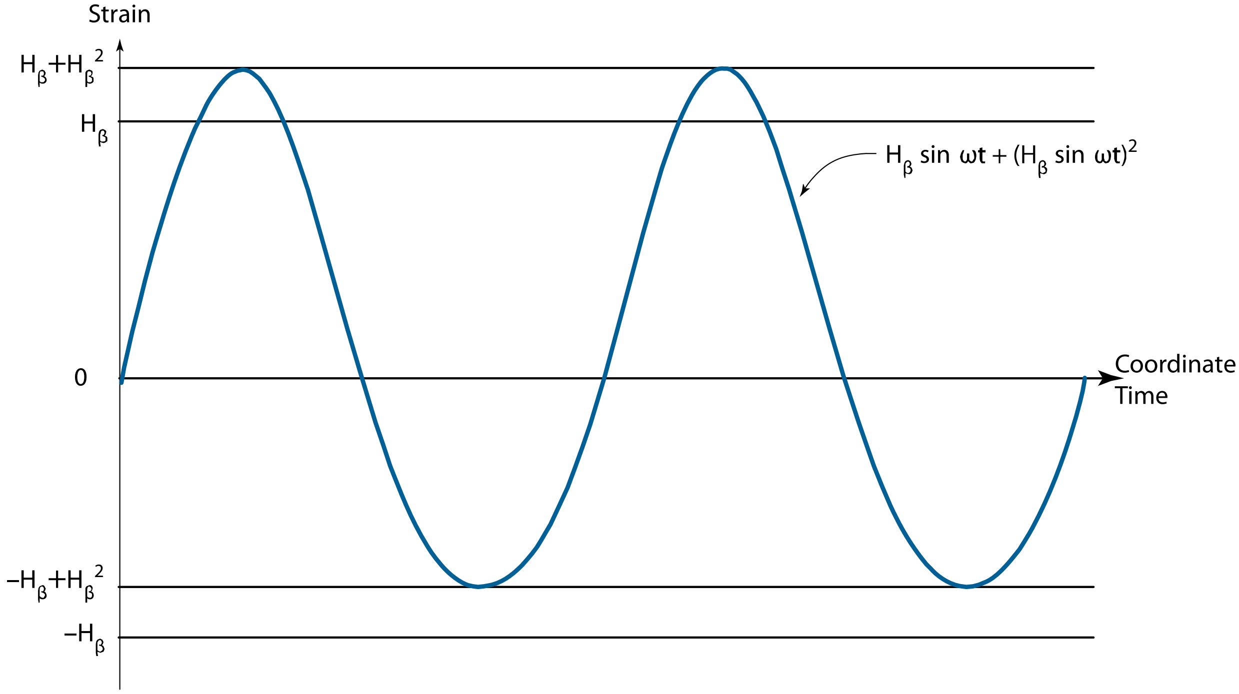

FIGURE 8-2

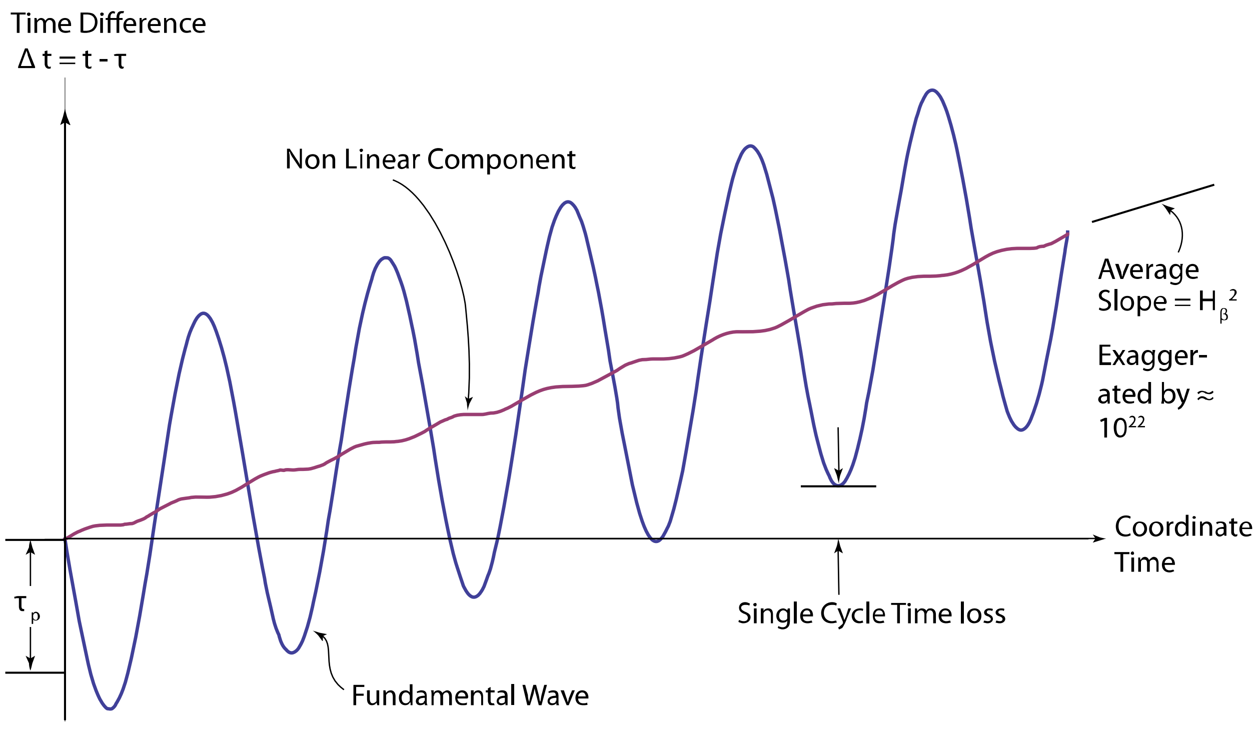

FIGURE 8-3

When we add the two waves together we obtain the plot in figure 8-2. Because of the artistic license, it is visually obvious that this is an unsymmetrical wave. There is a larger area under the positive portion of the wave than the area under the negative portion of the wave. The peak amplitude for the positive portion is $H_\beta + H_\beta^2$ while the negative portion has peak negative amplitude of: $-H_\beta + H_\beta^2$. If this was a plot of electrical current, we would say that this unsymmetrical wave had a DC bias on an AC current. To use the analogy further, it is as if the nonlinearity causes spacetime to have the equivalent of a small DC bias in its stress.

The dipole clock does not return to synchronization with the coordinate clock each cycle. Figure 8-3 attempts to illustrate this with a greatly exaggerated plot of the difference between the coordinate clock and the dipole clock. The X axis of this figure is time as indicated on the coordinate clock while the Y axis is the difference between the coordinate clock and the dipole clock $(t - \tau)$. If the two clocks ran at exactly the same rate of time, the plot would be a straight line along the X axis. Normally this plot for a few cycles should look like a sine wave similar to figure 5-3. However, the purpose of figure 8-3 is to illustrate that over time the coordinate clock pulls ahead of the dipole clock (or the dipole clock loses time). Therefore, for purposes of illustration, this effect of the accumulated time difference has been exaggerated by a factor of roughly 10^{22}.

The unsymmetrical strain plot in figure 8-2 produces a net loss of time on the dipole clock relative to the coordinate clock. In the first quarter cycle of figure 8-3, the coordinate clock falls behind the dipole clock by an amount approximately equal to Planck time. This occurs when the fast lobe of the rotating dipole passes the dipole clock first. However, with each cycle, the coordinate clock gains a small amount of time on the dipole clock. The amount of time gained per cycle is illustrated by the gap labeled "Single cycle time loss". This is equal to $T_p^2\omega_c$ which is about 2.2 x 10^{-66} s for an electron.

The point of figure 8-3 is to illustrate the contribution of the nonlinear effect. The nonlinear wave with strain of $H_\beta^2 sin^2\omega t$ at distance R_q produces the contribution that causes the net loss of time for the dipole clock relative to the coordinate clock. This net time difference between the two clocks (after subtracting $H_\beta\ sin\omega t$) is shown as the wavy line labeled "nonlinear component". The average slope of this line is equal to the gravitational magnitude for the quantum volume which has been designated as $H_\beta^2 = \beta_q$. For an electron this slope is about 1.75 x 10^{-45} which means that it takes about 30 seconds for the coordinate clock to have a net time gain of Planck time over the dipole clock. This takes about 4 x 10^{21} cycles rather than 4 cycles as illustrated in figure 8-3. If we subtracted the nonlinear wave component from figure 8-3, we would be left with a sine wave with amplitude of T_p.

The slope on this nonlinear wave component is H_β^2 at distance R_q which is obtained from the strain equation:

$H_\beta \sin\omega t + (H_\beta \sin\omega t)^2 = H_\beta \sin\omega t - ½ H_\beta^2 \cos 2\omega t + ½ \mathbf{H_\beta^2}$

The important part has been made bold for emphasis.

Connection to the Gravitational Magnitude *β*: The DC equivalent term (non-oscillating term) is $½ H_\beta^2$. We have been ignoring dimensionless constants throughout this book, so we will ignore the ½ and concentrate on H_β^2. This is the square of a rotar's strain amplitude at distance R_q.

$$H_\beta^2 = \frac{L_p^2}{R_q^2} = T_p^2\omega_c^2 = \frac{Gm^2}{\hbar c} = \beta_q \qquad \text{where } \beta_q = \beta \text{ at a rotar's } R_q$$

$$H_\beta^2 = \beta_q$$

Therefore, the equivalent of a DC bias term from the nonlinear wave component (H_β^2) is equal to the gravitational magnitude β of the rotar at distance R_q. This equality makes use of the approximation previously discussed: $\beta \equiv 1 - \sqrt{1 - \frac{2Gm}{c^2R}} \approx \frac{Gm}{c^2r}$

For a single electron at distance R_q, this approximation is accurate to better than one part in 10^{44}. For many of the more massive rotars the approximation is accurate to roughly one part in 10^{40}. Therefore this approximation is treated as being exact when we are dealing with the gravity of single rotars. Another equality for β is:

$$\beta = 1 - \frac{d\tau}{dt} \approx \frac{dt - d\tau}{dt} \qquad \text{approximation valid when } dt >> (dt - d\tau)$$

$$\beta dt \approx (dt - d\tau)$$

The approximation of $\beta \approx (dt - d\tau)/dt$ is also virtually exact for a single rotar and it will be treated as exact. Since dt is the rate of time on the coordinate clock and dτ is the rate of time on the dipole clock, we have $H_\beta^2 = (dt - d\tau)/dt$ and the time dilation has been tied to the nonlinear term H_β^2 at distance R_q from a rotar.

Non-Linear Effects in the External Volume: At distance greater than R_q from a single rotar, the non-oscillating strain amplitude will decrease in a way that matches up to H_β^2 when $r = R_q$. Since we know that $H_\beta^2 = \beta_q$ at the distance of the quantum radius, the connection to the gravitational magnitude β has been established. Our knowledge of β as a function of mass and distance $(\beta = Gm/c^2r)$ can be used to determine how the non-oscillating strain amplitude decreases with distance.

$\beta = \frac{Gm}{c^2 r} = \left(\frac{Gm^2}{\hbar c}\right)\left(\frac{\hbar}{mcr}\right)$ set: $\left(\frac{Gm^2}{\hbar c}\right) = H_\beta^2$; $\left(\frac{\hbar}{mc}\right) = \mathrm{R_q}$ $H_\beta = L_p/R_q$

$\beta = H_\beta^2 \left(\frac{R_q}{r}\right) = H_\beta^2/\mathcal{N}$ non oscillating term (the strain amplitude) in the external volume

The term r/R_q will be used numerous times in the remainder of this book both in the explanation of gravity and later in the explanation of the electromagnetic force. When we move into the external volume of a rotar, it will be shown that everything becomes very simple if we express distance from a rotar as a dimensionless number $\mathcal{N}$ equal to the number of quantum radius units R_q (reduced Compton wavelengths $\lambda\!\!\!^{-}_c$). Therefore the definition of $\mathcal{N}$ is:

$$\mathcal{N} = \frac{r}{R_q} = \frac{r}{\lambda\!\!\!^{-}_c} = \frac{rmc}{\hbar}$$

Therefore, the non-oscillating amplitude (strain amplitude) associated with gravity scales as $H_\beta^2(R_q/r) = H_\beta^2/\mathcal{N}$. While we assumed a connection between the gravitational magnitude β and the nonlinear strain amplitude H_β^2 to obtain this relationship, the fact that the equation is so physically reasonable can be used to support a causal connection between gravitational magnitude and non-oscillating strain amplitude. We know that waves of all types with wavelength λ that emit into 4π ster-radians decrease amplitude proportional to λ/r. Since $\lambda_c = 2\pi R_q$, (where λ_c equals Compton wavelength) it is reasonable that the non-oscillating strain amplitude would scale proportional to $R_q/r = 1/\mathcal{N}$. The gravitational magnitude β of a rotar also scales proportional to H_β^2 because this is the nonlinear component of the quantum volume strain amplitude H_β. Recall that spacetime is a nonlinear medium for Planck amplitude waves in spacetime and the nonlinearity is proportional to amplitude squared. Therefore, it appears as if the rotar model and other proposals offered here give a reasonable and conceptually understandable explanation for curved spacetime. Recall that:

$$\Gamma = \frac{dt}{d\tau} = \frac{dL}{dR}$$
$$\beta = 1 - \frac{d\tau}{dt} = 1 - \frac{dR}{dL}$$

Oscillating Component of Gravity: There is proposed to be another residual gravitational effect that has not been observed because it is oscillating and too weak. In figure 8-3 the non-linear wave component is shown as a wavy line labeled “nonlinear component”. We can interact with the non-oscillating part of this line responsible for gravity, but there is also a residual nonlinear oscillating component. At distance R_q this oscillating component has amplitude H_β^2 and frequency $2\omega_c$. What happens to this oscillating component beyond R_q in the external volume? We know that the few frequencies that form stable and semi stable rotars exist at resonances with the vacuum fluctuations of spacetime which eliminate energy loss. If the amplitude of the oscillating component was $H_\beta^2/\mathcal{N}$, then there would be continuous radiation of energy. Energetic composite particles such as protons or neutrons would radiate away all their energy in a few million years. In the chapter 10 an analogy will be made to the energy density of a rotar's electric field. The amplitude term for the oscillating component of gravity will then be proposed to scale as $H_\beta^2/\mathcal{N}^2$. This would be an extremely small amplitude and furthermore it is a standing wave that does not radiate energy.

Summary: Since we need to bring together several different components to achieve gravitational attraction, we will do another review. This time we will emphasize the role of vacuum energy, circulating power, the canceling wave and non-oscillating strain in spacetime.

A rotar is a rotating spacetime dipole immersed in a sea of vacuum energy which is equivalent to a vacuum pressure. This vacuum energy/pressure is made up of very high energy density ($> 10^{46}$ J/m^3) dipole waves in spacetime that lack angular momentum. The rotar also has a high energy density that is attempting to radiate away energy at the rate of the rotar's circulating power. The rotar survives because it exists at one of the few frequencies that achieve a resonance with the vacuum energy/pressure.

This resonance creates a new wave that has a component that propagates radially away from the rotating dipole and a component that propagates radially towards the rotating dipole. (Tangential wave components are also created, but these add incoherently and effectively disappear.) The resonant wave that is propagating away from the dipole cancels out the fundamental radiation from the dipole. Besides having the correct frequency and phase to produce destructive interference, the canceling wave also must match the rotar's circulating power. This means that the correct pressure is generated from the vacuum energy/pressure that is required to contain the energy density of the rotar. Only a few frequencies that form stable rotars completely satisfy these conditions.

For example, an electron has a circulating power of about 64 million watts. In order to cancel this much power from being radiated from the quantum volume, the cancelation wave generated in the vacuum energy must have an outward propagating component of 64 million watts and an inward propagating component of the same power. The recoil from the outward propagating component provides the pressure required to stabilize the rotating dipole that is the rotar (the electron). This pressure can be thought of as being carried by the inward propagating component that replenishes the rotating dipole.

If it was possible to see this process, we would not see the cancelation wave. We would only see that the rotating dipole did not seem to be emitting any radiation and that there were some smaller amplitude standing waves in the external volume. These standing waves are responsible for the rotar's electric field (discussed later). We would also see that there was a slight residual strain in spacetime with strain $H_\beta^2/\mathcal{N} = \beta$. The gravitational magnitude β of a single rotar at distance r from the rotar is:

$$\beta = H_\beta^2/\mathcal{N} = H_\beta L_p/r \approx Gm/c^2r = 1 - \frac{d\tau}{dt} = 1 - \frac{dR}{dL}$$

These are approximations that are virtually exact for single rotars.

Therefore we have succeeded in producing a non-oscillating strain of spacetime that produces the time dilation (*dt* versus *dτ*) and the non-Euclidian effect on space (*dL* versus *dR*). Together this is the curvature of spacetime that we associate with gravity.

Newtonian Gravitational Force Equation: There are still two more steps before we arrive at the explanation that gives the correct attracting force at arbitrary distance between two rotars. We will start by assuming two of the same rotars (mass m) separated by distance r. It was previously explained that deflecting all of a rotar's circulating power generates the rotar's maximum force F_m. A rotar always depends on vacuum energy to contain its circulating power. When the rotar is isolated, the force required to deflect the circulating power is balanced. However, a gravitational field produces a gradient in the gravitational magnitude $d\beta/dr$.

When a first rotar is in the gravitational field of a second rotar, there is a gradient *dβ/dr* that exists across the quantum radius of the first rotar. This means that there is a slight difference in the force exerted by vacuum energy/pressure on opposite sides of the first rotar. This difference in force produces a net force that we know as the force of gravity.

This will be restated in a different way because of its importance. Imagine mass m_1 being a rotar (rotating dipole) attempting to disperse but being contained by pressure generated within the vacuum energy/pressure previously discussed. This pressure exactly equals the dispersive force of the dipole wave rotating at the speed of light. However, if there is a gradient in the gravitational magnitude $d\beta/dr$ then there is a gradient across the rotar which we will call $\Delta\beta$. This affects the normalized speed of light and the normalized unit of force on opposite sides of the rotar. Recall from chapter 3 we had:

$C_o = \Gamma C_g$ normalized speed of light transformation
$F_o = \Gamma F_g$ normalized force transformation
$\Gamma \approx 1 + \beta$ approximation considered exact for rotars

Therefore, because of the strain in spacetime, the two sides of the rotar (separated by R_q) are living under what might be considered to be different standards for the normalized speed of light and normalized force. On an absolute scale, it takes a different amount of pressure to stabilize the opposite sides of the rotar because of the gradient $\Delta\beta$ across the rotar. The net difference in this force is the force of gravity exerted on the rotar.

We will first calculate the change in gravitational magnitude $\Delta\beta$ across the quantum radius R_q of a rotar when it is in the gravitational field of another similar rotar (another rotar of the same mass). In other words, we will calculate the difference in β at distance r and distance $r + R_q$ from a rotar of mass m.

$$\Delta\beta = \left(\frac{Gm}{c^2 r}\right) - \left(\frac{Gm}{c^2(r+R_q)}\right) \approx \frac{GmR_q}{c^2 r^2} \qquad \text{approximation valid if } R_q << r$$

The force exerted by vacuum energy/pressure on opposite hemispheres of the rotar is equal to the maximum force $F_m = m^2c^3/\hbar$. The difference in the force (absolute value) exerted on opposite sides of the rotar is the maximum force times $\Delta\beta$. Therefore, the force generated by two rotars of mass m separated by distance r is:

$$F = \Delta\beta\, F_m = \left(\frac{GmR_q}{c^2 r^2}\right)\left(\frac{m^2c^3}{\hbar}\right) = \left(\frac{Gm}{c^2 r^2}\right)\left(\frac{\hbar}{mc}\right)\left(\frac{m^2c^3}{\hbar}\right) = \frac{Gm^2}{r^2}$$

If we have two different mass rotars (mass m_1 and mass m_2), then we can consider mass m_1 in the gravitational field of mass m_2. In this case, R_q and F_m are for mass m_1 and $\Delta\beta$ is change in the gravitational magnitude from mass m_2 across the quantum radius R_q from mass m_1.

$$F_g = \Delta\beta\, F_m \approx \left(\frac{Gm_2R_{q1}}{c^2 r^2}\right)\left(\frac{m_1^2\, c^3}{\hbar}\right) = \left(\frac{Gm_2}{c^2 r^2}\right)\left(\frac{\hbar}{m_1 c}\right)\left(\frac{m_1^2c^3}{\hbar}\right)$$

$$F_g \approx \frac{\mathrm{Gm_1m_2}}{\mathrm{r^2}} \qquad \text{Newtonian gravitational force equation derived from a dipole wave model}$$

Gravitational Attraction: We have derived the Newtonian gravitational equation from starting assumptions, but we still have not shown that this is a force of attraction. However, from the previous considerations, this last step is easy. There is a slightly different pressure required to stabilize the rotar depending on the local value of β or Γ (in weak gravity $\Gamma \approx 1 + \beta$). This can be considered as a difference in net force exerted by vacuum energy on the hemisphere of the rotar that is furthest from the other rotar compared to the hemisphere that is nearest the other rotar. The furthest hemisphere has a smaller average value of Γ than the nearest hemisphere. The normalized speed of light is greater and the normalized force exerted on the farthest hemisphere must be greater to stabilize the rotar. This produces a net force in the direction of increasing Γ. The magnitude of this force is $F = Gm_1m_2/r^2$ and the vector of this force is in the direction of increasing Γ (towards the other mass).

We consider this to be a force of attraction because the two rotars want to migrate towards each other (increasing Γ). However, the force is really coming from the vacuum energy exerting a repulsive pressure. There is greater normalized pressure being exerted on the side with the lower Γ. The two rotars are really being pushed together by a force of repulsion that is unbalanced.

Corollary Assumption: **The force of gravity is the result of unsymmetrical pressure exerted on a rotar by vacuum energy. This is unbalanced repulsive force that appears to be an attractive force.**

Example: Electron in Earth's Gravity: We will do a plausibility calculation to see if we obtain roughly the correct gravitational force for an electron in the earth's gravitational field based on the above explanation. We will be using values for the electron's energy density and the electron's maximum force that were previously calculated by ignoring dimensionless constants. Therefore, we will continue with this plausibility calculation that ignores dimensionless constants. An electron has internal energy of 8.19 x 10^{-14} J and a quantum radius of 3.86 x 10^{-13} m. Ignoring dimensionless constants, this gives an energy density of about 1.4 x 10^{24} J/m^3. This rotar model of an electron is exerting a pressure of roughly 1.4 x 10^{24} N/m^2. This pressure produces the rotar's maximum force which for an electron is $F_m = 0.212$ N (obtained from $P_c/c = \mathbb{P}_q R_q^2 \approx 1.4 \times 10^{24}$ N/m^2 x R_q^2).

At the surface of the earth the gravitational magnitude is: $\beta \approx 6.95 \times 10^{-10}$. To obtain the gradient in this magnitude we divide by the earth's equatorial radius 6.37 x 10^{6} m to obtain a gradient of $d\beta/dr$ = 1.091 x 10^{-16}/m. The change in gravitational magnitude $\Delta\beta$ across the quantum radius (3.862 x 10^{-13} m) of an electron is:

$\Delta\beta = (1.091 \times 10^{-16}/\text{m})\ (3.862 \times 10^{-13}\ \text{m}) = 4.213 \times 10^{-29}$ $\Delta\beta$ across an electron's R_q

Therefore the difference in force across the quantum radius of an electron in the earth's gravitational gradient is $\Delta\beta$ times the electron's maximum force F_m = .212 N = the force being exerted on opposite hemispheres of the rotar if there was no gravitational gradient. The earth's gravitational gradient produces a net difference in the maximum force exerted on opposite sides of the electron as previously explained. The difference in force ΔF is:

$\Delta F = \Delta\beta\, F_m = 4.213 \times 10^{-29} \times .212\ \text{N} = 8.89 \times 10^{-30}\ \text{N}$

This is the correct force exerted on an electron by the earth's gravity with: g = 9.78 m/s^2

$F = m\text{g} = 9.1 \times 10^{-31}\ \text{kg} \times 9.78\ \text{m/s}^2 \approx 8.89 \times 10^{-30}\ \text{N}$

Apparently the ignored dimensionless constants cancel. This is another successful plausibility test.

At the beginning of this chapter two quotes were presented that pointed out that general relativity does not identify the source of the force that occurs when a particle is restrained from following the geodesic. M. R. Edwards states: "However successful this geometric interpretation may be as a mathematical model, it lacks physics and a causal mechanism." The ideas proposed in this book give a conceptually understandable explanation for both the magnitude and the vector direction of the gravitational force. The gravitational force was obtained from the starting assumptions without using analogy of acceleration.

Connection between Gravitational Force and Electromagnetic Force: In chapter 6 we found that there is a logical connection between the gravitational force and the electromagnetic force. The force relationship becomes very simple between two of the same fundamental particles ($m_1 = m_2$) with Planck charge ($q = q_p = \sqrt{4\pi\varepsilon_0\hbar c}$) and separated by their quantum radius $(r = R_q)$. When the forces are expressed in Planck units the equation obtained in chapter 6 was: $\underline{\boldsymbol{F}}_g = \underline{\boldsymbol{F}}_E^2$. Recall from chapter 6 that the symbol F_E is used to represent force between hypothetical particles with Planck charge (q_p) and F_e is used for elementary charge e. Now we will generalize this to an arbitrary separation distance. There are several ways of doing this, but the one that preserves the importance of the size of the rotar (preserves the relationship to R_q) is to specify the separation distance as a multiple of the quantum radius R_q. Recall that the quantum radius is equal to the reduced Compton wavelength $\lambda\!\!\!^-_c = R_q = c/\omega_c = \hbar/mc$. Therefore, we want to specify the separation distance in terms of the dimensionless ratio: $\mathcal{N} = r/R_q = r(mc/\hbar)$. Therefore when two of the same mass particles with hypothetical Planck charge are separated by $\mathcal{N}$ units of R_q, the relationship between the gravitational force and the electromagnetic force (in Planck units) is:

$$\underline{\boldsymbol{F}}_g = \underline{\boldsymbol{F}}_E^2\mathcal{N}^2 \qquad \text{where } \mathcal{N} = r/R_q = r(mc/\hbar) \qquad \text{(dimensionless ratio)}$$

This can be demonstrated by showing that both sides of this equation equal: $\dfrac{G^2m^2}{r^2c^4}$

$$\underline{\boldsymbol{F}}_g = \frac{F_g}{F_p} = \left(\frac{Gm^2}{r^2}\right)\left(\frac{G}{c^4}\right) = \frac{G^2m^2}{r^2c^4}$$

$$\underline{\boldsymbol{F}}_E^2\mathcal{N}^2 = \left(\frac{F_E\,r}{F_pR_q}\right)^2 = \left(\frac{q_p^2}{4\pi\varepsilon_o r^2}\right)^2\left(\frac{G}{c^4}\right)^2\left(\frac{rmc}{\hbar}\right)^2 = \left(\frac{\hbar^2c^2}{r^4}\right)\left(\frac{G^2r^2m^2}{c^6\hbar^2}\right) = \frac{G^2m^2}{r^2c^4}$$

A previously stated fundamental assumption of this book is that there is only one truly fundamental force $F_r = P_r/c$. If this is correct, then we would expect that the force relationship between rotars would also be a simple function of the rotar's circulating power. When we state both force and circulating power in dimensionless Planck units at distance R_q we obtained: $\underline{\boldsymbol{F}}_E = \underline{\boldsymbol{P}}_c$ and $\underline{\boldsymbol{F}}_g = \underline{\boldsymbol{P}}_c^2$. Now we can generalize these relationships to any separation distance using $\mathcal{N}$ as follows:

$\underline{\boldsymbol{F}}_g = \underline{\boldsymbol{P}}_c^{\ 2}/\mathcal{N}^2$ gravitational force between two rotars ($m_1 = m_2$) separated by $\mathcal{N}$ units of R_q
$\underline{\boldsymbol{F}}_E = \underline{\boldsymbol{P}}_c/\mathcal{N}^2$ electrostatic force - two rotars ($q = q_p$) and ($m_1 = m_2$) separated by $\mathcal{N}$ units of R_q

So far we have dealt with two of the same rotars. This can be broadened to two different rotars. Rotar #1 has circulating power of $\underline{\boldsymbol{P}}_{c1}$ and rotar #2 has circulating power of $\underline{\boldsymbol{P}}_{c2}$ (both in Planck units of power). Rotars 1 and 2 also have quantum radius R_{q1} and quantum radius R_{q2}. The separation distance r is designated by $\mathcal{N}_1 = r/R_{q1}$ and $\mathcal{N}_2 = r/R_{q2}$. The gravitational and electromagnetic forces between these two different rotars in Planck units of force are:

$\underline{\boldsymbol{F}}_g = \underline{\boldsymbol{P}}_{c1}\underline{\boldsymbol{P}}_{c2}/\mathcal{N}_1\mathcal{N}_2$
$\underline{\boldsymbol{F}}_E = (\underline{\boldsymbol{P}}_{c1}\underline{\boldsymbol{P}}_{c2})^{1/2}/\mathcal{N}_1\mathcal{N}_2$

These equations can be rewritten using the Compton angular frequencies ω_{c1} and ω_{c2} using the substitutions from chapter 6 of : $\underline{\boldsymbol{P}}_c = \underline{\boldsymbol{\omega}}_c^2$

$\underline{\boldsymbol{F}}_g = (\underline{\boldsymbol{\omega}}_{c1}\underline{\boldsymbol{\omega}}_{c2})^2/\mathcal{N}_1\mathcal{N}_2$
$\underline{\boldsymbol{F}}_E = (\underline{\boldsymbol{\omega}}_{c1}\underline{\boldsymbol{\omega}}_{c2})/\mathcal{N}_1\mathcal{N}_2$

The reason for making this substitution is that these two equations help to illustrate the point that gravity only differs from the electromagnetic force by a square term when the two force equations ($F_g = Gm_1m_2/r^2$ and $F_E = q_p^2/4\pi\varepsilon_o r^2$) are written using only the wave properties of fundamental particles and expressing force on the absolute force scale that sets Planck force equal to 1. Previously we discussed the square relationship between forces with $\underline{\boldsymbol{F}}_g = \underline{\boldsymbol{F}}_E^2$. However, that equation might be considered somewhat suspect since it assumed a single separation distance of $r = ƛ_c = R_q$. However, the above equations are for arbitrary separation distance and two different mass particles. The only difference between the above two equations is that the gravitational equation has $(\underline{\boldsymbol{\omega}}_{c1}\underline{\boldsymbol{\omega}}_{c2})^2$ while the electromagnetic equation has $(\underline{\boldsymbol{\omega}}_{c1}\underline{\boldsymbol{\omega}}_{c2})$ with no square. Even for physicists that might not agree with the concepts in this book, these equations are undeniably correct. They clearly show this previously unknown square relationship. This relationship reveals itself when the separation distance is expressed in as $\mathcal{N}$ multiples of the reduced Compton wavelength $ƛ_c$ (multiples of R_q) and referencing the absolute force scale that sets the largest possible force equal to 1.

I propose that this insight is an important step towards the unification of forces. The standard model does not include gravity and general relativity considers gravity not to be a true force. The argument made here is that the electromagnetic force is considered to be a true force. If there is a close relationship between the gravitational force and the electromagnetic force when both forces are expressed using the wave properties of fundamental particles, then gravity must also be a true force. However, these equations seem to be incompatible with the commonly held physical interpretation that forces are transferred by messenger particles such as gravitons or virtual photons.

The spacetime-based model described in this book is not only compatible with this square force relationship, this model actually predicted this force relationship. There was a time when I realized that the rotar and force model was implying that there must be this square force relation between the gravitational force and the other three forces. Once I realized that this is a prediction of the model, it was easy to prove that this prediction is correct.

So far we have assumed Planck charge which set the electrostatic coupling constant equal to 1. However, now we will switch to assuming elementary charge e which is signified by using the symbol F_e for force generated by charge e. Making the substitutions $q_p = \sqrt{4\pi\varepsilon_o\hbar c} = e/\sqrt{\alpha}$ and $\alpha = e^2/4\pi\varepsilon_o\hbar c$, we obtain:

$\underline{\boldsymbol{F}}_e = \alpha(\underline{\boldsymbol{\omega}}_{c1}\underline{\boldsymbol{\omega}}_{c2})/\mathcal{N}_1\mathcal{N}_2$
$\underline{\boldsymbol{F}}_e = \alpha(\underline{\boldsymbol{P}}_{c1}\underline{\boldsymbol{P}}_{c2})^{1/2}/\mathcal{N}_1\mathcal{N}_2$

The electromagnetic force equation $\underline{\boldsymbol{F}}_e = \alpha(\underline{\boldsymbol{\omega}}_{c1}\underline{\boldsymbol{\omega}}_{c2})/\mathcal{N}_1\mathcal{N}_2$ is particularly interesting. For example, suppose that there is an electron and a muon at separation distance r. They both have charge e but their Compton frequencies (masses) differ by about a factor of about 206. The current understanding of the laws of physics assumes that both are point particles or vibrating strings. Electrical charge is regarded as a mysterious property that lacks physical understanding. Therefore, the understanding of the electrostatic force between two charged objects ignores the importance of the frequency (mass) of the two particles because this term cancels.

However, the above equation for electrostatic force says that the spacetime wave model of the universe does not ignore the frequency/mass difference. The frequency term is present in both the numerator and denominator. The numerator is obvious, but the number of wavelengths in the separation distance also carries frequency dependence ($\mathcal{N}_1\mathcal{N}_2 = \omega_{c1}\omega_{c2}r^2/c^2$). Therefore for the electrostatic force equation the frequency terms cancel and the magnitude of the force is independent of frequency. However, if we look at the waves in spacetime that actually generate the effect that we call an electric field, the waves in spacetime are different for an electron and a muon.

While this analysis relates force frequency and circulation power, it does not address the following question: Exactly what is an electric field? What distortion of spacetime takes place to produce an electric field? A more complete explanation of the electromagnetic force, charge and electric fields will be given in chapters 9 and 10. It will be shown that there is both an oscillating component and a non-oscillating component to an electric field.

Gravitational Rate of Time Gradient: In the weak field limit, it is quite easy to extrapolate from the gravitational magnitude β produced by a single rotar at a particular point in space to the total gravitational magnitude produced by many rotars. Nature merely sums the magnitudes of all the rotars at a point in space without regard to the direction of individual rotars. The gravitational acceleration g was previously determined to be:

$g = c^2\, d\beta/dr = -\, c^2\, d(d\tau/dt)/dr$.

A gravitational acceleration of 1 m/s^2 requires a rate of time gradient of 1.11 x 10^{-17} seconds per second per meter. The earth's gravitational acceleration of 9.8 m/s^2 implies a vertical rate of time gradient of 1.09 x 10^{-16} meter^{-1}. This means that two clocks, with a vertical separation of one meter at the earth's surface, will differ in time by 1.09 x 10^{-16} seconds/second. Similarly, there is also a spatial gradient. A gravitational acceleration also implies that there is a difference between circumferential radius R and radial length L. In the earth's gravity this spatial difference is 1.09 x 10^{-16} meters/meter $(\beta \approx 1 - dR/dL)$.

Out of curiosity, we can calculate how much relative velocity would be required to produce a time dilation equivalent to a one meter elevation change in the earth's gravity. If elevation 2 is 1 meter higher than elevation 1, then: $dt_1/dt_2 = 1 - 1.09 \times 10^{-16}$. Using special relativity:

$$v = c\sqrt{1 - \left(\frac{dt_1}{dt_2}\right)^2} \qquad \text{set} \quad dt_1/dt_2 = 1 - 1.09 \times 10^{-16}$$

$v = 4.4$ m/s

This 4.4 m/s velocity is exactly the same velocity as a falling object achieves after falling through a distance of 1 meter in the earth's gravity. Carrying this one step further, an observer in gravity perceives that a clock in a spaceship in zero gravity has the same rate of time as a clock in gravity, if the spaceship is moving at a relative velocity of v_e, the gravity's escape velocity. For example, an observer on earth would perceive that a spaceship in zero gravity moving tangentially at about 40,000 km/hr has the same rate of time as a clock on the earth. On the other hand, an observer in the spaceship perceives that a clock on the earth is slowed twice as much as if there was only gravity or only relative motion.

Equivalence of Acceleration and Gravity Examined: Albert Einstein assumed that gravity could be considered equivalent to acceleration. This assumption obviously leads to the correct mathematical equations. However, on a quantum mechanical level, is this assumption correct? Today it is commonly believed that an accelerating frame of reference is the same as gravity if the volume is small enough that tidal effects can be ignored and all external clues are eliminated. A corollary to this is that an inertial frame of reference eliminates gravity. The implication is that gravity is not as real as an electron or a photon which cannot be made to disappear merely by choosing a particular frame of reference. General relativity does not consider gravity to be a force.

The concepts presented in this book fundamentally disagree with this physical interpretation of general relativity. There is no disagreement with the equations of general relativity. To explain why an inertial frame of reference does not eliminate gravity, we will use the previous example of an electron in a vacuum chamber in the earth's gravitational field. It was shown that force exerted on an electron in the Earth's gravitational field is the result of the gradient in the Earth's gravitational field $d\beta/dr \approx 1.1 \times 10^{-16}$ per meter. This gradient produces a slight difference in the force exerted by vacuum energy/pressure on opposite sides of the electron's quantum volume. This force difference was shown to be equal to about 8.89×10^{-30} N. This force difference does not disappear if the electron is in an inertial frame of reference (free fall). Also, the electron's inertial pseudo force does not disappear when the acceleration is caused by a free fall in gravity. Both forces remain. The force required to accelerate the electron at 9.8 m/s^2 is still 8.9×10^{-30} N (recall accelerating light in a box). Also, the gradient dβ/dr across the electron is still producing a 8.9×10^{-30} N force. **When the electron is being accelerated by gravity, the gravity is still exerting its force**. In free fall the two forces offset each other and the electron appears to experience no force. However, this is an erroneous perception. Both forces remain. An inertial frame of reference (following a geodesic) does not eliminate the force of gravity.

For most physicists the most important feature of gravity is the gravitational force exerted on matter in a gravitational field. However, for me the most important effect is the gravitational effect on the rate of time and proper volume. When an electron is falling in a gravitational field, it might be possible to argue about whether there is a force or not. However, there is no argument about whether the electron is moving from a location with a faster rate of time to a location with a slower rate of time. It might be argued that the accelerating frame of reference eliminated the time gradient while the electron is falling. However if the electron stops falling (returns to the initial rest frame), it is obvious that the electron is at a location (elevation) with a slower rate of time. The fall did not eliminate the effect of gravity. The accelerating frame of reference only temporarily offset the effects of gravity with an opposite gradient during the fall.

The inertial frame of reference of an object in free fall in a gravitational field is actually an accelerating frame of reference relative to the cosmic microwave background (CMB). This accelerating frame of reference relative to the CMB is no more fundamental than a rotating frame of reference. To simulate gravity by physically accelerating a mass such as a rotar, it takes the continuous expenditure of power and the exchange of momentum. The inertial pseudo force at a specific acceleration can equal the magnitude of a gravitational force, but the origins of the forces are different. The force of gravity is caused by a differential in the pressure exerted by vacuum energy while the force exhibited by acceleration is caused by a difference in the Doppler shift exhibited by waves in spacetime circulating at the speed of light in a confined volume.

Another point is that the acceleration of gravity is only one aspect of a gravitational field. There is also the effect on the rate of time $(dt = \Gamma d\tau)$ and the effect on proper length $(dL = \Gamma dR)$. Being in an inertial frame of reference does not eliminate these additional effects. Recall the thought experiment from chapter 2 involving a clock in a cavity at the center of the earth. This clock is in an inertial frame of reference but the inertial frame of reference did not affect the rate of time which depends on the gravitational potential at the center of the earth.

If gravity and acceleration are not equivalent down at the level of waves in spacetime, why did Einstein obtain the correct equations by assuming that they were equivalent? The answer is that in free fall the effects of gravity on a rotar exactly offset the measurable effects of accelerating a rotar. Not only are there offsetting force vectors, but the offsetting effects extend to the rate of time gradient and the volume gradient. Therefore assuming that gravity is indistinguishable from acceleration is a good assumption for mathematical analysis of gravity if neither the source of inertia force nor the gravitational force is understood. However, on the quantum mechanical scale involving vacuum fluctuations and internal effects in a rotar, there is a difference between gravity and acceleration.

Quantum Gravity: If the field of quantum gravity is broadly defined as any attempt to combine general relativity and quantum mechanics, then the wave-based model of gravity proposed here can be categorized as part of the broad field of quantum gravity. However, if the field of quantum gravity is defined as any attempt to show that gravity results of quantized "pulses" of force between particles, then it is more difficult to categorize this model. Here is the problem. There are no gravitons, but there theoretically is a sinusoidal oscillation in the magnitude of the force exerted between two fundamental particles. Figure 8-1 shows a sine wave labeled $H_\beta{}^2\sin^2\omega t$. This sine wave implies a high frequency, very weak pulsation in the gravitational force. For example, this frequency is equal to twice the reduced Compton frequency of the attracting fundamental particle. For an electron this frequency would be in excess of 10^{21} s^{-1}. The pulsation effect would be completely impossible to measure by any means because the oscillating difference in force would theoretically produce an effect much smaller than Planck length. Furthermore, if the recipient of the electron's gravitational force was another electron, the rotar model of this second electron is a rotating strain in spacetime distributed over a volume with a radius about 10^{22} times bigger than Planck length. Therefore, unlike the photo-electric effect, there will never be any measurable evidence of "quantized" gravitational pulsations. Therefore, this model supports the idea that gravity is not quantized on any measurable scale.

Grav Field in the Quantum Volume: The above discussion of gravitational acceleration from a rate of time gradient prepares us to return to the subject of the "grav field" inside the quantum volume of a rotar. Recall that the rotating dipole that forms the quantum volume of an isolated rotar was shown in figure 5-1. This rotating dipole wave has two lobes that have different rates of time and different effects on proper volume. The difference in the rate of time between the two lobes produces a rotating rate of time gradient that was depicted in figure 5-2. A rotar is very sensitive to a rate of time gradient. A rate of time gradient of 1.11 x 10^{-17} seconds/second/meter causes a rotar to accelerate at 1 m/s^2 and the acceleration scales linearly with rate of time gradient. Therefore, the rotating rate of time gradient in the center of a rotar model can be considered to be a rotating acceleration field.

We normally encounter rate of time gradients in a gravitational field and these are the result of a nonlinearity that produces a static stress in spacetime. There is no angular frequency associated with a static gravitational field (static rate of time gradient), therefore there is no energy density associated with a static rate of time gradient. However, if a rotating gravitational field is somehow generated, then such a rotating field would have an energy density. The rotating rate of time gradient (rotating grav field) that is present near the center of the quantum volume of a rotar does have energy density that will be calculated next.

In a time period of $1/\omega_c$, the fast time lobe of the dipole gains Planck time (displacement amplitude T_p) and the slow time lobe loses Planck time T_p. These lobes are separated by $2R_q$. Therefore, in a time of $1/\omega_c$ there is a total time difference of $2T_p$ across a distance of $2R_q$. The rate of time gradient per meter is:

$$\frac{dt - d\tau}{dtdr} = \frac{2T_p}{\left(\frac{2R_q}{\omega_c}\right)} = \frac{L_p\omega_c^2}{c^2} = \frac{L_p}{R_q^2}$$

The acceleration produced by this rate of time gradient (grav acceleration A_g) is the rate of time gradient times c^2. The following are several equalities for grav acceleration A_g:

$$A_g = \left(\frac{dt - d\tau}{dtdr}\right)c^2 = L_p\omega_c^2 = H_\beta^2 A_p = \sqrt{\frac{m^4c^5G}{\hbar^3}}$$

A_g = grav acceleration and $A_p = c/t_p = \sqrt{c^7/\hbar G}$ = Planck acceleration

Comparison of Grav Acceleration and Gravitational Acceleration: How does the rotating grav acceleration at the center of a rotar's quantum volume (A_g) compare with the non-rotating, gravitational acceleration (g_q) at the edge of the same rotar's quantum volume? .

$g_q = H_\beta^2\omega_c c$ rotar's non-rotating gravitational acceleration at distance R_q

$A_g = H_\beta\omega_c c$ rotar's rotating (ω_c) grav acceleration at the center of a rotar

$\frac{g_q}{A_g} = H_\beta$ ratio of g_q (static gravitational acceleration at R_q) to rotating grav acceleration A_g

For an electron H_β = 4.18 x 10^{-23}, so the rotating grav field is about 2 x 10^{22} times stronger than the non rotating gravitational field at distance R_q. This results in an electron having a rotating grav acceleration of: $A_g = 9.73 \times 10^6$ m/s². The gravitational acceleration (not rotating) of an electron at distance R_q is: $g_q = 4.07 \times 10^{-16}$ m/s². Therefore the grav acceleration in the quantum volume of an electron is about a million times greater than the gravitational acceleration at the surface of the earth. The earth's gravity is not rotating and is a nonlinear effect. The electron's grav field is rotating and is a first order effect resulting from the rate of time gradient established in the electron's rotating dipole wave.

Recall the incredibly small difference in the rate of time that exists between the lobes of an electron. It would take 50,000 times the age of the universe for the hypothetical lobe clock running at the rate of time inside the slow lobe to lose one second compared to the coordinate clock. The difference between the rate of time on the slow lobe clock and the coordinate clock is comparable to the difference in the rate of time exhibited by an elevation change of about 4×10^{-7} m in the earth's gravity. The reason that the rotating grav field has a million times larger acceleration than the earth is because this difference in the rate of time occurs over approximately a million times shorter distance ($\sim 4 \times 10^{-13}$ m). The rotating rate of time gradient inside a rotar is a first order effect related to H_β while the non-rotating gravitational field produced by the rotar is a second order effect related to H_β^2.

Conservation of Momentum in the Grav Field: It would appear that the concept of a grav field must violate the conservation of momentum. An example will illustrate this point. Suppose that a small neutral particle (such as a neutral meson) wanders into the center of an electron's quantum volume. Even if the mass of the meson is 1000 times larger than the electron, the rotating grav field of the electron should produce the same acceleration of the neutral particle. This would be a violation of the conservation of momentum unless the displacement produced by the rotating grav field is equal to or less than Planck length (the uncertainty principle detectable limit). We will calculate the maximum displacement $(\mathcal{X})$ that takes place in a time period of: $t = 1/\omega_c$. We choose this time period because the rotating vector of the grav field is changing by one radian in a time period of $1/\omega_c$. Hypothetically the neutral particle would nutate in a circle with a radius related to $\mathcal{X}$ (ignoring dimensionless constants).

$$\mathcal{X} = \tfrac{1}{2}\, a\, t^2 = k\,\frac{H_\beta \omega_c\, c}{\omega_c^2} = \frac{\left(\frac{L_p}{R_q}\right)\left(\frac{c}{R_q}\right)c}{\left(\frac{c}{R_q}\right)^2} = L_p$$

$\mathcal{X} = L_p$ $\qquad$ $\mathcal{X}$ = maximum radial displacement produced by a rotar's rotating grav field

Therefore any mass/energy rotar always produces the same displacement equal to Planck length (ignoring dimensionless constants) in the time required for the grav field to rotate one radian. This displacement is permitted by quantum mechanics and is not a violation of the conservation of momentum. This is another successful plausibility test.

Energy Density in the Rotating Grav Field: An accelerating field that is rotating possesses energy density. It would hypothetically be possible to extract energy from such a field if the field produced a nutation that was larger than the quantum mechanical limit of Planck length. No energy can be extracted from a rotar's rotating grav field because the nutation is at the quantum mechanical limit of detection. However, this field still possesses energy density.

Previously we designated the strain amplitude of a rotar as $H_\beta = L_p/R_q = T_p\omega_c = \omega_c/\omega_p$. These were originally defined in terms of the strain amplitude of a dipole wave that is one wavelength in circumference. This definition tended to imply that the energy density of a rotar was distributed around the circumference. However, it is proposed that the rotating gradient that is present at the center of the rotar model can also be characterized as having a dimensionless amplitude of $H_\beta = L_p/R_q = T_p\omega_c$. This amplitude H_β is just in the form of a rotating rate of time gradient and a rotating spatial gradient. The spatial gradient from the lobe to the center is still L_p/R_q. The rate of time gradient is still related to $T_p\omega_c$, although this is harder to see. Previously we substituted H_β, ω_c and Z_s into $U = H^2\omega^2 Z/c$ and obtained a rotar's energy density in the quantum volume $U_q = k\, mc^2/R_q^3$. If we ignore the dimensionless constant k, this is the rotar's internal energy in the volume of a cube that is R_q on a side. Here are some other equalities for U_q.

$$U_q = \frac{m^4c^5}{\hbar^3} = \frac{E_i}{R_q^3} = H_\beta^4 U_p \qquad \text{set } \frac{m^4c^5G}{\hbar^3} = A_g^2$$

$$U_q = \frac{A_g^2}{G}$$

If we broaden the definition of H_β so that it also defines rotating rate of time gradients and rotating spatial gradients, then the energy density of the rotar model becomes homogeneous. The energy density near the center of a rotar is the same as the energy density near the edge. This energy density is just in two different forms. In chapter 6 we attempted to calculate the angular momentum of a rotar. If we assumed that all the energy was concentrated near the edge of a hoop with radius R_q, then we obtained an answer of angular momentum of $\hbar$. However, if we assumed that the energy was distributed more uniformly (like a disk) then the rotar model would have angular momentum of ½ $\hbar$. The fact that energy is contained in the grav field does smooth out the energy distribution, thereby tending towards the correct answer of ½ $\hbar$.

If a rotating grav field has energy density, does a static gravitational field also have energy density? It is possible to investigate this question because we also have the equation for the static gravitational acceleration produced by a rotar at distance R_q. We can see if a purely static field also is equitable to energy density. Previously we obtained: $g_q/A_g = H_\beta$ and $U_q = A_g^2/G$

$$U_q = \frac{A_g^2}{G} = \frac{L_p^2\omega_c^4}{G} \qquad \text{set } A_g = L_p\omega_c^2$$

The energy density equation seems to imply that an oscillating wave is required for there to be any energy density (if $\omega_c = 0$ then $U_q = 0$). This is reasonable because it is not possible to extract energy from a static gravitational field but it would be possible to extract energy from a rotating gravitational field if the displacement exceeded Planck length. In figure 8-3 the sloping line with small undulations is made up of a DC-like component that does not oscillate and an AC-like component that does oscillate. We interact with the DC-like component which produces the temporal and spatial characteristics that we normally associate with gravity. However, this component has zero frequency and therefore does not have energy density. The AC like component needs to be studied further. It may be the component that converts the observable energy in the early universe into vacuum energy. This will be discussed later. The DC-like components produced by different rotars add constructively to make the curved spacetime we consider the gravity of a massive object.

Energy Density in Dipole Waves: The above insights into the grav field also have implications for any Planck amplitude dipole wave in spacetime, not just the rotating dipoles that form rotars. I am going to talk about dipole waves in spacetime but start off by making an analogy to sound waves in a gas. Sound waves can be depicted with a sinusoidal graph of pressure. The compression regions have pressure above the local norm and the rarefaction regions have pressure below the local norm. These can be represented as a sine wave maximum and minimum. However, if a graph was to be drawn showing the kinetic energy of the molecules in the gas, the maximum kinetic energy occurs in the regions between the pressure maximum and minimum. A kinetic energy graph depicting motion (velocity) left and right would have a 90 degree phase shift to the pressure graph. The energy in the sound wave is being converted from kinetic energy (particle motion) to energy in the form of high or low pressure gas. When these two forms of energy are added together, then a sound wave with a plane wavefront has a uniform total energy density $(\sin^2\theta + \cos^2\theta = 1)$. The energy is just being exchanged between two forms.

This concept of energy being exchanged between two different forms also applies to dipole waves in spacetime. In one form, energy exists because the vacuum energy of spacetime is distorted so that there are regions where the rate of time is faster or slower than the local norm. Perhaps this is analogous to the compression and rarefaction representation of a sound wave. The regions between the maximum and minimum rates of time have the greatest gradient in the rate of time. These are the grav field regions and they are analogous to regions in the sound wave where the gas molecules have the greatest kinetic energy. Adding together the two forms of energy density present in either sound waves or dipole waves in spacetime produces a total energy density without the characteristic wave undulations.

The waves in spacetime have sometimes been discussed emphasizing either the temporal characteristics (rate of time gradients, etc.) or emphasizing the spatial characteristics (for example L_p/r). Actually both characteristics are always present; it is sometimes easier to explain using just one characteristic. Therefore, the grav field could have been explained emphasizing the proper volume gradient rather than the rate of time gradient.

Gravitational Potential Energy Storage: The non-oscillating strain in spacetime produced by a rotar has amplitude of: $H_G = H_\beta^2/\mathcal{N} = \beta = 1 - 1/\Gamma$. For weak gravity we can use the approximation $\Gamma \approx 1 + \beta$. When we look at the gravitational effect that a rotar has on spacetime, we conclude that the slowing of the rate of time also produces a slowing of the normalized speed of light ($C_o = \Gamma C_g$ from chapter 3). To reach this conclusion we must assume that proper length is constant, even when there is a change in Γ. This is an unspoken assumption for physics that does not involve general relativity.

The effect on the rate of time and on the normalized speed of light ultimately effects energy, force, mass, etc. as previously discussed. The reason for bringing this up now is that I want to address gravitational potential energy. Gravitational potential energy is considered a negative energy that has its maximum value in zero gravity and decreases when a mass is lowered into gravity. What physically changes when a rotar is elevated or lowered in gravity?

In chapter 3 it was found that substituting the normalized speed of light C_g and the normalized mass M_g into the equation $E = mc^2$ gives energy that scales inversely with gravitational gamma Γ (rest frame of reference). We illustrated this concept by calculating the difference in the internal energy of a 1 kg mass for an elevation of sea level and one meter above sea level. The calculated difference in the normalized internal energy was 9.8 Joules which is exactly the same as the gravitational potential energy.

This change in energy is due to the change in the normalized speed of light affecting the Compton frequency of the rotar as seen from zero gravity. For example, a free electron in zero gravity has a Compton angular frequency of 7.76×10^{20} s^{-1}. Earth's gravity has $\beta \approx 7 \times 10^{-10}$. A free electron in earth's gravity has a normalized Compton angular frequency that is slower than a zero gravity electron by about 5.4×10^{11} radians per normalized second ($7 \times 10^{-10} \times 7.76 \times 10^{20}$ s^{-1}). This lower Compton frequency decreases the normalized internal energy of an electron and decreases the gravity (non-oscillating strain) generated by an electron. The non-oscillating strain is responsible for the rotar's gravity, so a rotar at rest in gravity contributes less gravity to the total gravity than the same rotar at rest (same temperature) in zero gravity. (Remember that in the normalized system discussed in chapter 3, gravity affects inertia and energy differently.) In this case, gravity scales with energy, not mass. The reduction in gravity generated by an electron in gravity is quite reasonable because energy was lost when an electron goes from being at rest in zero gravity to being at rest in gravity, given the same temperature. For example, an electron on the earth's surface experiences a gravitational magnitude of $\beta \approx 7 \times 10^{-10}$. If the earth were the only body in the universe, then an electron near the earth's surface would have $1 - (7 \times 10^{-10})$ of the energy and gravity of an electron in a "zero gravity" location far from the earth. The electron's missing energy resides somewhere else in the universe. Usually this missing energy is removed by thermal radiation.

These concepts also lead to a physical explanation for potential energy. In chapter 3 the concept of potential energy was related to a reduction in the normalized speed of light reducing the $E = mc^2$ internal energy. Now we go one step further and trace the loss of energy in a gravitational field to a reduction in the rotational frequency of a rotar in a gravitational field. This not only affects the internal energy of the rotar, but it also affects the amount of gravity generated by the rotar.

Since a change in Γ affects mass and energy differently and since gravity scales with energy (not mass), to be technically correct the gravitational equations should be written in terms of energy, not mass. The transformations and insights provided here have forced us to recognize that the term "mass" is a quantification of inertia. Mass is not synonymous with matter and mass scales differently than energy when viewed by an observer using the zero gravity coordinate rate of time.

Personal Note:

I want to tell two short personal stories that relate to this chapter. The first story has to do with the gravitational effect on rotar frequency. I normally run almost every day. Some of the best ideas in this book came to me during these daily runs. Many years ago I used to run on flat ground but to preserve my knees I now run up a steep section of a hill and walk down to the starting point. I repeat this for ½ hour which typically is about 14 round trips. As I run up the hill I often am aware that the work that I am doing is ultimately resulting in an increase in the Compton frequency of all the electrons and quarks in my body. Locally there is no measurable change in the Compton frequencies of these rotars, but using the absolute time scale of a zero gravity observer, I am increasing the frequency of these particles. It somehow is comforting to understand the physics of running up a hill. The concept of "gravitational potential energy" has been demystified. I now understand why it is difficult to run up a hill.

The second story is about the experience of resolving a mystery about gravity. When I was initially writing this book, I thought that I had unlocked the key to understanding gravity when I had developed the concepts presented in chapter 6 (the concepts that are now regarded as being oversimplified). The magnitude of the gravitational force was correct and I thought I could easily extrapolate to larger distances and larger mass. Then it occurred to me that the vector was wrong and it was obvious that I was missing other major concepts. I was far from finishing my quest to explain important aspects of gravity.

My initial reaction was to try to rationalize changes that would make the simplified model explain the correct vector (attraction rather than repulsion). This thought process was something like trying to reverse engineer gravity. I was attempting to work backwards from the desired result (attraction) to find the changes to the model that would give the desired result. I spent a long time working backwards from result to cause, but it was getting nowhere. Therefore, in frustration I returned to the approach that I had previously used to develop the model to that point. That approach merely moved forward from the starting assumption (the universe is only spacetime) and accepted the logical extensions of this assumption. Once I got back on this track, I realized that the energy density of the rotar model implied pressure. When I took the logical steps to contain this pressure, I eventually obtained not only the gravitational force with the correct vector but also obtained improved insights into the strong force, the electromagnetic force and the stability of fundamental particles.

While other people are attempting to adjust models to explain specific physical effects, I am finding that logically extending the starting assumption gives unexpected explanations. The expanded model explains diverse effects not initially under consideration. These experiences have given me a great deal of confidence in this model and approach.

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Chapter 9

Electromagnetic Fields & Spacetime Units

Introduction: In the last chapter we analyzed gravitational attraction and established the necessity of vacuum energy/pressure in generating the gravitational force. This chapter is an introduction to the electromagnetic (EM) radiation and electrical charge. We will start with a preliminary examination of the spacetime characteristics responsible for the electric field of charged particles. After some insights are developed with charged particles we will then switch and examine the properties of spacetime that are affected when electromagnetic radiation is present. An experiment will be proposed. We will then switch back and use some of the insights gained from electromagnetic radiation to develop further the model of a charged particle's electric field. Finally, we will develop a system of fundamental units based only on the properties of spacetime. These units designate charge utilizing only the properties of spacetime.

We tend to think of the electric and magnetic fields associated with EM radiation as being very similar to the electric and magnetic fields associated with charged particles. However, there are obvious differences. The fields associated with EM radiation are always oscillating and they propagate at the speed of light. The fields associated with charged particles are not oscillating and they are not freely propagating. With these differences, it should be expected that there should also be considerable differences in the explanations of the electric field associated with photons compared to the electric field associated with electrons. Developing a model of electric and magnetic fields has been the most difficult task of this entire book. While considerable progress has been made, the model is not complete. Furthermore, the model of the electric field associated with charged particles is less complete than the model of EM radiation. This chapter begins by examining the magnitude and type of distortion of spacetime required to produce elementary charge e.

Spacetime Interpretation of Charge: If the universe is only spacetime, there should be an interpretation of electrical charge, permeability, electric field, etc. that interprets these electrical characteristics using only characteristics of waves and/or a non-oscillating strain in spacetime. It will be recognized that there are two types of electric field: 1) The static electric field associated with a charged particle and 2) the oscillating electric field of electromagnetic radiation. This distinction is made because it will be shown that the electric field associated with a charged particle is more complex. The goal of this section is to quantify the distortion of spacetime required to produce electrical charge. The following calculations will assume that we are dealing only with fundamental rotars of elementary charge $(q = e)$. Effectively this means that we are focusing on the three charged leptons (electron, muon and tauon). Composite particles such as protons are more complex and will be discussed in a later chapter.

We will not be concerned with negative signs, but we will attempt to pay attention to the constants that are associated with electrostatic units. We will start with the force between two elementary charges e separated by distance r:

$$F_e = \left(\frac{1}{4\pi\varepsilon_o}\right)\left(\frac{e^2}{r^2}\right) = \alpha \left(\frac{L_p^2}{r^2}\right) \mathrm{F_p}$$

This equality comes directly from the substitution of $\alpha = e^2/4\pi\varepsilon_o\hbar c$; $L_p^2 = \hbar G/c^3$ and $F_p = c^4/G$. Canceling out the $1/r^2$ terms from this equation we obtain:

$$\left(\frac{1}{4\pi\varepsilon_o}\right) e^2 = \alpha L_p^2 F_p$$

Charge Conversion Constant *η*: This equation will be rearranged to group like terms together. This means that the force related terms (Planck force F_p and the Coulomb force constant $1/4\pi\varepsilon_o$) will be placed on one side of the equal sign and the charge related terms (e and α) will be placed on the other side of the equal sign. The only real question in this grouping is where to place L_p^2. If we place L_p^2 on the charge side then the units of both sides will be (meter/Coulomb)^2 while if we group the L_p^2 on the force side then the units of both sides will be merely Coulomb^2. The objective of this exercise is to designate a constant that converts charge (Coulomb) into a property of spacetime with units of length and/or time. If the universe is only spacetime, then even charge must have an explanation that incorporates only the properties of spacetime. A grouping with units that can be reduced to meters per Coulomb is exactly the type of answer that we want. Therefore, we are going to propose a new constant of nature that converts charge into a strain in spacetime with units of meter/Coulomb. This proposed factor will be called the "charge conversion constant" and designated by the Greek symbol eta (η).

$$\frac{e^2}{\alpha L_p^2} = 4\pi\varepsilon_0 F_\mathrm{p} \equiv \frac{1}{\eta^2}$$

$$\eta \equiv \frac{\sqrt{\alpha} L_p}{e} = \sqrt{\frac{1}{4\pi\varepsilon_o F_p}} \qquad \text{set: } \frac{e}{\sqrt{\alpha}} = q_\mathrm{p} \text{ Planck charge}$$

$$\eta \equiv \frac{L_p}{q_p} = 8.617 \times 10^{-18}\ \mathrm{m/C} \qquad \eta = \text{charge conversion constant (meters/Coulomb)}$$

The proposed charge conversion constant $\eta = L_\mathrm{p}/q_\mathrm{p}$ will serve as the conversion factor between units that contain charge and the distortion of spacetime produced by charge or an electric field. Equating charge to length is not conceptually understandable if we assume length to be static ruler length. It was previously explained that the symbol L_p was wave amplitude with dimensions of length. Similarly, the "meters" in η (meters/Coulomb) is also different from ruler length. Later a physical interpretation will be given to this physical effect that has dimensions of length (meters) but is not the same as ruler length.

The following three equations utilize η to achieve a conversion between SI units incorporating charge and the distortion of spacetime responsible for charge.

$e = \left(\frac{1}{\eta}\right)\sqrt{\alpha}L_p$ elementary charge e conversion

$q_p = \left(\frac{1}{\eta}\right)L_p$ Planck charge q_p converts to a Planck length distortion in spacetime

$\frac{1}{4\pi\varepsilon_o} = \eta^2 F_p$ Coulomb force constant converts to Planck force

Physical Interpretation: Before proceeding to use the charge conversion constant η to transform other units which incorporate charge, we will first examine the physical interpretation of this constant and see if it seems reasonable. What does it mean to say that elementary charge e is somehow related to $\sqrt{\alpha}L_p$? This is a distortion of spacetime with dimensions of length. Part of the physical interpretation will be given here and part will be given later in this chapter. An insight into the physical interpretation of $e = \sqrt{\alpha}L_p/\eta$ can be obtained by expressing the electrical potential (the voltage relative to electrical neutrality) produced by a single charge e when the electrical potential at radial distance r is expressed in dimensionless Planck units. The equation for electrical potential (V) for charge e at distance r, expressed in SI units is: $V = e/4\pi\varepsilon_o r$. We will designate the symbol for electrical potential in dimensionless Planck units as $\underline{\boldsymbol{V}}$ in keeping with the convention previously established for Planck units. To convert conventional electrical potential V to $\underline{\boldsymbol{V}}$ it is necessary to divide by Planck voltage V_p according to the equation

$\underline{\boldsymbol{V}} = \frac{V}{V_p}$ where: $V_p = \frac{E_p}{q_p} = \sqrt{\frac{c^4}{4\pi\varepsilon_o G}} = 1.043 \times 10^{27}$ Volts

Next we will find the electrical potential in Planck units ($\underline{\boldsymbol{V}}$) produced by a single elementary charge e at radial distance r by converting $V = e/4\pi\varepsilon_o r$ to Planck electrical potential units (Planck voltage units if we reference neutrality)

$$\underline{\boldsymbol{V}} = \left(\frac{e}{4\pi\varepsilon_o r}\right)\sqrt{\frac{4\pi\varepsilon_o G}{c^4}} = \left(\frac{1}{r}\right)\sqrt{\frac{e^2}{4\pi\varepsilon_o \hbar c}}\sqrt{\frac{\hbar G}{c^3}}$$

$$\underline{\boldsymbol{V}} = \frac{\sqrt{\alpha}L_p}{r}$$

Converting the electrical potential to Planck units reveals the effect on spacetime produced by charge e at distance r. Planck electrical potential V_p represents the theoretical largest electrical potential that spacetime can sustain. It can be shown that achieving Planck electrical potential represents the energy density and dimensions that would form a black hole. Planck electrical potential V_p is equivalent to $\underline{\boldsymbol{V}} = 1$. This represents the maximum possible strain of spacetime (100% strain of spacetime). Expressing electrical potential in dimensionless Planck units is expressing the fractional strain of spacetime on the universal scale where the maximum possible strain is $\underline{\boldsymbol{V}} = 1$.

Another concept can be best explained with a numerical example. At a distance of 10^{-12} m from an electron we would have $\underline{\boldsymbol{V}} = 1.38 \times 10^{-24}$ and 1 meter from an electron the value would be $\underline{\boldsymbol{V}} = 1.38 \times 10^{-36}$. Extending either of these slopes back to the center of the electron (10^{-12} m or 1 m respectively) gives a Z axis intersection equal to $\sqrt{\alpha}L_p$ meters (1.38×10^{-36} m). For comparison, Z axis intersection for a hypothetical Planck charge q_p would be Planck length. The strain of spacetime produced by a charge can be thought of as $\Delta L/L$ which at radial distance r can be expressed as $\Delta L/r$. For a single elementary charge e at any distance the ΔL term is always equal to $\sqrt{\alpha}L_p$ meters. This results in the following strain equation:

$\Delta L/r = \underline{\boldsymbol{V}} = \sqrt{\alpha}L_p/r$ strain in spacetime at distance r from charge e

An explanation will be given later in this chapter of the type of distortion (with dimensions of length) which is associated with electrical potential. However, here it is possible to describe the magnitude of this distortion between two points at different distances from charge e. We will designate these points as r_1 and r_2 where $r_2 > r_1$. An electron (charge e) produces a strain in spacetime that results in a type of length change (ΔL) obtained from integration of the strain curve and equal to:

$\Delta L = \sqrt{\alpha}L_p \ln(r_2/r_1)$ distortion produced by the electron's charge between r_2 and r_1

For example, if $r_2 = 1$ meter and $r_1 = 10^{-12}$ meter, then $\Delta L = 2.36 \times L_p \approx 3.8 \times 10^{-35}$ m. While this seems like a very small net distance, it must be remembered that the strain is affecting the enormously large energy density of vacuum energy. Later it will be shown that this type of strain of spacetime can produce the magnitude of the force we expect of an electric field acting on an electron (rotar). If there are multiple charges, the strain produced by each elementary charge is a vector which adds to the vector strains produced by all the other charges. For example, if there are a large number of electrons (n_e electrons) on a charged sphere, then the value of ΔL becomes:

$\Delta L = n_e\sqrt{\alpha}L_p \ln(r_2/r_1)$ distortion produced by n_e electrons

The ability to increase ΔL by increasing the charge (increasing n_e) suggests the possibility of an experiment which will be discussed later.

Use of the Charge Conversion Constant η: We will now return to the discussion of the charge conversion constant η. It is easiest to explain the use of η with an example. The units of the Coulomb force constant $(1/4\pi\varepsilon_o)$ are m^3kg/C^2s^2 or in dimensional analysis terminology this is: L^3M/Q^2T^2. If we want to eliminate charge squared from the denominator, we must multiply the Coulomb force constant by $1/\eta^2$ which is multiplying by units of Coulonmb²/meter².

This conversion of the Coulomb force constant to Planck force does not seem intuitively reasonable because Planck force ($\sim10^{44}$ N) is such a big number. However, this conversion is correct as illustrated by an example. Imagine what would happen if we were dealing with two charged point particles (each with charge e) and it was possible to reduce the separation distance r between these point particles down to Planck length $(r = l_p)$. In this case the electrostatic repulsion indeed would be equal to the fine structure constant times Planck force (αF_p). The equivalence to Planck force extends to any other value of separation distance r because increasing the separation distance from Planck length to separation distance r decreases the force from αF_p to $\alpha F_p(L_p^2/r^2)$.

The following is a conversion of vacuum permittivity ε_o and vacuum permeability $\mu_o = 1/\varepsilon_o c^2$ into a distortion of spacetime:

$\varepsilon_o = \left(\frac{1}{\eta^2}\right)\frac{1}{4\pi F_p}$ vacuum permittivity conversion

$\mu_o = \eta^2\, 4\pi c^2/G$ vacuum permeability conversion

Impedance Calculation

Before proceeding with the following calculation, I want to tell a story. There are two calculations in this book that gave me the biggest thrill. One of them was when I was able to derive Newton's gravitational equation from my starting assumptions. The second is the following calculation that converts the impedance of free space Z_o into a distortion of spacetime. This does not seem like a particularly important relationship, which is perhaps the reason that it was so surprising.

Impedance of Free Space and Planck Impedance: The impedance of free space Z_o is a physical constant that relates the magnitudes of the electric field $\mathcal{E}$ and the magnetic field strength $\mathcal{H}$ in electromagnetic radiation when this electromagnetic radiation is propagating through a vacuum.

$Z_o \equiv \mathcal{E}/\mathcal{H} = \mu_0 c = \frac{1}{\varepsilon_o c} = \sqrt{\frac{\mu_o}{\varepsilon_o}} \approx 376.7\ \Omega$ impedance of free space

Planck impedance Z_p is:

$Z_p = \frac{Z_o}{4\pi} = \frac{1}{4\pi\varepsilon_o c} \approx 29.98\ \Omega$ Planck impedance

Planck units relate most closely to the spacetime wave calculations made previously, so we will first convert Planck impedance into a property of spacetime. The units of the impedance of free space Z_o and Planck impedance Z_p are: L^2M/Q^2T. Therefore to eliminate $1/Q^2$ we must multiply $Z_p = (1/4\pi\varepsilon_o c)$ by $1/\eta^2 = 4\pi\varepsilon_o F_p$.

$$\left(\frac{1}{\eta^2}\right) Z_p = \left(\frac{4\pi\varepsilon_o c^4}{G}\right)\left(\frac{1}{4\pi\varepsilon_o c}\right) = \frac{c^3}{G} = Z_s$$

$$Z_p = \eta^2 Z_s \quad \text{and} \quad Z_o = \eta^2\, 4\pi Z_s$$

Planck impedance Z_p corresponds to the impedance of spacetime Z_s and the impedance of free space Z_o corresponds to $4\pi Z_s$ – **Fantastic!**

Planck Impedance Converts to the Impedance of Spacetime: When we convert Planck impedance using the charge conversion constant, Planck impedance becomes the impedance of spacetime $(Z_p = \eta^2 Z_s)$. Also, the impedance of free space is: $Z_o = \eta^2 4\pi Z_s$ with this conversion. This is a fantastic outcome because it implies that electromagnetic radiation is some form of wave in spacetime. Spacetime has the highest possible impedance of $Z_s = c^3/G \approx 4 \times 10^{35}$ kg/s. Now we discover that not only does electromagnetic radiation propagate at the same speed as gravitational waves, but electromagnetic radiation also experiences the same impedance as gravitational waves (the impedance of spacetime). The conclusion is:

Electromagnetic radiation must be a wave in the sea of vacuum fluctuations of spacetime.

The equation $Z_s = c^3/G$ is only applicable when waves use spacetime as the propagation medium. This is understandable and fully expected for gravitational waves, but now we find that electromagnetic radiation must also use spacetime as the medium. The impedance of free space Z_o (fundamental to everything electromagnetic) is: $Z_o = \eta^2 4\pi Z_s$ when expressed using a conversion constant η that converts charge to dynamic length. This says that photons are not packets of energy that travel <u>THROUGH</u> spacetime. Photons are waves <u>IN</u> the medium of spacetime. They appear to also have particle properties because photons possess quantized angular momentum. The proposed property of unity makes the energy in the distributed waves collapse (transfer their quantized angular momentum) at faster than the speed of light. This apparently localized interaction gives particle-like properties to waves in spacetime that possess quantized angular momentum.

The waves that form a photon are not dipole waves in spacetime since we can detect light waves as discrete waves. It is impossible to detect dipole waves in spacetime with the Planck length/time limitation because they are below the quantum mechanical detectable limit. However, light waves still must be a wave disturbance of spacetime. The equation $Z_o = \eta^2 4\pi Z_s$ also implies that photons are first cousins to gravitational waves. Photons and gravitational waves disturb spacetime's sea of superfluid dipole waves in different ways, but they both are transverse disturbances in spacetime that do not modulate the rate of time. Recall from chapter 4 that spacetime is an elastic medium with impedance and the ability to store energy and return energy to a wave propagating in this medium. The implication is that gravitational waves are also quantized and carry quantized angular momentum, just like photons.

Is it reasonable that light waves are propagating in the medium of spacetime? For example, the Michelson-Morley experiment and spacial relativity prove that the speed of light is constant in all frames of reference. Gravitational waves are definitely propagating in the medium of spacetime and they always propagate at the speed of light. Therefore spacetime, with its chaotic dipole waves, possesses the properties required to make the speed of light constant in all frames of reference.

Accuracy Check: There is another more subtle implication from the equation $Z_p = \eta^2 Z_s$. This equation implies to me that the many steps that started with gravitational wave equations and ended with this relationship are probably correct. The impedance of spacetime c^3/G was deduced from gravitational wave equations. The impedance of free space Z_o was derived from Maxwell's equations of electromagnetism. Starting from the assumption that the universe is only spacetime, we went looking for a constant to convert charge into a distortion of spacetime. This resulted in $Z_o = \eta^2 4\pi Z_s$. These apparently dissimilar impedances are the same when we use the charge conversion constant η. The impedance of spacetime $Z_s = c^3/G$ was first deduced from a comparison of a gravitational wave equation with the equation for sound waves. Since that time, there were many steps that led to this point. I cannot say that this equality proves that these intermediate steps were correct, but it certainly gives support to this contention.

Wave Equation: The electromagnetic wave equation, derived from Maxwell's equations, proves that electromagnetic radiation (photons) have an interaction with the properties of spacetime. The homogeneous form of the wave equation can be written in terms of either the electric field $\boldsymbol{\mathcal{E}}$ or the magnetic field $\boldsymbol{\mathcal{B}}$.

$$\left(\Delta^2 - \varepsilon_o \mu_o \frac{\partial^2}{\partial t^2}\right)\boldsymbol{\mathcal{E}} = 0$$

$$\left(\Delta^2 - \varepsilon_o \mu_o \frac{\partial^2}{\partial t^2}\right)\boldsymbol{\mathcal{B}} = 0$$

In these equations, Δ^2 is the Laplace operator. No attempt will be made to explain these two forms of the electromagnetic wave equation. Detailed explanations are available in standard texts. The reason for showing these equations is to emphasize the point that ε_o and μ_o are required for the description of an electromagnetic wave. If a photon was an energy packet propagating like a bullet through the void of a vacuum, then the properties of the void would not be needed to express the propagation. However, if a photon is a quantized wave propagating in the medium of spacetime, then the properties of the medium ($\varepsilon_o = 1/\eta^2 4\pi F_p$ and $\mu_o = \eta^2 4\pi c^2/G$) would be required in the equation expressing the propagation characteristics. This insight offers additional proof that light is a wave with quantized angular momentum propagating in the medium of spacetime.

Spacetime Model of an Electric Field

Electric Field Conversion: Next we will attempt to gain additional insights into electric fields. An electric field produced by a charged particle is more complex than an electric field produced by electromagnetic radiation. Therefore we will switch to electromagnetic radiation to examine electric and magnetic fields then come back to charged particles later.

In chapter 4 it was stated that the wave-amplitude equation for intensity ($\mathcal{I} = kH^2\omega^2 Z$) is a universal classical equation that is applicable to waves of any kind provided that the amplitude and impedance is stated in units that are compatible with this equation. Unfortunately, electromagnetic radiation commonly uses electric field $\boldsymbol{\mathcal{E}}$ for wave amplitude and the impedance of free space for impedance ($Z_o \approx 377$ ohms). This way of stating amplitude and impedance is not compatible with the above wave-amplitude equation. Therefore, this creates the impression that this wave-amplitude equation is less than universal. However, it is possible to convert electric field of EM radiation into an amplitude term that is compatible with the 5 wave-amplitude equations. For example, amplitude of EM radiation can be expressed using strain amplitude H, angular frequency ω and the impedance of spacetime Z_s. It is informative to analyze the connection between electric field (or magnetic field) and the strain in spacetime. This can be easily done using the two different ways of expressing intensity: $\mathcal{I} = kH^2\omega^2 Z_s$ and $\mathcal{I} = ½\,\mathcal{E}^2/Z_o$. We will equate these and solve for $\boldsymbol{\mathcal{E}}$ and $\boldsymbol{\mathcal{H}}$. Since these assume EM radiation and not necessarily the electric field of a charged particle, we will designate the electric field of EM radiation as $\boldsymbol{\mathcal{E}}_\gamma$ and the magnetic field as $\boldsymbol{\mathcal{H}}_\gamma$.

$\boldsymbol{\mathcal{E}}_\gamma^2/Z_o = H^2\omega^2 Z_s$ intensity equations ignoring numerical factors near 1

$\boldsymbol{\mathcal{E}}_\gamma = H\omega\sqrt{Z_s Z_o} = \frac{H\omega c}{\sqrt{G\varepsilon_o}}$ $\boldsymbol{\mathcal{E}}_\gamma$ = Electric field of EM radiation expressed utilizing H, ω, Z_s and Z_o

$\boldsymbol{\mathcal{H}}_\gamma = H\omega\sqrt{\frac{Z_s}{Z_o}} = H\omega\sqrt{F_p\varepsilon_o}$ $\boldsymbol{\mathcal{H}}_\gamma$ = magnetic field of EM radiation obtained from $\boldsymbol{\mathcal{H}}_\gamma = \boldsymbol{\mathcal{E}}_\gamma/Z_o$

This is interesting, but it still uses Z_o and ε_o which implies charge. Next we will convert the electric field and magnetic field of EM radiation into a distortion of spacetime using η.

$\boldsymbol{\mathcal{E}}_\gamma = \eta H\omega Z_s$ $\boldsymbol{\mathcal{E}}_\gamma$ = electric field strength of EM radiation

$\boldsymbol{\mathcal{H}}_\gamma = (1/\eta)H\omega$ $\boldsymbol{\mathcal{H}}_\gamma$ = magnetic field strength of EM radiation

These equations express $\mathcal{E}$ and $\mathcal{H}$ in terms of $H\ \omega$ and Z_s. However, the remaining task is to be able to define the electromagnetic wave amplitude as a strain in spacetime (define amplitude H). Also, there should be a factor of $\sqrt{4\pi}$ in these equations, but there are other unknown numerical factors near 1 which have been ignored, so these equations are stated ignoring all numerical factors near 1.

What Is an Electric Field? I find the currently accepted explanation of an electric field as totally inadequate. The electromagnetic force that exists between charged particles is supposedly carried by exchanging virtual photons. This almost seems plausible until it is examined more carefully. Photons generate electric fields and can accelerate charged particles (Thompson scattering). Do real photons generate an electric field by sending out transverse virtual photons? Why do virtual photons transfer force but not angular momentum? Why does an electric field have energy density if the energy of virtual photons averages out to zero? How exactly do virtual photons achieve attraction? What prevents the energy density (the implied pressure) of a static electric field from dissipating? I could go on with more examples, but the truth is that there are so many conceptual mysteries in the quantum mechanics that physicists learn to embrace the lack of conceptual understanding. The desire for conceptual understanding is often criticized as a ruminant of classical physics that cannot be fulfilled by quantum mechanics. The equations of quantum mechanics obviously are correct but the conceptual models are lacking. The objective of this book is to present a new model that is conceptually understandable yet is compatible with the equations and experimental verifications of quantum mechanics and general relativity. We start with the electric field associated with EM radiation.

Maximum Confinement of a Photon: Before developing a model of a freely propagating photon in chapter 11, we will first look at the simplified case of a photon confined to a reflecting chamber. If we had 100% reflecting walls, what is the smallest volume that would confine a single photon? Combining the transmission characteristics of waveguides with the resonance characteristics of lasers, it is possible to answer this question. In waveguides, a sharp cutoff occurs when the width of the waveguide in the polarization direction is equal to or less than ½ wavelength. However, the width needs to only be slightly larger than ½ wavelength to achieve good transmission. For linearly polarized electromagnetic radiation the width transverse to the linearly polarized direction can be ¼ wavelength. For circularly polarized electromagnetic radiation, a cylindrical waveguide slightly more than ½ wavelength in diameter has good transmission and mode characteristics. Making a waveguide into a resonator requires adding two flat and parallel reflectors separated by ½ wavelength and oriented perpendicular to the axis of the cylinder. This cylindrical waveguide resonator is the minimum evacuated volume (maximum confinement) that we can achieve for coherent circularly polarized light of a particular wavelength. This configuration will be called the "maximum confinement resonator" and will be utilized in both calculations and a proposed experiment later.

When electromagnetic radiation is freely propagating, the electric and magnetic fields are perpendicular to each other and in phase. However, when electromagnetic radiation is confined in a resonator such as the maximum confinement waveguide resonator described here (or even in a laser resonator) the radiation forms standing waves that have the electric and magnetic fields 90° out of phase. This is easiest to see by imagining electromagnetic radiation reflecting off a metal mirror. The electric field is a minimum at the surface of each mirror but the magnetic field is at a maximum at the mirror surfaces. The electrons in the metal mirror are undergoing a motion that minimizes the electric field but this creates an oscillating magnetic field. If the reflectors are separated by ½ wavelength, the standing wave created between the two mirrors has maximum electric field oscillations in the central plane of the ½ wave cavity (antinode) and the minimum electric field at the mirror surfaces (nodes). Conversely, the magnetic field is at a minimum (node) in the central plane and at a maximum at the mirror surfaces (antinodes).

Displacement of Spacetime Produced by a Single Photon: Next we will calculate the displacement of spacetime produced by a single photon in this maximum confinement resonator. By specifying the "maximum confinement condition", we can avoid specifying the characteristics of a freely propagating photon that will be discussed in chapter 11. Since we are ignoring numerical factors near 1, we will model the displacement required to produce a uniform oscillating electric field in a maximum confinement volume of $\lambda\!\!\!^-{}^3$. In the resonant waveguide described, the dimensions are approximately $\pi\lambda\!\!\!^-$ rather than just $\lambda\!\!\!^-$, but the electric field strength is also minimum at the walls and maximum in the center. Also we are not specifying whether we are designating the peak electric field strength or the RMS electric field strength. Therefore, ignoring these factors (assuming a volume of $\lambda\!\!\!^-{}^3$), the energy density of a single photon with energy $\hbar\omega$ and uniform energy density in a volume of $\lambda\!\!\!^-{}^3$ we have:

$U = \hbar\omega/\lambda\!\!\!^-{}^3 = \hbar c/\lambda\!\!\!^-{}^4 = \hbar\omega^4/c^3 = (L_p/\lambda\!\!\!^-)^4 U_p$.

To find the displacement amplitude of spacetime required to produce this energy density, we will equate $U = \hbar\omega^4/c^3$ with $U = H^2\omega^2 Z_s/c$ and solve for ΔL in $H = \Delta L/\lambda\!\!\!^-$.

$$U = \frac{\hbar\omega^4}{c^3} = \frac{H^2\omega^2 Z_s}{c} = \left(\frac{\Delta L^2\omega^2}{c^2}\right)\omega^2\left(\frac{c^3}{G}\right)\left(\frac{1}{c}\right) = \frac{\Delta L^2\omega^4}{G} \qquad \text{solve for } \Delta L$$

$\Delta L = \sqrt{\frac{\hbar G}{c^3}} = L_p$ displacement amplitude of a single photon in "maximum confinement"

$H = L_p/\lambda\!\!\!^-$ the strain amplitude H of a single photon in "maximum confinement"

The equation $\Delta L = L_p$ is for a single photon in volume $\lambda\!\!\!^-{}^3$. Therefore this calculation presumes a total path length of $\lambda\!\!\!^-$ (ignoring numerical factors near 1). A total path length of $\pi\lambda\!\!\!^-$ (the diameter of the maximum confinement waveguide) is within the allowed range, especially since the electric field is maximized over the central $ƛ$. Since photons are bosons and many photons can occupy the same volume, we will next calculate the displacement of spacetime required if many coherent photons (same frequency and phase) are introduced into the volume $ƛ^3$. In this calculation we will use "n_γ" as the number of photons occupying the volume. Therefore $U = n_\gamma \hbar\omega/ƛ^3 = n_\gamma \hbar\omega^4/c^3$.

$$U = \frac{\Delta L^2 \omega^4}{G} = \frac{n_\gamma \hbar \omega^4}{c^3} \qquad \text{Solve for } \Delta L$$

$$\Delta L = \sqrt{n_\gamma}\, L_p \qquad \text{displacement amplitude } n_\gamma \text{ photons in "maximum confinement"}$$

The equation $\Delta L = \sqrt{n_\gamma}\, L_p$ is the oscillating displacement of spacetime for "n_γ" photons in the maximum confinement previously discussed. This value of ΔL is over distance $ƛ$, therefore the strain in spacetime produced by n_γ coherent photons in maximum confinement is:

$$H = \frac{\Delta L}{L} = \frac{\sqrt{n_\gamma} L_p}{ƛ} \qquad \text{strain produced by } n_\gamma \text{ coherent photons in maximum confinement}$$

The equation $\Delta L = \sqrt{n_\gamma} L_p$ is very revealing. It is not possible to detect both the wave properties and particle properties of a single photon because that would be attempting to detect a displacement of Planck length. References in chapter 4 showed that it is fundamentally impossible (device independent) to detect a displacement of spacetime equal to or less than Planck length. It is theoretically possible to detect the wave properties of many photons ($n_\gamma >> 1$ photons) because many coherent photons produces $\Delta L >> L_p$. Now we can conceptually understand this effect.

Comparison of Electric Fields: Previously it was calculated the value of ΔL for n_e electrons on a charged sphere. We now have an equation for the value of ΔL produced by n_γ photons in the maximum confinement. Comparing these equations we have:

$\Delta L = n_e \sqrt{\alpha} L_p \ln(r_2/r_1)$ displacement of spacetime produced by n_e electrons between r_2 and r_1

$\Delta L = \sqrt{n_\gamma} L_p$ displacement of spacetime produced by n_γ photons in volume $ƛ^3$ over distance $ƛ$

Upon initial examination it appears as if there must be a difference between the ΔL produced by photons and electrons for equal electric fields. The ΔL effect from photons scales with the square root of the number of photons $\sqrt{n_\gamma}$ while the ΔL produced by electrons is linear with n_e but contains the factor of $\sqrt{\alpha}$. The calculation is not shown here, but if we assume a vacuum capacitor with a volume equal to the $ƛ^3$ volume of the maximum confinement cavity, it works out that equal electric fields produce equal values of ΔL (ignoring numerical factors near 1).

Similarity to Gravitational Wave: We previously learned that Planck impedance Z_p is the same as the impedance of spacetime Z_s when we use the charge conversion constant η. This conversion constant and a wave-amplitude equation also give that n_γ photons in the maximum confinement condition gives the oscillating strain amplitude in spacetime H equal to $H = \sqrt{n_\gamma}\, L_p/\lambda\!\!\!^-$. This implies that electromagnetic waves are very similar to gravitational waves. While gravitational waves appear to be completely dissimilar to electromagnetic waves, they must be first cousins. Both are transverse waves that propagate at the speed of light through the medium of the vacuum energy that is spacetime. They both experience the same impedance therefore electromagnetic waves must also be waves in spacetime. The quantum mechanical description of spacetime is vacuum fluctuations with Planck length/time displacements at all frequencies up to Planck frequency. This description of spacetime has a high energy density. Spacetime has elasticity and very large impedance. Waves in spacetime propagate at the speed of light but the displacement of spacetime is very small because spacetime also has an incredibly large bulk modulus. A single photon in maximum confinement (volume $\lambda\!\!\!^-{}^3$) only affects spacetime by a Planck length displacement over a distance of $\lambda\!\!\!^-$.

One of the biggest differences is that positive and negative electrically charged particles are available to generate electromagnetic radiation. Gravitational waves can only be generated by particles that have a single polarity (only positive mass) therefore only quadrupole gravitational waves are possible. However, if we are attempting to understand the physics of electromagnetic radiation propagating in spacetime the differences in generation are not too important.

A gravitational wave is a transverse wave that causes a spherical volume to become a transverse oscillating ellipsoid. If we freeze this ellipsoid for a moment there is an axis that increases the distance between points and an orthogonal axis that decreases the distance between points. However, there is no polarization vector that distinguishes between opposite directions along either of these two axes. The effect on spacetime by gravitational waves is symmetrical (reversible). This effect can be thought of as a difference between the coordinate speed of light and the proper speed of light along the two axes. We interpret this difference as a change in the distance between points because we assume that the proper speed of light is constant. Also, all physical objects (meter sticks, proton radius, etc.) scale their size with proper length which in turn scales with the proper speed of light. This is understandable from the proposed spacetime based model of the universe because all matter and forces are ultimately dipole waves in spacetime which scale with the proper speed of light.

Electromagnetic Vectors: Electromagnetic radiation has transverse oscillating electric and magnetic fields. If we imagine freezing the wave, the electric field has a specific vector direction which by convention we say points away from positive and towards negative and the magnetic field by convention points from North to South. Therefore one difference between an electromagnetic wave and a gravitational wave is that the electromagnetic wave produces transverse vectors which are unsymmetrical (electric and magnetic fields) while the gravitational wave is a symmetrical transverse wave. We can also designate the unsymmetrical effect on spacetime produced by EM radiation as “polarized spacetime”. Both EM radiation and gravitational waves do not modulate either the rate of time or proper volume. The impedance of free space (associated with electromagnetic radiation) is the same as the impedance of spacetime (associated with gravitational waves) when charge is converted to a length distortion of spacetime. Therefore electromagnetic waves are also waves in the vacuum fluctuations of spacetime.

If we are going to explain electromagnetic fields using only the properties of spacetime, it is necessary to incorporate into the explanation a nonreversible (polarized) effect that does not produce an oscillation of either proper volume or the rate of time. Explaining an electric field (and later a magnetic field) using only the properties of spacetime has been the most difficult task (invention) of any creative new idea described in this book. In particular, it was difficult to 1) initially recognize that the solution must involve polarized spacetime, 2) to find a model that would generate the correct force 3) not modulate proper volume and 4) result in the unsymmetrical (polarized) characteristics required for an electric field. For example, there must be a physical difference between the positive electric field direction and the negative electric field direction (the opposite direction). This requires asymmetry in the spacetime model of both electric and magnetic fields. This asymmetry necessitates the consideration of an unconventional solution.

It is proposed that an electric field is a distortion of one spatial dimension of spacetime that results in a slight asymmetric speed of light in opposite propagation directions. This produces a one way distance between points measured by light propagation time in the positive electric field direction that is different than the light propagation time between the points measured in the negative electric field direction. There is no net proper volume change or no net rate of time change because the round trip time between the points is unchanged (except for a slight gravitational effect discussed later).

While this proposal was developed by examining the electric field of a confined photon, it applies equally to the electric field produced by a charged particle. However, the electric field produced by a charged particle is more complex than the electric field produced by a confined photon. In chapter 11 it will be proposed that that the charged particle not only has a non-oscillating strain that we know as the particle’s electric field, but there is also an standing wave that is oscillating at the rotar’s Compton frequency. It is the interaction of this oscillating standing wave with vacuum energy that produces the non-oscillating strain (the particle’s electric field). The distortion of spacetime that produces a magnetic field will be discussed later.

Gravitational Wave Comparison: Electromagnetic radiation is a first cousin of a gravitational wave. They both are transverse waves that propagate at the speed of light in the medium of spacetime. They both experience the same impedance of spacetime ($Z_s = c^3/G$). Another way of saying this is that they both propagate as a quantized angular momentum disturbance in the superfluid dipole waves that is spacetime. Therefore, what is the key difference? A gravitational wave produces an oscillating distortion of the two spatial dimensions - transverse to the propagating direction. A spherical volume becomes an oscillating ellipsoid with one transverse dimension elongating while the orthogonal transverse dimension contracts. There is no change in the net volume.

The electric field direction of electromagnetic radiation is proposed to distort only one transverse dimension. This is easier to visualize if we imagine a static electric field – for example, the electric field between two parallel plates of a vacuum capacitor. Polarized spacetime is spacetime that has a different property in opposite propagation directions. Furthermore, we know that the polarization effect cannot produce a net change in proper volume. A gravitational wave meets this requirement because the increase in one dimension is offset by a decrease in the orthogonal transverse dimension. An electric field is similar, except simpler. The dimensional increase and decrease happens in the same dimension. One propagation direction experiences the increase while the opposite propagation dimension experiences the decrease. The round trip propagation time (round trip distance) is unchanged.

We know that an electric field must have some difference between the positive electric field vector and the negative electric field vector. The proposed difference is the simplest possible difference that produces a net polarization of spacetime without also producing a net change in volume or a net change in the rate of time. This proposed model of an electric field will be further supported in chapter 10 by a calculation which shows that this model produces the correct electrostatic force between rotars with elementary charge *e*. The calculation cannot be presented here because it requires the introduction of additional concepts.

Note to Reader: *The following pages contain proposed experiments. They are presented in the chronological order that they were developed. These experiments are theoretically possible but they have practical difficulties because the effects are small. However, the description of these difficult experiments expands the model.*

Proposed Experiment Using Photons: Earlier in this chapter a "maximum confinement resonant waveguide" was described. Briefly this cavity was a reflecting cylindrical cavity slightly more than ½ wavelength in diameter with flat reflective surfaces separated by ½ wavelength oriented perpendicular to the cylindrical axis. This cavity will confine circularly polarized photons in the minimum resonant volume. When a standing EM wave is set up in this cavity, the maximum rotating electric field strength would be in the central plane that is half way between the flat reflectors. A standing EM wave has the electric and magnetic fields 90° out of phase. This is different than a traveling EM wave which has these two fields in phase. Therefore, the rotating "standing wave" that forms in this cavity would have the magnetic field minimized in the central plane where the electric field is at its maximum.

It is hypothetically possible to detect a periodic path length change in a plane perpendicular to the cylindrical axis provided that there are a large number of photons resonating in the cavity. We previously calculated that a single photon in this maximum confinement cavity would produce displacement amplitude equal to dynamic Planck length across the distance of $\lambda\!\!\!^-$ (ignoring a numerical factor near 1). It is impossible to detect this short a path length change but many coherent photons (n_γ photons) produce displacement amplitude of $\sqrt{n_\gamma}L_p$ which is theoretically detectable if $n_\gamma >> 1$. If this is correct, then it should be possible to characterize the displacement of spacetime produced by the electric field and the magnetic field using two beams of light propagating in opposite directions perpendicular to the microwave radiation. We will discuss the effect of a magnetic field on spacetime later, so for now we will only discuss the effect of the rotating electric field. The rotating electric field should produce an unsymmetrical displacement (opposite sign for opposite directions) of $\sqrt{n_\gamma}L_p$ and this effect would be maximum in the center of the cavity.

To detect this effect, counter propagating laser beams wound propagate through the central plane of the resonant microwave cavity. The path length that these beams experience should be modulated by the electric field of the rotating radio wave. At any instant in time one direction would be experiencing an elongation in the optical path length of the probe laser beam while the opposite direction would experience a decrease in the optical path length. This effect would then reverse every half cycle of the radio wave. If the beams are combined in a beam splitter after a single pass through the chamber, then the two combined output beams should exhibit a slight amplitude modulation at either the frequency of the radio wave or twice the frequency of the radio wave depending on the phase relationship of the two laser beams. The two output beams exiting the measurement interferometer would be amplitude modulated 180° out of phase. To increase the strength of the modulation, it would be desirable to have the laser beams make multiple passes through the chamber. This is possible provided that the optical path is chosen such that the effect is additive.

An example will be given of a hypothetical experiment. Suppose we assume a maximum confinement resonant cavity is constructed for a radio wave with a reduced wavelength of $\lambda\!\!\!^- = 1$ m (angular frequency of $\omega \approx 3 \times 10^8$ s^{-1}). This cavity would have a ½ wavelength dimension of π meters and resonate at about 48 MHz. If we ignore numerical factors near 1, we can say that the central volume containing the strongest electric field has volume of $\lambda\!\!\!^{-3} \approx 1$ m^3. If a single photon at the resonant frequency is placed into the cavity, then the proposed difference in the optical path length between two laser beams propagating in opposite directions across the width of the cavity one time would be equal to about Planck length. At a frequency of 48 MHz a single photon has energy of 3 x 10^{-26} Joules.

Many coherent photons (n_γ photons) would produce a path length difference between the opposite propagating beams approximately equal to $\sqrt{n_\gamma}\ L_p$. For example, suppose that the resonant cavity had a Q of 10,000. Then perhaps it is possible to obtain a confined radio wave with total short term energy of 30,000 Joules in this cavity. At a frequency of 48 MHz this would be 10^{30} photons and the single pass oscillating path length change would be about 10^{15} times greater than Planck length (~ 10^{-20} m). Multiple passes (ℕ passes) could achieve a path length difference of about 10^{15} x L_p x ℕ meters. For example, the LIGO experiment currently attempting to detect gravitational waves uses a Fabry-Perot interferometer that achieves a sensitivity equivalent to $\mathbb{N} \approx 1{,}000$.

If the cavity had a diameter exactly equal to ½ wavelength of the radio wave, then this circularly polarized radio wave would rotate 180° in the time required for the laser beam to propagate once across the cavity. Since the diameter needs to be slightly larger than ½ wavelength, this means that one of several possible provisions must be made to keep multiple passes of the laser beam in phase with the rotating radio wave to achieve an additive effect.

The hypothetical experiment described here indicates that it is theoretically possible to detect an effect because the displacement of spacetime is much bigger than the theoretical detectable limit of Planck length. However, there is a question of whether current technology is capable of detecting the small displacement described here. For example, the single pass displacement of roughly 10^{-20} meter is less than the single pass detectable limit of the LIGO experiment.

Experiment Using Particle Accelerators: The previous experiment suggested to detect the polarization of spacetime produced by the electric field of EM radiation involved a hypothetical experiment that would require the construction of a specialized RF resonant cavity. It should also be possible to devise an experiment which used an electric field generated by charged particles rather than photons. In the simplest case, imagine a parallel plate vacuum capacitor which consists of two parallel plates separated by distance L_1 where the plates have dimensions larger than L_1. It was previously shown in this chapter that $\Delta L/r = \underline{V}$ where $\underline{V}$ is voltage in Planck units. If we equate $r = L_1$, the electric field induced strain $\Delta L/L_1$ and the value of ΔL between the two plates of a vacuum capacitor is:

$\Delta L/L_1 = \underline{V}$ $\Delta L/L_1$ = the strain in spacetime between two charged plates separated by L_1
$\Delta L = \underline{V}\,L_1$ ΔL = difference in one way optical path length between two charged plates
$\underline{\boldsymbol{\Delta L}} = \underline{V}\,\underline{\boldsymbol{L}}_1$ another way of expressing $\Delta L = \underline{V}\,L_1$ where all terms are in Planck units

$\Delta L = \underline{V}\,L_1$ can be expressed using SI units of voltage as follows:

$\Delta L = \underline{V}\, L_1$ set $\underline{V} = V/V_p$ and $V_p = \sqrt{\frac{F_p}{4\pi\varepsilon_o}}$ = 1.043 x 10^{27} Volts therefore:

$\Delta L = \frac{VL_1}{V_p} = VL_1\sqrt{\frac{4\pi\varepsilon_o}{F_p}} = VL_1/1.043 \times 10^{27}$ Volts

A linear particle accelerator is essentially a series of capacitors with an axial bore and phased electrical potential. These capacitors are driven by klystrons which are generating an oscillating electric field. For example, the Stanford Linear Accelerator is driven at 2.856 GHz which has a half wavelength of about 5.2 cm. The significance of this is that the propagating electric field generated in the accelerator reverses its polarity every 5.2 cm. Parts of a beam of laser light would always be experiencing a positive electric field and parts of the beam (5.2 cm separation) would always be experiencing a negative electric field (assuming proper phasing). The reversal in electric field happens every 5.2 cm. A Michelson interferometer has two arms that can be adjusted to have different optical path lengths. There should be a slight difference in the interference when the arms have equal path lengths compared to when the arms are unequal by 5.2 cm (by ½ of the microwave wavelength).

The value of ΔL is not just a function of the total electrical potential accumulated along the length of the accelerator; it is also a function of the effective capacitor spacing of each segment of the accelerator. The total change in path length produced by the entire length of the accelerator (designated ΔL_{tot}) should be considered as the sum of the change in path lengths produced by the many capacitor sections, each with spacing L_1. Therefore the value of the path length change is $\Delta L = \underline{V}\, L_1$ but in this case $\underline{V}$ is the total accelerator electrical potential but L_1 is the effective length of each of the capacitor segments rather than being the total length of the accelerator.

For example, the Stanford linear accelerator has a total acceleration voltage of 50 gigavolts. From the specifications, it appears as if the accelerator should have about 28,000 segments (acceleration gaps) with the distance L_1 being approximately $L_1 \approx 0.026$ m. However, since this is an unconfirmed estimate. Assuming these numbers, each segment would add about 1.76 x 10^6 Volts over 0.026 meters for an average electric field is $\mathcal{E} \approx 6.7 \times 10^7$ V/m. The maximum electric field is limited by unwanted field emission of electrons. We will designate the number of segments with the symbol N_s. For this example $N_s \approx 28{,}000$. Therefore the total value of ΔL from all the segments will be the ΔL for a single segment times the number of segments N_s. The single segment ΔL is:

$\Delta L = \underline{V}\, L_1 = (V_1/V_p)L_1$ set $V = 1.76 \times 10^6$ volts, $V_p = 1.04 \times 10^{27}$ volts and $L_1 = 0.026$ m
$\Delta L \approx 4.4 \times 10^{-23}$ m the path length difference produced by a single segment
$\Delta L_{tot} = \Delta L\, N_s \approx 1.2 \times 10^{-18}$ m total path length change produced by all segments $N_s \approx 28{,}000$

Even though this is almost 10^{17} times larger than the theoretical limit of Planck length, this is still a small path length change to detect with current technology. Detecting this small a path length change becomes a signal to noise ratio problem. It appears to be slightly below the practical detection limit set by signal to noise ratio. However, this is merely a preliminary analysis without including improvements such as multiple passes or improved equipment design.

Prediction: Implied Energy Density Limit: When I first developed the equations for the amplitude produced by electromagnetic radiation, I quickly realized that there was implied in these equations a maximum energy density that any given frequency of electromagnetic radiation can achieve. This theoretical maximum energy density would occur when the model demands 100% modulation of the properties of spacetime. The implied prediction was that it should be impossible to exceed this 100% modulation condition which would occur when $\Delta L/\lambda\!\!\!{}^{-} = 1$ at a frequency of $\omega = c/\lambda\!\!\!{}^{-}$. Fortunately, this prediction could be easily proven or disproven without an experiment. Here is the reasoning.

Recall that we are loosely defining a volume of $\lambda\!\!\!{}^{-3}$ by ignoring numerical constants near 1. We will start with the previously determined equation: $\Delta L = \sqrt{n}L_p$. We will designate n_c as the critical number of photons at frequency ω required to theoretically achieve 100% modulation at wavelength $\lambda\!\!\!{}^{-}$. This condition occurs at $\Delta L/\lambda\!\!\!{}^{-} = 1$ or $\Delta L = \lambda\!\!\!{}^{-}$. This critical number of photons in volume $\lambda\!\!\!{}^{-3}$ has a critical amount of energy of E_c. Therefore we will analyze the critical energy E_c in volume $\lambda\!\!\!{}^{-3}$ to see if there is any obvious reason preventing electromagnetic radiation from exceeding the implied limit that would achieve 100% modulation (achieve $\Delta L = \lambda\!\!\!{}^{-}$.)

$$n_c = \frac{E_c}{\hbar\omega} = \frac{E_c\lambda\!\!\!{}^{-}}{\hbar c} \qquad \text{set } \Delta L^2 = n_c L_p^2$$

$$\Delta L^2 = n_c L_p^2 = \left(\frac{E_c\lambda\!\!\!{}^{-}}{\hbar c}\right)\left(\frac{G\hbar}{c^3}\right) \qquad \text{set } \Delta L = \lambda\!\!\!{}^{-}$$

$$\lambda\!\!\!{}^{-} = \frac{GE_c}{c^4} = \frac{Gm}{c^2} = R_s \qquad \text{where } R_s = \text{the classical Schwarzschild radius for energy of } \frac{E_c}{c^2}$$

This is a fantastic result! It is not necessary to do an experiment to prove that this prediction is correct. The intensity (energy density) that would achieve 100% modulation of spacetime (radius dependent) would also produce a black hole. Therefore, it is indeed impossible to exceed the implied limit that would achieve 100% modulation. This is a successful test of the "prediction" that the spacetime model of electromagnetic radiation cannot exceed the intensity that would demand more than 100% modulation of spacetime. This successful test not only supports the model of EM radiation propagating in the medium of spacetime, but it also gives an insight into the conditions that create a black hole. A black hole can be explained purely on the basis of equaling the energy density of spacetime without resorting to the concept of "curved spacetime".

Magnetic Field Analysis

Comparison between Electric and Magnetic Fields: What is the effect on spacetime produced by a magnetic field? We know that an electric field and a magnetic field are intimately connected by the speed of light ($\mathcal{E} = c\mathcal{B}$). A magnetic field in one frame of reference can appear to be an electric field and magnetic field in another frame of reference.

There are two common ways of producing a magnetic field 1) an electric current in a wire and 2) the magnetic field associated with the spin of subatomic particles. There is a very good explanation of a magnetic field generated by current in a wire. This explanation by Ed Lowry[1] is based on the special relativity transformation of an electric field. When current flows in a wire, the negatively charged electrons in the wire are moving relative to the positively charged protons in the wire. Therefore, the positive and negative charges in the wire are in two different average frames of reference. When an external electron moves parallel to the wire, it also is in a different frame of reference. The moving electron experiences a transverse electric field that exerts a transverse force on the electron. This force will be towards the wire if the external electron is moving in the same direction as the electrons in the wire. The force will be away from the wire if the movements are in opposite directions. While this explanation gives important insights, it does not explain the distortion of spacetime produced by a magnetic field.

The force on the external electron increases with relative speed. When the electron is traveling near the speed of light, the energy density of the magnetic field has been almost completely transformed into a transverse electric field. A photon is propagating at the speed of light, therefore if it is propagating in a transverse magnetic field the photon experiences a transverse electric field. The direction of the electric field is 90° relative to the transverse magnetic field. What effect would this have on a photon? Unfortunately, a transverse electric field produces a subtle effect. A transverse electric field is polarized spacetime exhibiting the asymmetry previously discussed. The transverse direction of the asymmetry would produce no effect on distance and no effect on the polarization of the light. Instead, I propose that the only effect would be that the direction of propagation of the light would not be precisely perpendicular to the wavefront. A converging beam of laser light would come to a focus at one spot when there is no transverse magnetic field and focus at a slightly different spot when there is a transverse magnetic field. In a typical experiment these spots would overlap to a degree that it would not be possible to measure the difference. The signal to noise ratio would be too low.

An Electron's Magnetic Field: The spin of an electron produces a magnetic field that is aligned with the spin axis. Therefore, perhaps it is possible to obtain an insight into the distortion of spacetime produced by a static magnetic field by looking at the rotar model of an

[1] http://users.rcn.com/eslowry/elmag.htm

electron. Since a magnetic field is closely related to an electric field, a magnetic field must also be associated with a strain of the length dimensions with no distortion of the rate of time and no change in total volume. An electron is most well-known for its electric field, but the spin of the electron also produces a magnetic field. The energy density of an electron's magnetic field decreases more quickly with distance than the electron's electric field. Therefore the electric field dominates when distance r is much greater than an electron's quantum radius R_q. However, when $r \approx R_q$, the electron's magnetic field should have a comparable energy density to the electron's electric field.

We will begin the quest to deduce the spacetime model of a magnetic field by doing some plausibility calculations to see if the rotar model of an electron can give plausible agreement with the magnetic properties of an electron. If the universe is only spacetime, then a magnetic field must be a distortion of spacetime. We are going to attempt to make a connection between an electrical current flowing around a loop of wire and the rotar model of a fundamental particle. We know that a current flowing around a loop of wire produces a magnetic field. If the proper connection is made, then we should be able to see how the rotating dipole wave of the rotar model produces an electron's magnetic field.

The rotar model of a fundamental particle has a dipole wave in spacetime chaotically propagating at the speed of light around a volume of space. This volume can be mathematically approximated by the rotar model with a circumference equal to the particle's Compton wavelength. Therefore the radius of this volume is equal to R_q. Even though the propagation is chaotic, there is a definable expectation rotation direction and rotation axis. Suppose that we test the postulate that the magnetic field produced by an electron is equivalent to a point particle with charge e propagating at the speed of light around a loop with radius equal to the rotar's quantum radius R_q. This radius has a circumference equal to the rotar's Compton wavelength λ_c. Since the propagation speed equals the speed of light, the rotation frequency around the loop would be equal to the particle's Compton frequency $\nu_c = \omega_c/2\pi$. We will assume a fixed axis of rotation rather than the chaotic axis of the dipole wave.

With these assumptions, it is possible to determine the electron's circulating current (designated I_e) that would be flowing around this hypothetical loop. We will assume the constants associated with an electron. Therefore R_q = 3.86 x 10^{-13} m and an electron's Compton frequency is equal to: $\nu_c = c/\lambda_c$ = 1.23 x 10^{20} Hz. The electron's equivalent circulating current (symbol I_e) is simply elementary charge e = 1.602 x 10^{-19} Coulomb times the electron's Compton frequency ν_c = 1.236 x 10^{20} Hz.

$I_e = e\nu_c \approx 19.796$ amps $\quad$ I_e = electron's equivalent circulating current ~ 19.8 amps

We can check to see if this current produces the correct magnetic effects if we imagine a loop of wire with radius equal to an electron's quantum radius R_q. Specifically, we will see if this current in this size loop of wire would produce the same magnetic moment as an electron (before QED interactions). The magnetic moment μ_m of a loop of wire with area $A = \pi r^2$ and current I is: $\mu_m = AI$. To simulate an electron, we will use: $A = \pi R_q^2$ and $I = I_c = e\nu_c$.

$\mu_m = \pi R_q^2 I_c = \pi\ (3.8616 \times 10^{-13}\ \text{m})^2 \times\ 19.796\ \text{amp} = 9.274 \times 10^{-24}$ J/Tesla

This is a successful test because 9.274×10^{-24} J/Tesla equals an electron's Bohr magneton ($\mu_B = e\hbar/2m_e\ =\ 9.274 \times 10^{-24}$ J/Tesla.) A more rigorous calculation (not shown here) incorporating R_q, e, ν_c etc. shows that the rotar model of an electron gives $\mu_B = e\hbar/2m_e$. The term "Bohr magneton" is used to express a simplified version of an electron's magnetic dipole moment. The experimentally measured value of an electron's dipole moment differs from this Bohr magnetron number by about 0.1%. This small correction factor obtained from QED (the anomalous magnetic moment) will not be discussed further because the objective here is to develop a spacetime based model of a magnetic field. To achieve this goal, we will test the postulate that the rotar model of an electron (on axis) produces the same magnetic field as if there was a point particle with charge e propagating at the speed of light around a loop with radius equal to the electron's quantum radius R_q. From this postulate, the electron's magnetic field calculated from I_c and R_q will be designated $\mathscr{B}_e$. The equation for the magnetic field at the center of a single circular loop of wire with radius r and current I is:

$\mathscr{B} = \mu_o I/2r$ set $I = I_c$ and $r = R_q$ for an electron ($R_q = 3.86 \times 10^{-13}$ m)
$\mathscr{B}_e = 3.22 \times 10^7$ Tesla $\mathscr{B}_e$ = electron's equivalent magnetic field

This large magnetic field would have energy density of 3.22×10^{22} J/m^3. To test the postulate, we must ask the question: Is this reasonable? How does the implied energy in the magnetic field compare to the energy in the electron's electric field external to the electron's quantum volume (external to R_q)? The calculation is not shown here, but the energy in the electric field external to an electron's radius R_q is $(½)\alpha E_i \approx 3 \times 10^{-16}$ J. We want to test whether the large magnetic field of 3.22×10^7 Tesla is reasonable by making a comparison to the energy in the electron's external electric field. We will make the assumption that the magnetic field fills a volume equal to the electron's quantum volume ($V_q = [4\pi/3]R_q^3 \approx 2.41 \times 10^{-37}$ m^3). It also produces an external magnetic field, so this estimate should be low. Is the energy in the electron's external electric field ($\sim 3 \times 10^{-16}$ J) comparable to, but more than, the energy in a 3.22×10^7 Tesla magnetic field filling the electron's quantum volume?

$E = UV_q = (B^2/2\mu_o)(4\pi/3)R_q^3 \approx 10^{-16}$ J energy in the calculated magnetic field in volume V_q

Therefore this simple calculation shows that a magnetic field of 3.22×10^7 Tesla is reasonable. We can also perform a more exact test. Recall that for any fundamental rotar such as an electron, the slope of the strain curve at arbitrary distance was always implied a spatial displacement at the center of an electron of $\sqrt{\alpha}\ L_p$ which is 1.38×10^{-36} m. Out of curiosity, we will look at the implied ΔL for a 3.22 x 10^7 Tesla magnetic field over a distance equal to the electron's quantum radius R_q = 3.86 x 10^{-13} m. Even though we have not yet proposed the physical interpretation of ΔL produced by a magnetic field, it is still possible to calculate the magnitude of ΔL for this magnetic field of 3.22 x 10^7 Tesla over a distance equal to R_q. For an electric field, we previously had $\underline{\Delta L} = \underline{\mathcal{E}}\,\underline{L_1}^2$ where L_1 was defined as the dimensions of a cubic vacuum capacitor. Now we will replace L_1 with R_q, which is the radius of the rotar model of a fundamental particle. We will not prove it here, but a Lorentz transformation of an electric field expressed in dimensionless Planck units ($\underline{\mathcal{E}} = \mathcal{E}/\mathcal{E}_p$) can be considered equivalent to a magnetic field expressed in dimensionless Planck units ($\underline{\mathcal{B}} = \mathcal{B}/\mathcal{B}_p$). In this equation $\mathcal{B}_p$ is Planck magnetic field which is $\mathcal{B}_p = Z_s/q_p$ = 2.15 x 10^{53} Tesla. This means that, ignoring numerical factors near 1, it is reasonable to convert $\underline{\Delta L} = \underline{\mathcal{E}}\,\underline{L_1}^2$ to $\underline{\Delta L} = \underline{\mathcal{B}}\;\underline{R_q}^2$ when we are dealing with a fundamental particle with radius R_q.

$\underline{\Delta L} = \underline{\mathcal{B}}\;\underline{R_q}^2$ Planck units

$\Delta L = \mathcal{B} R_q^2/\mathcal{B}_p L_p$ converted from Planck units to SI units

Set $\mathcal{B}$ =3.22 x 10^7 Tesla, $\mathcal{B}_p$ = 2.15 x 10^{53} Tesla, L_p = 1.6 x 10^{-35} m, R_q = 3.86 x 10^{-13} m

ΔL = 1.38 x 10^{-36} m = $\sqrt{\alpha}\,L_p$

A more general calculation (not using numbers) can be made and it gives the same answer that $\Delta L = \sqrt{\alpha}\,L_p$. Therefore, this is a successful plausibility calculation on two fronts. First, it says that the calculated magnetic field produces the same magnitude of ΔL over the same distance R_q as the electric field for the rotar model of an electron. However, the physical interpretation of ΔL is different for a magnetic field than for an electric field. Secondly, it gives added assurance that we can look to the rotar model of an electron to understand the distortion of spacetime that produces a magnetic field.

As previously explained, the rotation of an electron's extremely small distortion of spacetime is chaotic because it is at the limit of causality. However for analysis, we can imagine a stabilized electron rotation with a fixed axis of rotation. Proceeding along this axis of rotation, we would experience the distortion of spacetime that is producing a magnetic field of about 3 x 10^7 Tesla. This is a very strong magnetic field compared to anything that can be generated by man. However, it is also very weak compared to Planck magnetic field of about 10^{53} Tesla. What is different about this quantum volume compared to a typical volume of spacetime that is not inside an electron and does not have a magnetic field? The "typical" volume of spacetime contains chaotic dipole waves with Planck energy density (about 10^{113} J/m^3), but the dipole wave distortion averages out to being as homogeneous as quantum mechanics allows The obvious difference is that the electron's axial volume also contains an organized spatial and temporal distortion of spacetime that has a small rotating component with strain amplitude equal to $H_\beta \approx$ 4.2 x 10^{-23}. For review, see figures 5-1 and 5-2 from chapter 5.

Extending this line of thought to the magnetic field produced by electrical current flowing in a solenoid would seem to imply that the magnetic field is associated with a rotation of spacetime. For example, the electrons flowing in the solenoid are in a rotating frame of reference. The external volume of each electron (chapter 10) extends far beyond the quantum volume. The effects of the moving electrons would extend to the center of the solenoid and beyond.

However, there are several problems with this magnetic model and more work is required. A simplified extension of this model implies that linearly polarized light propagating along a magnetic field will experience a slight rotation of the plane of polarization (a Faraday Effect). This suggests another experiment which has been analyzed but not presented here. Calculations indicate that this small rotation angle to the plane of polarization would be slightly less difficult to detect then the previously calculated electric field effects if the magnetic field effect could be isolated. However, the magnetic field also has some competing masking effects not encountered by the electric field experiments. Spacetime is filled with activity which includes electron/positron pairs. These virtual particle pairs should also produce a slight Faraday Effect which can mask the calculated spacetime Faraday Effect which excludes the resonances we consider to be virtual particle pairs. Furthermore, any residual gas molecules in a partial vacuum would also produce a competing Faraday Effect. For these reasons, the vacuum Faraday Effect will not be analyzed further because any experiment would not be conclusive proof of the spacetime model.

Comparison of Models: As a parting gesture, I just want to stand back and compare the proposed spacetime based model of a static electric or magnetic field to the currently accepted standard model. In the standard model all force is conveyed by “messenger particles”. The electromagnetic force is conveyed by virtual photons which are not to be confused with virtual photon pairs (see chapter 7).

A static electric field and a static magnetic field both have energy density. This is a real effect that implies some tangible difference between a volume of spacetime that has an electric/magnetic field and a volume of spacetime that has no electric/magnetic field. The “Reissner-Nordstrom" solution to Einstein's field equation gives the gravitational effect of this energy density, but there is no theoretical model of an electric or magnetic field itself. The electromagnetic force is supposedly transferred by messenger particles. This implies that an electric or magnetic field must generate virtual photons without any contact with the matter that is generating the field. Two examples will illustrate this. First, suppose that a free neutron is stationary in a magnetic field. When it decays it generates a rapidly moving electron, a proton and electron antineutrino. The rapidly moving electron and the slower proton immediately feel a Lorentz force exerted by the magnetic field. The force happens before speed of light communication exerts an opposing force on the source of the magnetic field. Therefore, the Lorentz force on the moving electron is being generated by virtual photons which must originate from within the magnetic field itself. Is there a limit to the amount of force that can be generated by a weak magnetic field without communication back to the source?

The second example will examine this question. Suppose that the magnetic field of a star equals the earth's magnetic field strength (~5 x 10^{-5} Tesla) at a distance of 3 x 10^{9} m from the star. Therefore, at this distance any force exerted by the magnetic field takes about 10 seconds to be communicated back to the star. Now at this distance, suppose that there is a square loop of wire that is one meter on each side. Furthermore, suppose that two of the 4 sides are parallel to the magnetic field and two of the 4 sides are perpendicular to the magnetic field. If a current flows in this wire, a Lorentz force will be exerted on the two perpendicular sections of wire (one meter each) and a net torque will be exerted on the loop of wire.

Theoretically, any current can be made to flow in the loop of wire up to Planck current which is about 3.5 x 10^{25} amps. For example, a current of 2 million amps would exert a 100 Newton force on each of the two wire sections that are perpendicular to the magnetic field. If the current flow is started quickly, then all the torque exerted on the wire loop comes from an interaction with a limited volume of the magnetic field. The energy density of a 5 x 10^{-5} Tesla magnetic field is only about 10^{-3} J/m^3 and it takes 10 seconds to transfer this torque to the star. Therefore, if the current started over 3 x 10^{-8} seconds, the maximum volume that could be accessed at speed of light communication would be about 1,000 m^3. This limited volume has only about 1 Joule of energy in its magnetic field. It would take 3 x 10^{10} watts of real photons to generate a force with a magnitude of 100 Newton. How do virtual photons with no real energy accomplish this?

This example does not imply a violation of the conservation of momentum. A powerful magnetic field is being established and the star's weak magnetic field is distorting the formation of the new magnetic field. However, the question remains: How exactly does the virtual photon model explain the force magnitude (100 N) and force vectors exerted on these wires? Carrying this thought experiment to an extreme; Planck current would generate a force of about 10^{21} N on each of the two wire sections without communicating any torque back to the star.

There is no commonly accepted explanation in the standard model for an electric/magnetic field in terms of something more fundamental. On the other hand, the spacetime based model of the universe can easily explain an electric/magnetic field in terms of a distortion of spacetime. Even the instantaneous generation of a 10^{21} Newton force can be explained. The magnetic field is a distortion of spacetime with its sea of dipole waves. The maximum force that spacetime can exert is equal to Planck force which is about 10^{44} N. The spacetime model of the universe has the ability to explain many of the mysteries of quantum mechanics.

Spacetime Units

In chapter 10 we will try to combine the insights gained from charged particles and from electromagnetic radiation to give a conceptually understandable model of the external volume of charged rotars. The last step in this chapter is to build on the insights that were gained in the exercise that eliminated charge as a unit. Eliminating charge and replacing this with a strain in spacetime is a step towards developing units based on the properties of spacetime. However, this step does not take the real plunge. It is necessary to eliminate mass as the fundamental unit and develop units based only on the properties of spacetime. Even though length and time are related to spacetime, the meter and second are human constructs. Planck units have always been considered the most fundamental of units since they are not human constructs. It has been said that if aliens attempted to communicate with us, they would use Planck units because these units are derived from the constants of nature. What could be more fundamental than a system of units based on $\hbar$, G and c?

If the universe is only spacetime, it should be possible to express constants and units such as kilogram, Newton and Coulomb using only the fundamental properties of spacetime. This spacetime conversion is not particularly convenient to use, and it is closely related to Planck units. However, it is very informative to see how common units can be constructed out of the properties of spacetime. In particular, it is important to grasp the idea that mass is not a fundamental unit when we look at the universe from the standpoint of spacetime being fundamental. Mass is a measurement of inertia and inertia is a characteristic of energy traveling at the speed of light in a confined volume. Deflecting energy traveling at the speed of light causes momentum transfer. This is the source of all forces including the pseudo-force of inertia. The goal is to express everything, including mass, in terms of the properties of spacetime.

We will start the search for spacetime units by looking at one of the 5 wave-amplitude equations previously described.

$U = H^2 \omega^2 Z/c$ equation giving the energy density in a wave

When we apply this wave-amplitude equation to spacetime, it should be easy to express this equation if we use the fundamental properties of spacetime. The first obvious candidate for a fundamental property of spacetime is "Z" the impedance of spacetime ($Z_s = c^3/G$). Another candidate is "c", the speed of light, but this is not as certain as Z_s.

Other candidates for being fundamental units of spacetime must be contained in the amplitude term H. We know that a general expression of the maximum permitted dipole wave in spacetime is: $H_{max} = L_p/\lambda\!\!\!- = T_p\omega$. This is the maximum strain amplitude which in turn is dictated by the maximum displacement amplitude of spacetime: dynamic Planck length L_p and dynamic Planck time T_p. It is proposed that dynamic Planck length L_p and dynamic Planck time T_p are both fundamental properties of spacetime. They are added to our list making a total of four candidates. Therefore, the four candidates are Z_s, L_p, T_p and c. We really only need three terms to express everything in the universe, therefore there are three possible combinations of three terms that could serve as the basic units of spacetime. These are: 1) T_p, L_p, Z_s; 2) c, L_p, Z_s; and 3) c, T_p, Z_s

All of these combinations have advantages and disadvantages. I will use the combination of: c, T_p, Z_s, as the units of spacetime. After working with the different combinations I find this combination the most intuitive. For example, the speed of light and the impedance of spacetime seem to belong together. The unit of Planck time becomes the quantized heartbeat of the universe. While working to develop the model of electric field and charge, this combination is somehow easier to visualize. Recall that the impedance of spacetime is Planck mass divided by Planck time. $(Z_s = M_p/T_p)$. Therefore all conventional units can be expressed using these 3 properties of spacetime. However, the use of c, T_p, and Z_s gives answers that correspond to Planck units which are not convenient for everyday use. To illustrate how these spacetime units work, the unit of force has dimensional analysis units of ML/T^2 and conventional units of kg m/s^2. The spacetime units of force are cZ_s. However, these units specify Planck force ($\sim 1.2 \times 10^{44}$ N) which is the largest force spacetime can exert. For another example, to specify the gravitational constant G using conventional units it is necessary to include a constant (6.673×10^{-11}) and the units of $m^3/kg\ s^2$. With spacetime units the gravitational constant is equal to 1 and the units of the gravitational constant are c^3/Z_s. The spacetime units on the next page treat charge as a strain of spacetime with units of length. Recall that the charge conversion constant η is:

We have long ago found the optimum ways of expressing conversion constants that simplify calculations. Instead, this exercise is intended to illustrate how the properties of spacetime can be manipulated to produce familiar constants and units of physics. It may be difficult for the reader to imagine physics without mass or energy being a fundamental unit. However, the maximum force that spacetime can support is cT_p and the maximum quantized mass is T_pZ_s. Mass and energy are a quantification of properties of spacetime. This change in perspective has a great deal of appeal once it is internalized.

On the following table:

$$\eta \equiv \frac{L_p}{Q_p} = \frac{\sqrt{\alpha}L_p}{e} = \sqrt{\frac{1}{4\pi\varepsilon_o F_p}} = 8.617 \times 10^{-18} \text{ meter/Coulomb}$$

Spacetime Units

Name	Spacetime Conversion
elementary charge	$e = (1/\eta)\sqrt{\alpha}\, cT_p$
impedance of free space	$Z_o = \eta^2\, 4\pi Z_s$
speed of light	$c = c$
Planck's constant	$\hbar = c^2 T_p^2 Z_s$
gravitational constant	$G = c^3/Z_s$
Coulomb force constant	$(1/4\pi\varepsilon_o) = \eta^2\, cZ_s$
permeability of free space	$(\mu_o/4\pi) = \eta^2\, Z_s/c$

Transformation of Planck Units into Spacetime Units

Planck Units	Standard Conversion	Spacetime Conversion
Planck length	$l_p = \sqrt{\hbar G/c^3}$	$l_p = cT_p$
Planck mass	$m_p = \sqrt{\hbar c/G}$	$m_p = T_p Z_s$
Planck frequency	$\omega_p = \sqrt{c^5/\hbar G}$	$\omega_p = 1/T_p$
Planck energy	$E_p = \sqrt{\hbar c^5/G}$	$E_p = c^2 T_p Z_s$
Planck force	$F_p = c^4/G$	$F_p = cZ_s$
Planck power	$P_p = c^5/G$	$P_p = c^2 Z_s$
Planck energy density	$U_p = c^7/\hbar G^2$	$U_p = Z_s/cT_p^2$
Planck impedance	$Z_p = 1/4\pi\varepsilon_o c$	$Z_p = \eta^2 Z_s$
Planck charge	$q_p = \sqrt{4\pi\varepsilon_o \hbar c}$	$q_p = (1/\eta)\, cT_p$
Planck electric field	$\mathcal{E}_p = c^4/G\sqrt{4\pi\varepsilon_o \hbar c}$	$\mathcal{E}_p = \eta\, Z_s/T_p$
Planck magnetic field	$\mathcal{B}_p = c^3/G\sqrt{4\pi\varepsilon_o \hbar c}$	$\mathcal{B}_p = \eta\, Z_s/cT_p$
Planck voltage	$V_p = \sqrt{c^4/4\pi\varepsilon_o G}$	$V_p = \eta\, cZ_s$

While it is possible to express all the units of physics using only the properties of spacetime (c, T_p and Z_s), it will be shown in chapter 14 that it is necessary to add one additional dimensionless designation (Γ_u) to quantify the changing properties of spacetime. As will be explained in chapter 14, spacetime is undergoing a transformation that is changing all the units of physics relative to an absolute standard that is unchanged since the Big Bang.

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Chapter 10

Rotar's External Volume

External Volume of an Electron (Conventional Model): Before presenting the spacetime based model of the external volume of a fundamental particle, we will first look at the competition. The conventional model of an electron is a point particle (or vibrating string with no volume) surrounded by an electric and magnetic field. The energy density of a macroscopic electric field from elementary charge *e* is: $U = (1/8\pi)(\alpha\hbar c/r^4)$. The energy external to a given radial distance *r* is: $E_{ext} = (1/8\pi\varepsilon_o)(e^2/r) = ½(\alpha\hbar c/r)$. This energy density shows that an electron's electric field is a real physical entity. An interaction with an electron's electric field does not exhibit any delay that would occur if messenger particles had to be sent out by an electron. In chapter 9 an example was given involving the magnetic field of a star. This example clearly illustrates the inadequacy of the exchange of virtual photon messenger particles to explain the electromagnetic force. In this chapter we will develop further the spacetime based explanation of electric and magnetic fields.

If the electron's radius is less than the classical radius of an electron (~ 10^{-15} m) then there is an additional problem with the point particle model because a smaller radius makes the energy in the electric field exceed the total energy of the electron. For example, if a particle or the vibrating string was considered to be contained in a volume with a radius of Planck length, then the energy in the surrounding electric field would be about 10^7 J. This problem is usually ignored by saying that the electron has an "intrinsic" electric field associated with elementary charge *e*. If we are attempting to give conceptually understandable explanations of quantum mechanics using the properties of spacetime, then we do not have the luxury of being able to ignore such problems. It is even necessary to describe charge and electric field in terms of the properties of spacetime.

External Volume of a Rotar: We will now look at the spacetime model of the "fields" associated with a fundamental particle. A rotar has previously been described as a unit of quantized angular momentum in a sea of vacuum fluctuations. These vacuum fluctuations have superfluid properties as previously described. The vacuum fluctuations cannot possess angular momentum and therefore any angular momentum must be isolated into quantized units just like superfluid liquid helium isolates angular momentum into quantized vortices. The "quantum volume" of a rotar possesses the angular momentum and this volume is not in the superfluid state. While the vacuum fluctuations surrounding a rotar avoid possessing angular momentum, the surrounding volume is still affected by the presence of a rotar (quantized angular momentum) in its midst. The rotar produces disturbances in the volume external to the rotar which slightly affect the sea of vacuum fluctuations that surround a rotar.

This chapter will examine the standing waves and static strain produced in the volume surrounding a rotar. These effects are responsible for not only the rotar's gravitational and electromagnetic fields but also numerous other effects including de Broglie waves and Compton scattering.

The probability of interacting with a rotar (finding a particle) does not end at the edge of the quantum volume. The edge of the quantum volume is mathematically significant because it allows us to characterize properties and dimensions, but the proposed quantum mechanical nature of a rotar is not bound by our convention. There is part of a rotar that extends far beyond the quantum radius R_q. These external effects will be shown to be both oscillating standing waves and static strains distributed across the sea of vacuum fluctuations that are part of spacetime. The volume beyond the quantum radius will be called the "external volume". This external volume is still considered to be part of the rotar but it has different characteristics than the quantum volume.

The dipole wave in spacetime responsible for a rotar has previously been described as rotating at its Compton angular frequency and possessing amplitude of: $H_\beta = L_p/R_q = T_p\omega_c$. It was also proposed that the rotar is attempting to radiate away its energy into the external volume (the sea of vacuum fluctuations). The amplitude of this attempted radiation has been designated the "fundamental amplitude" H_f. This fundamental amplitude decreases with distance r such that the hypothetical amplitude would be: $H_f = L_p/r = cT_p/r$. If there were no offsetting effects, this amplitude would radiate away a rotar's full energy in a time of $1/\omega_c$ which is typically in the range of 10^{-21} to 10^{-25} s. This is the same as having no stability. The few rotar frequencies that are stable or semi-stable must produce an interaction with vacuum energy that generates a new wave that cancels energy loss but leaves oscillating standing waves. For example, an electron has long term stability therefore the probability of energy loss is zero. However, this does not mean that all of the energy of an electron is confined to its quantum volume. There is a battle going on in the external volume between the attempted emission and the cancelation waves. The residual effects that exist in the electron's external volume are responsible for the electron's gravity and the electron's electric/magnetic fields.

Gravitational and Electromagnetic Strain Amplitudes: In chapters 6 and 8 it was shown that gravity is the result of spacetime being a nonlinear medium for dipole waves in spacetime. While there is cancelation of the fundamental wave emission, the nonlinear effects remain from the battle. This results in a non-oscillating strain in spacetime with strain amplitude (gravitational magnitude) of $H_G = \beta = H_\beta^2/\mathcal{N}$ where $\mathcal{N}$ is the dimensionless ratio: $\mathcal{N} = r/R_q$. This number designates distance from a rotar as a multiple of the rotar's quantum radius R_q which is the rotar's natural unit of length. It was shown in chapter 8 that this combination ultimately results in the Newtonian gravitational equation $F_g = Gm_1m_2/r^2$. There was also a proposed oscillating component of gravity that will be discussed further here. It will be shown that this oscillating gravitational component in the external volume results in energy external to R_q that is in the range of 10^{40} times smaller than a rotar's internal energy therefore it is undetectable.

As before, the simplest example used for illustration in this chapter is a single isolated fundamental particle with elementary charge e. Only electrons, muons and tauons meet this criterion. To further simplify the semantics it is easiest to use electrons in examples. Therefore, this chapter will attempt to describe the external volume of an electron. Once this is done there will be some discussion of the external volume of protons, neutrons, etc.

As previously stated, understanding the connection between electric fields (magnetic fields) and dipole waves in spacetime has been the most difficult task in developing the spacetime based model of the universe. Furthermore, the most difficult component of this explanation has been modeling the electric field of a rotar. In chapter 9 we concluded that an electron and other charged leptons with charge e produce a non-oscillating strain in spacetime. At distance r this strain corresponds to the dimensionless Planck electrical potential $\underline{\mathbf{V}} = \sqrt{\alpha}\ L_p/r$. So far it is not clear how this non-oscillating strain is produced. The breakthrough occurred with the realization that gravity has an oscillating component (figure 8-1) and a static component. On close examination it was found that the electric field produced by a charged particle such as an electron must also have an oscillating component and a static component. Therefore a gravitational field has two strain components (one oscillating and one static) while the electric/magnetic field also has two strain components (one oscillating and one static). The static component of a gravitational field has already been discussed in chapters 6 and 8. This chapter will concentrate on the remaining three components

The model assumes that the electric field produced by an isolated electron possesses the classical energy density external to the quantum volume where $r > R_q$. There is no continuous loss of the electron's energy, so these external oscillations must be standing waves that remain after the proposed cancelation that must take place to eliminate emission of energy at frequency ω_c and amplitude $H_f = L_p/r$. In order for the standing waves to achieve the energy density of the electric field, it is necessary for some part of the electron's energy to reside outside distance R_q. We will calculate the oscillating "standing wave" amplitude distribution required to achieve this energy density.

$U = (½)\ \varepsilon_o\mathcal{E}^2$ energy density in an electric field $\mathcal{E}$ of a single electron

$\mathcal{E} = (1/4\pi\varepsilon_o)\ e/r^2$ electric field produced by a particle with charge e

$U = \dfrac{\alpha\hbar c}{8\pi r^4}$ substitution including $\alpha\hbar c = \left(\dfrac{e^2}{4\pi\varepsilon_o}\right)$

We also have $U = H^2\ \omega^2\ Z_s/c$ from the 5 wave-amplitude equations. Therefore we can set these two energy density equations equal to each other and ignore dimensionless constants.

$H^2\ \omega^2\ Z_s/c = \alpha\hbar c/r^4$ substitute $Z_s = c^3/G$ and $\omega = c/R_q$, then solve for H
$H^2 = \alpha\ (\hbar G/c^3)\ R_q^2/r^4$ set $\hbar G/c^3 = L_p^2$; $H = H_e$ and $\mathcal{N} = r/R_q$

$$H_e = \frac{\sqrt{\alpha}L_p R_q}{r^2} = \left(\frac{\sqrt{\alpha}L_p}{R_q}\right)\left(\frac{R_q}{r}\right)^2 = \sqrt{\alpha}\,\frac{H_\beta}{\mathcal{N}^2}$$

H_e = oscillating (standing wave) amplitude component of the electric field at frequency ω_c

Note that the different Compton frequencies of an electron and a muon are absorbed into the H_β and $\mathcal{N}$ terms which both have a frequency dependence ($H_\beta = L_p/R_q = \omega_c/\omega_p$ and $\mathcal{N} = r/R_q = r\omega_c/c$) While this oscillating amplitude H_e gives the correct energy density, these standing waves do not directly convey force between charged rotars. If the oscillating component was responsible for electrostatic force, this would imply that oscillating energy in the external volume was propagating and energy would be continuously radiated. The standing waves in a rotar's external volume do not directly generate forces. However, they are indirectly responsible for the forces between rotars. Here is the picture that has emerged after lengthy examination.

A rotar is attempting to radiate away its energy to the surrounding sea of vacuum energy. The few fundamental particles that are stable exist at one of the few special frequencies that generate canceling waves in vacuum energy eliminating the loss of energy. Even though the loss of energy is eliminated, there are four residual effects that show that a battle has taken place. These 4 residual effects are really combined, but for analysis it is convenient to separate them into component parts.

1) There are standing waves (associated with the electric field) remaining in the vacuum energy that surrounds the rotar. These standing waves are at the rotar's Compton frequency ω_c and have the oscillating amplitude $H_e = \sqrt{\alpha}\ H_\beta/\mathcal{N}^2$.
2) There is non-oscillating strain in spacetime responsible for gravity and previously discussed in chapters 6 and 8. This strain has been designated as the gravitational magnitude β, but to make a designation H_G in keeping with other amplitude terms we will also designate the non-oscillating term as $H_G = \beta = H_\beta^2/\mathcal{N}^2$.
3) There is an oscillating nonlinear effect associated with gravity and illustrated in figure 8-3 as the small amplitude waves on the line designated "nonlinear component". This oscillating component of gravity has previously been shown to have amplitude of H_β^2 at distance R_q. It will be proposed that this gravitational oscillating term external to R_q has amplitude $H_g = H_\beta^2/\mathcal{N}^2$.
4) It is proposed that there is a non-oscillating term associated with the electric field with amplitude $H_\mathcal{E} = \sqrt{\alpha}\ H_\beta/\mathcal{N} = \underline{\mathbf{V}}$. Here is the reasoning.

In the last chapter it was determined that a single photon in maximum confinement (in volume $\lambda\!\!\!^-{}^3$) would produce a displacement of L_p across a distance of $\lambda\!\!\!^-$. The dimensionless strain amplitude of this would be $H_\gamma = L_p/\lambda$. It was proposed that to produce the directionality required by an electric field, this amplitude would have to imply polarized spacetime that produces an unsymmetrical time required for light to propagate towards and away from the electron (opposite electric field directions).

Now imagine a single electron present in a radio wave with a frequency of 1 MHz. The electron feels the effect of the oscillating electric field produced by the radio wave and undergoes a 1 MHz oscillating displacement. The electron has a Compton frequency in excess of 10^{20} Hz so the difference in frequency is more than a factor of 10^{14}. The point is that the radio wave would change its electric field so slowly on the electron's time scale that it can be considered almost like a static electric field. The force exerted on the electron by the radio wave's electric field would appear to be almost constant on the time scale of the electron. The electric field produced by a charged particle must also have a non-oscillating component if we extrapolate the radio wave interaction to a frequency approaching zero. If two electrons (or an electron and a muon) are repelling each other, we should not expect the interaction to be taking place between two rapidly oscillating waves at the respective Compton frequencies $\sim 10^{20}$ to 10^{22} Hz. The electric field associated with an electron or muon must also have a non-oscillating component that is equivalent to an infinitely low frequency electromagnetic wave. It will be shown that there is a non-oscillating strain of $H_\mathcal{E} = \sqrt{\alpha}\, H_\beta/\mathcal{N}$ between rotars with charge e.

The picture that emerges is that both the gravity of an electron and the electric field of an electron possess an oscillating component and a non-oscillating component. The following apply only to the 3 charged leptons because these equations assume a single isolated rotar with charge e. This table repeats information but it is presented in a way to show the similarities and differences between these 4 types of amplitudes.

$H_e = \sqrt{\alpha}\,\frac{H_\beta}{\mathcal{N}^2}$ H_e = electromagnetic standing wave amplitude oscillating at ω_c

$H_\mathcal{E} = \sqrt{\alpha}\,\frac{H_\beta}{\mathcal{N}} = \underline{\boldsymbol{V}}$ $H_\mathcal{E}$ = electromagnetic non-oscillating strain amplitude

$H_g = \frac{H_\beta^2}{\mathcal{N}^2}$ H_g = gravitational standing wave amplitude oscillating at $2\omega_c$

$H_G = \frac{H_\beta^2}{\mathcal{N}} = \beta$ H_G = gravitational non-oscillating strain amplitude

The introduction of H_e, $H_\mathcal{E}$, H_g and H_G is merely a case of giving new symbol designations to the concepts previously discussed. We just derived $H_e = \sqrt{\alpha}\,H_\beta/\mathcal{N}^2$ as the amplitude required to produce the energy density of an electric field associated with energy density $U = (½)\,\varepsilon_o\mathcal{E}^2$ (numerical constant ½ is ignored). In chapter 8 we developed $H_G = \beta = H_\beta^2/\mathcal{N}$ as the non-oscillating amplitude required to produce the gravitational field of a rotar. H_e is the symbol given to the non-oscillating strain developed in chapter 9. Finally H_g is the symbol given to the oscillating component of gravity previously discussed and depicted in figures 8-1 and 8-3.

Non-Oscillating Strain Amplitude $H_\mathcal{E}$: The proposed electromagnetic non-oscillating strain amplitude $H_\mathcal{E}$ is responsible for what we consider to be the electric field of charged leptons such as an electron or muon. The strain $H_\mathcal{E} = \sqrt{\alpha}\, H_\beta/\mathcal{N}$ looks similar to the fundamental amplitude $H_f = H_\beta/\mathcal{N}$ which is the theoretical oscillating strain amplitude that is being canceled in the rotars that are stable enough to be considered fundamental particles. However, there are several key differences. First is the obvious difference of $\sqrt{\alpha}$ which reduces the amplitude by a factor of about 11.7 at any given value of $\mathcal{N}$. Second, $H_\mathcal{E}$ is a non-oscillating strain while H_f is a hypothetical oscillating amplitude at frequency ω_c that is attempting to radiate away the rotar's energy.

The third difference is associated with the fact that the type of displacement of spacetime associated with electric fields is different from the type of displacement of spacetime produced by dipole waves in spacetime with their Planck length/time limitation. This was discussed in the last chapter. It was proposed that electric and magnetic fields imply that there is a physical difference in the positive electric field direction and the negative electric field direction. This unsymmetrical characteristic was associated with a slight difference in the proper speed of light that results in a slight difference in the one way distance between points which is the same as saying a slight difference in the one way travel time for light propagation between two points.

Electrostatic Force Calculation: We will next check to see if the non-oscillating strain amplitude $H_\mathcal{E}$ gives the correct electrostatic force between two charged leptons (two electrons). When we calculated the gravitational force on a rotar produced by another rotar creating the non-oscillating strain $H_G = H_\beta^2/\mathcal{N}$, we calculated the implied difference in the rate of time across the radius of a rotar and converted this to the difference in gravitational magnitude $\Delta\beta$ across the rotar. This was necessary because for force generation it is only the gradient in β or Γ that is important, not the absolute value.

The proposed characteristic of an electric field is different in the sense that the difference is between opposite directions, not the gradient across a rotar. In fact, the difference across the width of a rotar is insignificant compared to the difference between opposite directions at the average location of the rotar feeling the force. Imagine the rotar model presented in chapter 5 rotating in otherwise homogeneous spacetime. Now imagine this rotar rotating in polarized spacetime where there is a difference in the time required for speed of light propagation in opposite directions across the rotar. The strain in spacetime producing this effect is static, but the interaction with the rotar is dynamic. The interaction occurs at a frequency equal to ω_c and the interaction modulates the rotar at amplitude of $H_\mathcal{E} = \sqrt{\alpha} \mathrm{H}_\beta/\mathcal{N} = \underline{V}$. This in turn affects the interaction with vacuum energy/pressure surrounding the rotar. This creates a pressure imbalance that can appear to be either attraction or repulsion. The magnitude of the force is:

$$F = \frac{H^2 \omega^2 Z_s A}{c}$$

set $H^2 = \alpha \frac{H_\beta^2}{\mathcal{N}^2} = \alpha\left(\frac{L_p^2}{R_q^2}\right)\left(\frac{R_q^2}{r^2}\right) = \alpha\left(\frac{\hbar G}{c^3 r^2}\right)$; $\quad \omega = \frac{c}{R_q}$; $\quad Z_s = \frac{c^3}{G}$; $\quad A = R_q^2$

$$F = \alpha\left(\frac{\hbar G}{c^3 r^2}\right)\left(\frac{c^2}{R_q^2}\right)\left(\frac{c^3}{G}\right)\left(\frac{R_q^2}{c}\right) = \alpha\left(\frac{\hbar c}{r^2}\right) = \left(\frac{e^2}{4\pi\varepsilon_o \hbar c}\right)\left(\frac{\hbar c}{r^2}\right) = \frac{e^2}{4\pi\varepsilon_o r^2} \quad \text{Success!}$$

This explanation is far from complete. For example, there is no explanation for the difference between a force of attraction and repulsion. Also, there is no explanation for the difference between an electron and a positron. However, the explanations offered here do make a first step towards developing a physically understandable explanation of electric and magnetic fields. The standard approach is to merely accept the existence of mysterious "fields" with no attempt to find an underlying causality.

Electric Field Cancelation: The non-oscillating component of the electric field produced by an electron does not have any inherent energy density. Only the oscillating component possesses energy density (oscillating at ω_c). These two components of the electric field are connected so it is not possible to have an electric field without any energy density. However, it is possible to cancel out the non-oscillating strain of an electric field and leave only neutral standing waves by bringing oppositely charged particles together. For example, at a sufficient distance from either a hydrogen atom or a neutron there is almost no electric field. This occurs because there is almost complete cancelation of the non-oscillating strains that forms the detectable portion of the electric field. The oscillating component (standing wave component) is proposed to remain even if there is cancelation of the detectable electric field. This remaining oscillating component is proposed to be responsible for de Broglie waves and other quantum mechanical effects that we associate with the wave properties of particles.

The reason for saying that the oscillating component remains even when opposite charges cancel the detectable electric field is because all composite particles exhibit de Broglie waves. For example neutrons and even Bucky balls (C_{60}) exhibit wave properties beyond their physical size. These wave properties are exhibited when they are passed through a double slit experiment. The waves imply a frequency addition of the component parts. For example, a neutron has de Broglie wave characteristics of a particle with rest energy of 939.6 MeV rather than the frequencies of the 3 component quarks that form the neutron. Therefore the bonding process must include some unknown mechanism for frequency addition of component parts. We will not speculate on this any further since this chapter is primarily about the external volume of the 3 charged leptons and about the electron's external volume in particular.

Energy in the External Volume: The electron's energy density external to the quantum volume (external to R_q) is: $U = \alpha\hbar c/8\pi r^4$. The total energy in the external volume (E_{ext}) of a charged lepton's electric field is:

$E_{ext} = ½\ e^2/4\pi\varepsilon_o r$ set: $e^2/4\pi\varepsilon_o = \alpha\hbar c$ and $r = R_q = \hbar c/E_i$

$E_{ext} = ½\ \alpha\hbar c E_i/\hbar c = ½\ \alpha E_i$

Therefore, the energy in the external volume caused by the oscillating component of the electric field is equal to $\alpha/2$ of the charged lepton's total energy or roughly 0.4% of the total energy of the charged lepton. Hadrons do not have a fixed percentage of their energy external to their radius but even a neutron has some of its energy external to its radius. The three quarks that form a neutron have addition/subtraction of the static strain components of the quark's electric fields. A short distance from the neutron there is effectively charge cancelation. However, this is the non-oscillating component of the electric field that results in vector addition or subtraction. The oscillating part is proposed to remain and produce standing waves in the neutron's external volume. These standing waves become the neutron's de Broglie waves when the neutron is observed in a moving frame of reference. For example, a neutron produces a diffraction pattern when it is passed through a double slit experiment. The implied frequency is equal to the sum of the frequencies of the three quarks. No effort has been expended to develop a model of frequency addition in hadrons and other composite particles.

A muon and an electron both have the same charge and same fraction of their total energy in their external volumes. However, a muon has about 200 total times more energy and 200 times smaller radius. Almost all of the muon's extra external energy is contained in the small difference between the quantum volume of a muon and the quantum volume of an electron. At a distance larger than the electron's quantum radius, they both generate the same electrostatic force because they both generate the same non oscillating strain in space. This can be shown by the following:

$$H_\varepsilon = \sqrt{\alpha}\,\frac{H_\beta}{\mathcal{N}} = \sqrt{\alpha}\left(\frac{\mathrm{L_p}}{\mathrm{R_q}}\right)\left(\frac{\mathrm{R_q}}{\mathrm{r}}\right) = \sqrt{\alpha}\,\frac{L_p}{r}$$ This is the same for all rotars with charge e

The equation $H_\varepsilon = \sqrt{\alpha}\,L_p/r$ has lost all terms which relate to a specific Compton frequency or a specific quantum radius size. Therefore the non-oscillating strain (the detectable electric field) produced by a muon is exactly the same as the non-oscillating strain produced by an electron. The oscillating components of an electron and muon retain their frequency dependence but these oscillating components are only detectable as de Broglie waves and other quantum mechanical wave characteristics.

Internal Electric Field: Even though this chapter is about the external volume of a rotar, we are going to take a brief diversion and talk about the extension of the non-oscillating strain of the electric field into the interior of a lepton's quantum volume. If rotars are slight distortions of spacetime that can partially overlap, does the electric field (the non-oscillating strain) continue to increase inside the rotar's quantum radius? The problem is that when two electrons collide relativistically, the repulsion force exceeds the force that could be generated if the electric field ended at the surface of the quantum volume. In chapter 9 it was determined that the strain in spacetime produced by charge e at distance r is: $\Delta L/L = \underline{\boldsymbol{V}} = \sqrt{\alpha} L_p/r$. I suspect that this equation changes gradually when $r < R_q$ if only because of the uncertainty of designating the location to specify as the central location to serve as the point where $r = 0$. However, the point is that the strain can continue to increase into the internal volume of a rotar such as an electron. Therefore, there is no reason why colliding two electron together should reveal any internal structure. The strain in spacetime, and therefore the repulsive force continues to increase as the two electrons overlap. Furthermore, the collision of two rotars causes both rotars to convert the kinetic energy to internal energy. For example, colliding two electrons with kinetic energy of 50 GeV causes both electrons to momentarily gain 100,000 times their original energy and shrink by a factor of 100,000 at the point of closest approach. This decrease in size combined with the strain equation ($\Delta L/L = \underline{\boldsymbol{V}} = \sqrt{\alpha} L_p/r$), permits an electron to appear to be a point particle in relativistic collisions.

Accelerating Charged Leptons: We will now return to the external volume discussion and focus on the electromagnetic properties, temporarily ignoring the gravitational effects. The external volume of a non-accelerating, isolated electron is a combination of standing waves at frequency ω_c with oscillating amplitude $H_e = \sqrt{\alpha}\, H_\beta/\mathcal{N}^2$ and a non-oscillating strain of spacetime with amplitude $H_\mathcal{E} = \sqrt{\alpha}\, H_\beta/\mathcal{N}$. Previously the electric field energy in a rotar's external volume was calculated at $E_{ext} = ½\, \alpha E_i$. To be precise, this is the limiting case of an isolated rotar that has not interacted with anything for an infinitely long time. In this idealized case a rotar's external volume has had sufficient time at speed of light communication to become fully established. In practice, the extent of a rotar's external volume (its undisturbed electric field) is limited by the length of time an isolated electron has remained undisturbed in a condition that does not radiate electromagnetic radiation.

Therefore what is commonly considered to be the electric field of a particle can be considered part of the rotar's external volume. However, in a larger sense both the electric "field" produced by the rotar and indeed the rotar itself are just strains in the sea of vacuum energy of spacetime. In chapter 4 it was said that there was only one truly fundamental field since all fields are just different distortions of vacuum energy/fluctuations. Keeping this in mind, we will use the term "electric field" to indicate the disturbance in vacuum energy that results in electromagnetism. The part of a rotar's external volume that produces the electromagnetic disturbance has speed of light communication back to the rotar's quantum volume. In chapter 9 a thought experiment involving the magnetic field of a star illustrated the fact that a magnetic field has the ability to exert a force before communication is established back to the source of the field (the star). Similarly, an electron's electric field (spacetime disturbance) can interact "before" communication is established back to the electron (frame of reference dependent).

There is an obvious objection to the concept that an electron's external volume can extend many meters from the quantum volume. This objection is that accelerating an electron would break contact (at speed of light) with a distant part of the external volume thereby abandoning a small part of an electron's structure and energy. However, rather than being a defect, this is actually a strength of this concept because it provides a mechanism for the emission of electromagnetic radiation (a photon with a quantized unit of angular momentum) when an electron is accelerated. The acceleration introduces a modulation $(\omega > 0)$ into what was previously a static strain $(\omega = 0)$. Also, a portion of the standing wave energy in the external volume loses contact when the quantum volume. The energy abandoned by the acceleration is converted to the energy of the photon that is formed when an electron is accelerated. The acceleration initially introduces a distortion into the waves of the rotar's external volume. This distortion both launches a photon and gives energy to reestablish the lost portion of the external volume. Chapter 11 will discuss freely propagating photons in more detail.

Another test of an electron's distributed energy is whether a test can be devised that distinguishes between the rotar model with its distributed energy and the currently accepted model of a charged point particle. It takes time to measure energy or inertia. The more accurate the measurement needs to be, the more time is required. This allows time for the energy in the external volume to communicate its presence at the speed of light and add to the total energy or inertia of the electron. It is possible to do a plausibility calculation to see if it would ever be possible to do an experiment that would give a different answer for the rotar model of an electron compared to a point particle model of an electron which has all of its energy localized but also experiences a retardation as part of the emission of a photon.

The energy in an electron's electric field external to radius r is: $E_{ext} = \alpha\hbar c/2r$. This is energy that is in the form of standing waves external to the electron's quantum volume. From the uncertainty principle $(\hbar/2 = \Delta E \Delta t)$, it is possible to calculate the integration time Δt that would be required to detect an energy uncertainty of $\Delta E = E_{ext}$.

$$E_{ext} = \frac{\alpha\hbar c}{2r} \qquad \text{set } \frac{\hbar}{2} = \Delta E \Delta t$$

$$E_{ext} = \left(\frac{\alpha c}{r}\right) \Delta E \Delta t \qquad \text{set } E_{ext} = \Delta E$$

$$\Delta t = \frac{r}{\alpha c} \approx 137\, \frac{r}{c}$$

Therefore, it would take an integration time 137 times longer than the time r/c to detect this energy discrepancy. However, this is 137 times longer than it takes for the discrepancy to be corrected to a degree that is undetectable. Therefore, a model of an electron with the proposed distribution of energy in the external volume is indistinguishable from a point particle.

Chaotic Waves: The transition from the quantum volume to the external volume of a rotar is actually ill defined because the quantum volume has a chaotic, probabilistic quality. The rotating dipole in spacetime is at the limit of causality. The quantum volume is attempting to radiate its full energy in a time of $1/\omega_c$. A fundamental amplitude of $H_f = R_q/r$ is actually attempting to carrying away the full energy. It is only the return wave generated in vacuum energy that is somehow canceling this emission. However, the chaotic process at the limit of causality can reconstruct the rotar (reconstruct the quantized angular momentum) at a different location described by the uncertainty principle. Also a double slit experiment can interfere with the normal reconstruction and result in the rotar being reconstructed on the other side of the double slit. This will be discussed later.

The point is that all of the quantum mechanical properties which seem mysterious for a point particle become conceptually understandable if a particle is a vortex of quantized angular momentum in a sea of vacuum fluctuations.

We have previously discussed that all rotars must satisfy a soliton condition in spacetime. This means that the few fundamental particles that exist must exhibit a combination of characteristics that offset the tremendous emission of dipole waves in spacetime that leave the vicinity of the quantum volume. The few leptons and hadrons that exist somehow achieve a soliton condition where the emission is offset by the generation of waves in vacuum energy that effectively cancel the emission from the rotar's rotating dipole core.

Model of the External Volume: Figure 10-1 is a simplified representation of the standing dipole waves that surround a rotar. Recall that the rotar is attempting to radiate away its energy and emits dipole waves with frequency ω_c and amplitude $H_f = L_p/r$. The few rotars that are stable or semi-stable must form a resonance with the surrounding vacuum energy that eliminates the energy loss but leaves both standing waves and non-oscillating strains in spacetime as previously discussed. All the figures in this chapter deal with the standing waves associated with the oscillating part of the electric field. These standing waves have amplitude $H_e = L_p/\mathcal{N}^2$ and angular frequency ω_c. Figure 10-1 is the first in this series of figures and this figure has been greatly simplified compared to an actual rotar. The rotating dipole has been replaced by a simple monopole source of waves. In fact, we will use a monopole emitter for the first series of figures because the initial illustrations are easier to understand without the added complexity of a rotating dipole source. The figures will later be illustrated using a dipole source when this source becomes important to the illustration.

Initially we will imagine that figure 10-1 represents sound waves being emitted by a monopole emitter of sound waves at the center circle and being reflected by a spherical reflector outside of the area shown in the figure. The interaction between the emitted and reflected waves forms the standing waves depicted in figure 10-1 and subsequent figures. An acoustic monopole emitter can be thought of as a sphere that expands and contracts its radius at an acoustic frequency.

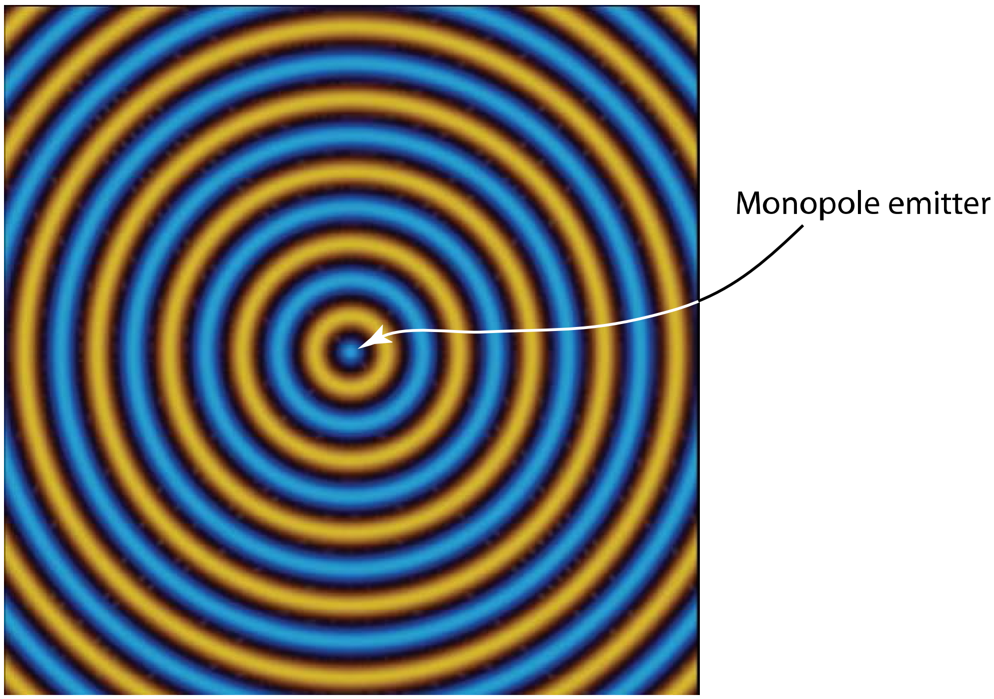

FIGURE 10-1 Monopole emission pattern

Figure 10-1 shows standing waves in an acoustic medium depicted at a moment in time. The blue regions can represent regions of maximum acoustic pressure and the yellow regions can represent regions of minimum acoustic pressure. A half cycle later the standing waves will reverse and regions that previously had maximum pressure will have minimum pressure. The black regions between the yellow and blue regions would be the wave nulls in this representation, but there is another way of depicting this standing sound wave.

The black regions have the maximum pressure gradient. This means that the black regions have the maximum kinetic energy of the acoustic medium. Therefore, there is another way of representing the standing acoustic wave where we emphasize the kinetic energy of molecules. In this type of representation the black regions would be depicted as regions of maximum kinetic energy, not the nulls shown above. In fact the energy in the standing acoustic wave is just being transferred between energy in compression/rarefaction and kinetic energy.

We will now switch to considering figure 10-1 as representing standing waves in spacetime. The vacuum fluctuations that form spacetime have a vastly larger energy density than the energy density of a rotar. As previously discussed, the pressure of vacuum energy is stabilizing the rotar and exerting the necessary pressure to confine the energy density of the rotar. Figure

10-1 represents a moment in time where the disturbance caused by the presence of the rotar results in standing waves in the surrounding vacuum energy. These standing waves fluctuate both the rate of time and proper volume. Regions of fast time are shown in blue and regions of slow time are shown in yellow. A half cycle later the fast and slow time regions will reverse. The black regions between yellow and blue have the maximum gradient in the rate of time. These regions are equivalent to the grav field previously explained. Just like the standing sound wave, there really are no nulls in the standing wave in spacetime. The regions of fluctuating rate of time have the same energy density as the regions of maximum grav field (maximum rate of time gradient). The total wave energy is constant $(\sin^2\theta + \cos^2\theta = 1)$.

Wavelets: All dipole waves in spacetime are proposed to have propagation characteristics that are similar to the Huygens Principle in optics. The Huygens principle assumes that every point on an advancing wavefront of an electromagnetic wave is the source of a new disturbance. The electromagnetic wave may be regarded as the sum of these secondary waves (called "wavelets"). Reflection, diffraction and refraction are explained by assuming that all parts of an electromagnetic wave are the source of these new wavelets. The surface that is tangent to any locus of constant phase of wavelets can be used to determine the future position of the wave.

As originally formulated by Christiaan Huygens, the Huygens Principle requires that the wavelets are hemispherical and only radiate into the forward hemispherical direction of the propagation vector. A modification of this was made by Gustav Kirchhoff where the wavelets emit into an amplitude distribution of $\cos^2(\theta/2)$. This distribution has maximum amplitude in the forward direction and zero amplitude in the reverse direction. The result is the classical Huygens-Fresnel-Kirchhoff principle that accurately describes diffraction, reflection and refraction. This will be discussed in more detail in chapter 11.

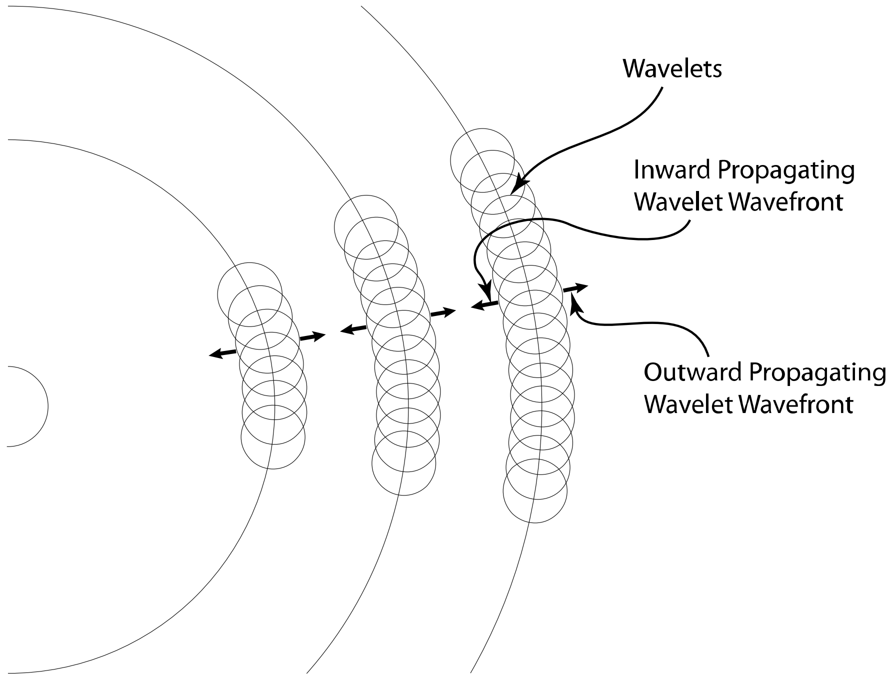

FIGURE 10-2 Simplified representation of waves propagating in spacetime. Each component becomes the source of a new wavelet.

It is proposed that the few frequencies that form rotars interact with vacuum energy in a way that allows them to emit wavelets that propagate into a complete spherical pattern as shown in Figure 10-2. With this hypothesis the $cos^2(\theta/2)$ amplitude distribution of the wavelets of light is not shared by the wavelets of vacuum energy that stabilizes rotars. The conditions that stabilize rotars require that both a forward propagating wave and an equal backwards propagating wave be formed in the external volume. This is accomplished if each wavelet propagates into a spherical disturbance pattern as shown in figure 10-2. These spherical wavelets add together to produce the next generation of dipole waves in spacetime. This results in wavefronts propagating in both the forward and backward radial directions. These new wavefronts are labeled inward propagating and outward propagating. In the tangential direction there is incoherent addition that produces cancellation. If the energy flow is equal in both directions, the result is standing waves in the external volume of a rotar. Standing waves are oscillating waves that have fixed regions of nodes and antinodes. They possess energy, but there is no continuous energy drain.

Path Integral: A key point here is that the wavelets of dipole waves in spacetime explore all possible paths between two points. Furthermore, the amplitude at any point is the coherent sum (amplitude and phase) of these waves. The intensity at any point is the square of the amplitude sum. This concept gives a physical interpretation to the path integral operation of quantum electrodynamics. It is a stretch to explain how point particles explore all possible paths between events, but waves in spacetime that form new wavelets intrinsically accomplish this task. Again, this proposed spacetime based explanation makes quantum mechanical operations conceptually understandable while the point particle model has numerous mysteries.

This explanation that involves backwards propagating waves sounds good, but there is a problem. If this was the only mechanism stabilizing a rotar, the residual standing waves would be much larger than the calculated amplitude of $H_e = \sqrt{\alpha}\ L_p/\mathcal{N}^2$ required for the standing wave part of the electric field. There appears to be an additional unknown mechanism generated in vacuum energy that forms a wave that provides additional cancelation. These standing waves remain even when the non-oscillating component of the electric field has been canceled. If others choose to model these standing waves, it should be noted that accurate modeling of the Huygens Principle in optics requires that the modeling must be done in three spatial dimensions[1]. If the Huygens's Principle is modeled in only 2 spatial dimensions, there is incomplete cancelation of waves that do not contribute to a wavefront.

de Broglie Waves: In chapter 1 it was shown that a laser contains light traveling in opposite directions. When the waves in this laser are observed from a stationary frame of reference, the bidirectional light forms standing waves. In other words, the standing waves are stationary relative to the laser mirrors. When the laser is translated relative to an observer, the standing light waves are still stationary relative to the moving mirrors, but the moving frame of reference means that the observer sees the light being Doppler shifted up in frequency in the direction of travel and being Doppler shifted down in frequency in the opposite direction. The superposition of these two Doppler shifted beams of light produces what appears to be a moving envelope of waves.

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[1] http://www.mathpages.com/home/kmath242/kmath242.htm

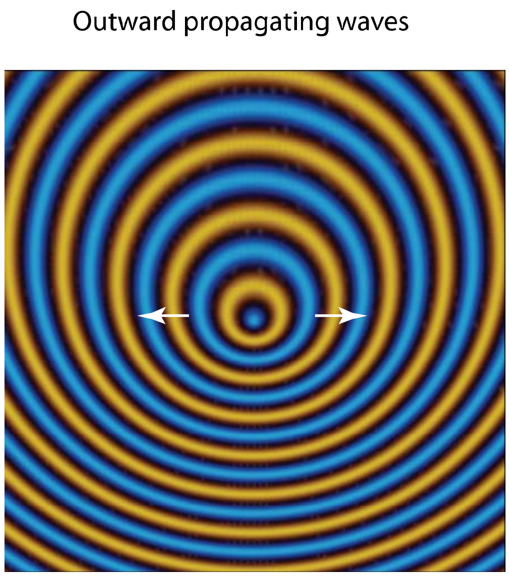

FIGURE 10-3 Doppler shift on outward propagating waves.

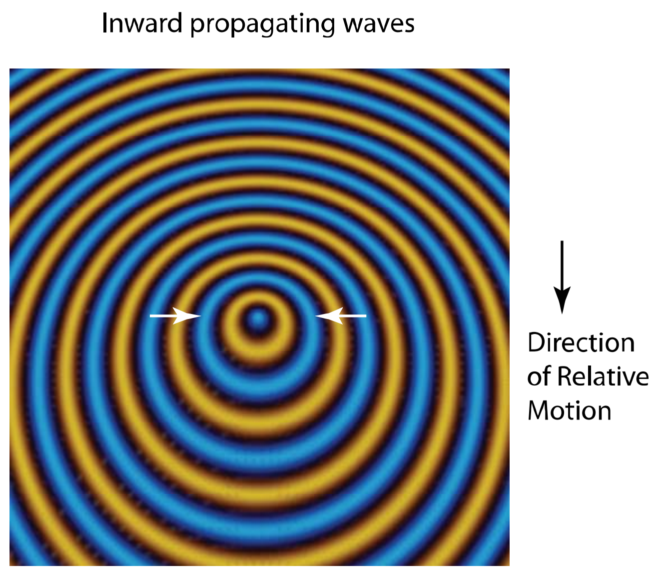

FIGURE 10-4 Doppler shift on inward propagating waves.

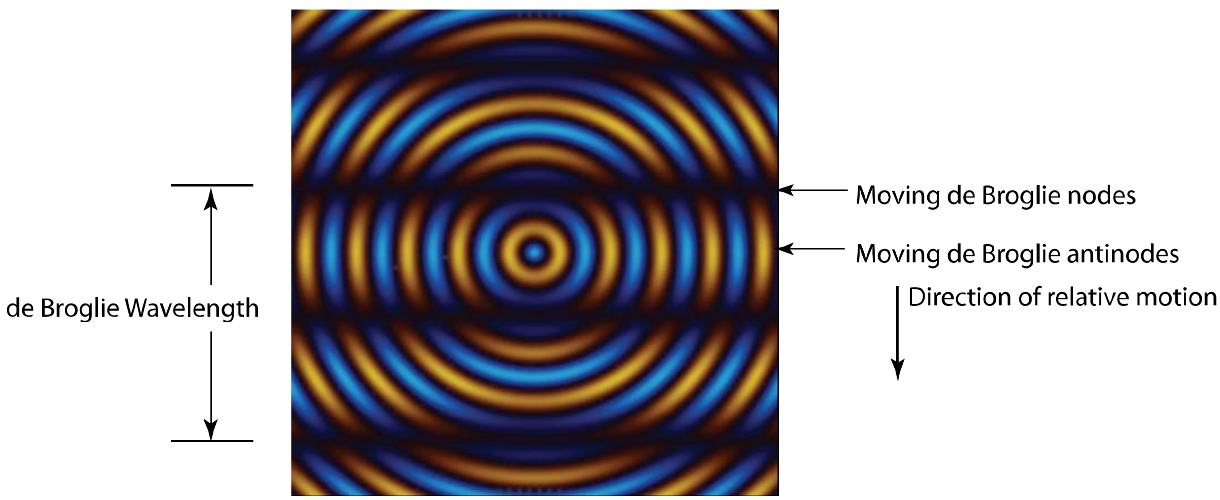

FIGURE 10-5 Linear de Broglei waves obtained from the translation of the rotar model (except monopole source)

Figure 1-1 shows the moving envelope of waves and moving laser mirrors. An analogy is proposed to be present when a rotar is observed in a moving frame of reference. It is desirable to examine the de Broglie waves of a rotar in greater detail. Figure 10-3 is similar to Figure 10 - 1, but there are two differences. First, Figure 10-3 shows waves propagating only away from the monopole source (arrows pointing away from the source). Second, Figure 10-3 shows the monopole source moving downward relative to the observer. The combination of these two factors produces the Doppler wave pattern shown. Figure 10-4 also has a downwards moving frame of reference, but the difference is that only waves propagating towards the source (inward propagation) are shown with arrows pointing towards the source.

The wavelets previously shown in figure 10-2 means that waves are simultaneously propagating both towards the source and away from the source. This means that a moving source will produce a wave pattern that is a superposition of figures 10-3 and 10-4. When we add these two patterns together we obtain the result shown in Figure 10-5. It is surprising to see that we obtain a linear wave pattern from the superposition of spherical waves in a moving frame of reference. These are the rotar's de Broglie waves. They have all the correct characteristics – correct de Broglie wavelength, correct de Broglie phase velocity and the correct de Broglie group velocity. Moving the rotar model produces the rotar equivalent of de Broglie waves.

This figure is not static. Not only is there translation relative to the observer, but the dark interference fringes are moving at a speed faster than the speed of light. For example, if the rotar model is moving at 1% of the speed of light relative to an observer, then the interference pattern is moving in the same direction as the relative motion, but at 100 times the speed of light $(w_d = c^2/v)$. Also notice that there is a phase shift going across the dark interference pattern. This is represented by a reversal of color following a wave across the dark de Broglie null.

Figure 10-5 makes no attempt to show that the amplitude decreases with radial distance from the source. Figure 10-6 is a 3-dimensional graphical representation of Figure 10-5 with the added feature of a $1/r$ amplitude dependence. The actual amplitude should fall off proportional to $1/r^2$, but this sharp decrease in amplitude makes it difficult to see the de Broglie modulation wave.

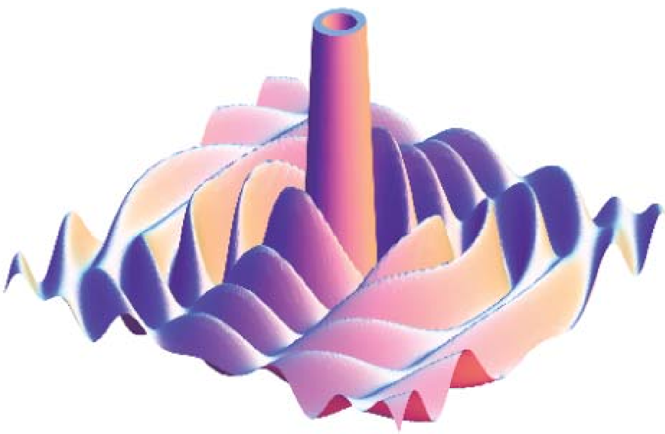

FIGURE 10-6 Three Dimensional Wave Plot Showing DeBrogle Waves and a Radial Amplitude Dependence

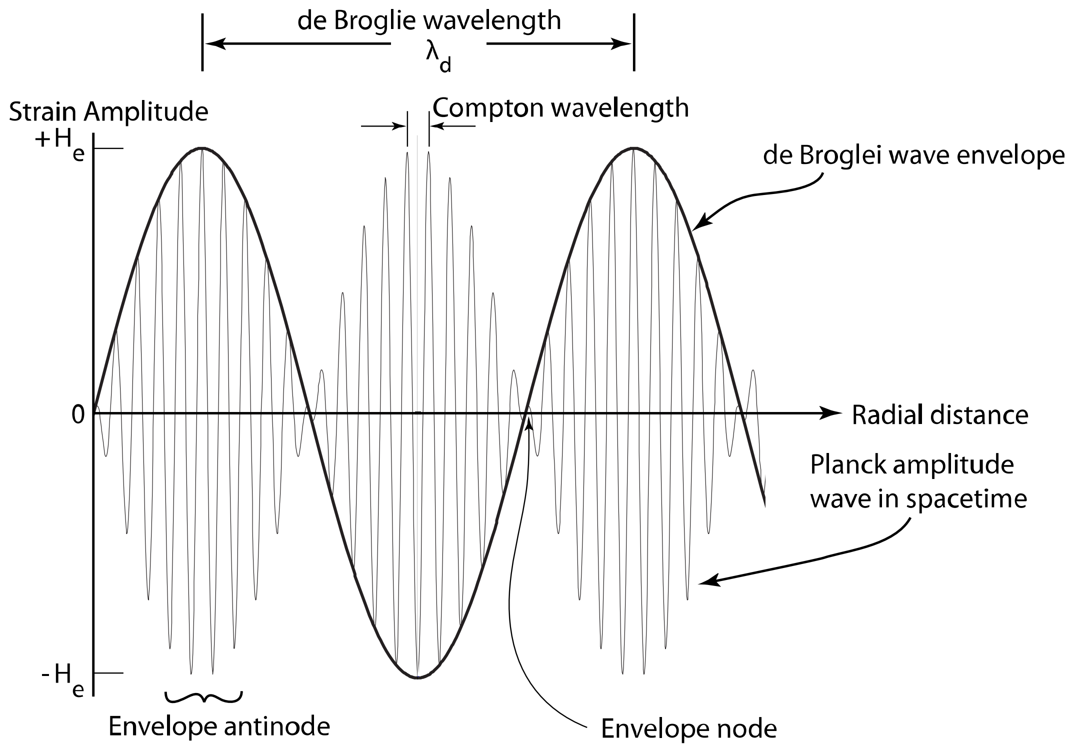

FIGURE 10-7 Graphical representation of a portion of the spacetime waves that form the external volume of a moving rotar.

Strain Amplitude Graph: It is easiest to explain the de Broglie modulation wave using Figure 10-7. This figure is a graph of the waves in figure 10-5 (radial cross-section). In figure 10-7, the high frequency waves are designated as "dipole waves in spacetime". When a rotar is stationary relative to the observer, then all the dipole waves in spacetime have equal amplitude. At this stationary condition the frequency of these waves is the rotar's Compton frequency (~ 10^{20} Hz for an electron) and the wavelength of these waves is the rotar's Compton wavelength λ_c. When the rotar is moving relative to the observer, then the rotar's de Broglie wave appears. This is just the modulation envelope that results from the different Doppler shift for waves propagating away from the rotar's quantum volume and towards the quantum volume.

Figure 10-7 shows a graphical representation of the rotar's de Broglie wavelength λ_d. This graph plots strain amplitude versus radial distance r. Only a short radial segment is shown. There should be a radial decrease in amplitude, but the short radial distance depicted does not show this decrease in amplitude. In the external volume of a rotar the fundamental traveling wave with amplitude L_p/r has been canceled leaving behind the standing wave responsible for the rotar's electric charge with amplitude of $H_e = \sqrt{\alpha}\ \ H_\beta/\mathcal{N}^2$. The nonlinear effect responsible for the oscillating portion of gravity is too small to be shown. Therefore, the Y axis of this graph is the strain amplitude H_e. The maximum value of H_e is the value given by the equation $H_e = \sqrt{\alpha}\ \ H_\beta/\mathcal{N}^2 = \sqrt{\alpha}\, L_pR_q/r^2$.

To give an idea of scale, the approximate Compton wavelength λ_c is shown. An electron's Compton wavelength is about 2.43 x 10^{-12} m. The de Broglie wavelength λ_d depends on relative velocity (v) and is illustrated as being approximately 20 times longer than the Compton wavelength in this example. Therefore, the de Broglie wavelength would be approximately 5 x 10^{-11} m in this example. The Compton wavelength λ_c and the de Broglie wavelength λ_d are related as follows: $\lambda_c = (v/c)\lambda_d$ (approximation $v << c$). Therefore, this figure illustrates the de Broglie wave pattern if an electron is traveling at about 5% the speed of light ($\lambda_d \approx 20\lambda_c$ in this figure).

The Y axis of this graph is strain amplitude which can be expressed either as a spatial strain (meters/meter) or as a temporal strain (seconds/second). Both ways of expressing this give the same dimensionless number for a specific point in space and instant in time. Suppose our observation point at a particular instant is one micrometer (10^{-6} meters) from an electron that is moving past us at 5% the speed of light. We can then quantify the strain amplitude depicted in Figure 10-7. Using $H_e = \sqrt{\alpha}\ \ H_\beta/\mathcal{N}^2 = \sqrt{\alpha}\, L_pR_q/r^2$ and substituting $r = 10^{-6}$ m and $R_q = 3.86 \times 10^{-13}$ m for an electron, we obtain: $H_e = 5.3 \times 10^{-37}$. This is the maximum value of H_e above and below the zero strain line (the "x" axis).

It is possible to calculate the displacement of spacetime required to produce this amount of dimensionless strain. This strain exists over approximately one radian of the wave which is a distance equal to R_q. For an electron R_q = 3.86 x 10^{-13} m therefore $H_e \, x \, R_q \approx$ 2 x 10^{-49} m. Therefore, the spatial displacement of spacetime (displacement amplitude) which causes the strain amplitude illustrated here is smaller than Planck length by a factor of about 10^{14}. If we would have chosen to work in the temporal domain we would obtain the same dimensionless strain which could be thought of as seconds/second. The temporal displacement amplitude causing this strain would then be $H_e/\omega_c \approx$ 6.8 x 10^{-58} s. This is smaller than Planck time and the difference is again a factor of about 10^{14}.

Ψ Function: It is not obvious in figure 10-7 but there is a 180 degree (π radian) phase shift between each de Broglie lobe. Therefore one complete de Broglie wavelength includes two lobes as shown. This 180 degree phase shift between lobes is a fundamental property of standing waves viewed from a moving frame of reference. This phase shift gives rise to the de Broglie wave interpretation shown in figure 10-7. Perhaps most important, **the wave designated de Broglie wave envelope is really the moving rotar's Ψ function.** It is sometimes said that the Ψ function has no physical interpretation. However, figure 10-7 is the proposed physical interpretation of the quantum mechanical Ψ function. This is another example of how the proposed spacetime based model makes quantum mechanical mysteries conceptually understandable.

Relativistic Contraction: Above it was stated that λ_c illustrated in figure 10-7 is "approximately" equal to the rotar's Compton wavelength. The reason that this is not exact is that this figure depicts a moving rotar and there is relativistic length contraction in the Compton wavelength. If the rotar was stationary, there would be no de Broglie wave modulation envelope and the dipole waves would be exactly equal to the Compton wavelength.

The reason for bringing up this point is that it is possible to see the physical cause of relativistic length contraction when there is relative motion. A moving rotar has waves that are Doppler shifter up in frequency and Doppler shifted down in frequency as previously explained. When these Doppler shifted waves are combined, the resultant wave has a shorter wavelength than the original wavelength without Doppler shifts. This was proven mathematically in Appendix A at the end of chapter 1. This analysis applies equally to standing waves in a moving laser cavity or to standing waves in the external volume of a rotar. The combination of the two Doppler shifts in the two oppositely propagating waves produces a net decrease in the Compton wavelength by a factor of: $\sqrt{1 - v^2/c^2}$. This is proposed to be the source of relativistic contraction. A moving meter stick will appear to decrease in length because all the waves that make up the meter stick decrease their wavelength because of this effect.

Rotating Dipole Model: We will now attempt to give a crude model of the standing waves present in the external volume of rotating spacetime dipoles. An accurate model of this requires high level computer modeling. It involves modeling a large number of wavelets that are added together and then become the source of new wavelets that form the next generation. This process is repeated a large number of times. This task is beyond the scope of this book. Furthermore, the simplest modeling would probably make no distinction between the infinite number of frequencies that do not form stable rotars and the few frequencies with the unusual characteristics that combine to form stable rotars. Also, how do we handle the chaotic spin distribution characteristics of spin ½ particles? The following modeling is a best guess model of the external volume of an electron. This can then serve as a starting point for others that can improve on this model.

Before attempting to model the external volume of rotars, it is desirable to first describe the chaotic spin properties exhibited by isolated rotars. Because a rotar is at the limit of causality, it should not be a surprise that a rotar has probabilistic characteristics. The displacement of spacetime is so small that dipole waves in spacetime do not violate the conservation of momentum. Recall the examples given previously comparing the minute volume and rate of time changes required to form an electron's spacetime dipole. (expanding the radius of Jupiter's orbit by a hydrogen atom or slowing the rate of time by several microseconds over the age of the universe.)

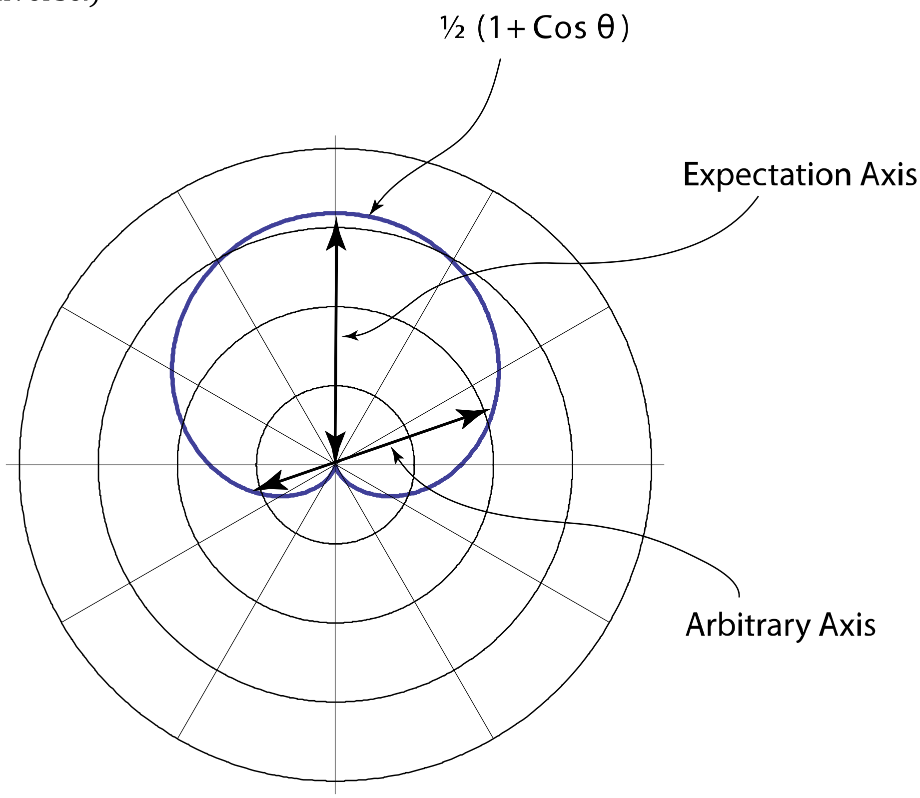

FIGURE 10-8 Probability of Spin Direction

Figure 10-8 shows a plot in spherical coordinates of the probability of spin being oriented in the direction *θ*. This spin direction probability is proportional to $cos^2 (\theta/2)$. Suppose that we concentrate not on the spin direction, but on the axis of spin. Figure 10-8 specifies the expectation axis and an arbitrary axis. The point of this is to show that a rotar can have a spherical distribution averaged over time even though the rotar has an expectation spin direction. The rotating dipole shown in figure 5-1 would not have a spherical distribution if the axis of rotation were fixed. However, figure 10-8 shows that the probability of spin direction is such that all axis orientations are equally probable. In other words, the expectation axis shown in figure 10-8 is the same length as the arbitrary axis when opposite spin probabilities are added together. If we consider the length of the spin axis probability as *ζ*, then we have:

$$\zeta = cos^2 (\theta/2) + cos^2 [(\theta + \pi) /2] = cos^2 (\theta/2) + sin^2 (\theta/2) = 1$$

With this being said, we will simplify the modeling by looking at the equatorial plane of the expectation rotation axis. For example, the expectation axis can be set by placing an electron in a magnetic field. This is the simplest to model and one step better than assuming a monopole emitter.

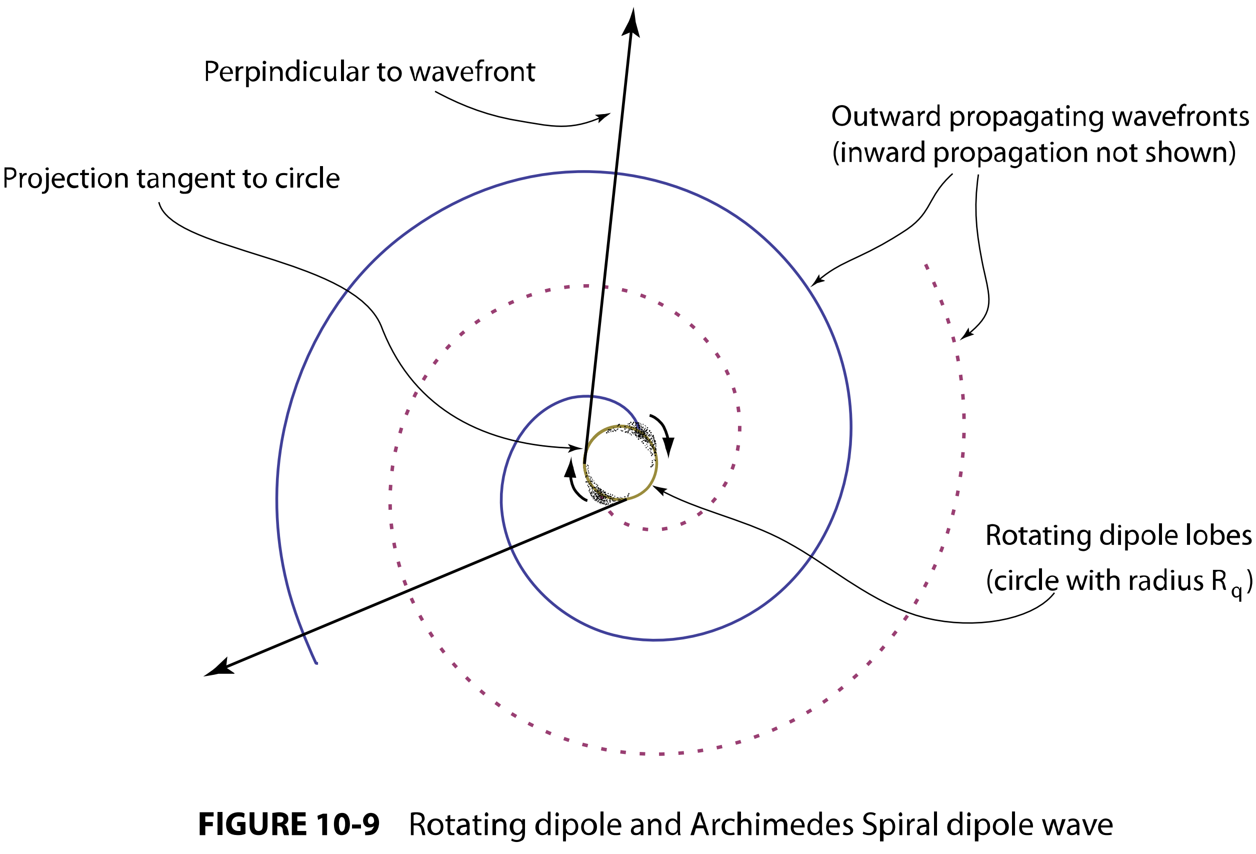

FIGURE 10-9 Rotating dipole and Archimedes Spiral dipole wave

Figure 10-9 shows a rotating dipole designated "rotating dipole lobes". The two lobes depicted represent the two dipole lobes discussed and depicted in chapter 5. When the lobes move around the imaginary circle at the speed of light, any disturbance propagates away from these lobes at the speed of light and forms the outward propagating Archimedes spirals shown. This simplified description does ignore the fact that every part of the wave forms new wavelets, but we will proceed with this description and attempt to include wavelets later.

For discussion, we will initially assume that the solid lines represent regions where the rate of time is faster than normal and the dashed lines represent regions where the rate of time is slower than normal. Since the rate of time affects all 3 spatial directions equally, these waves are neither longitudinal nor transverse. They are simply time waves. Besides affecting the rate of time, these waves also represent a spatial distortion.

So far, we have ignored the fact that the model calls for every point on the wavefront to be the source of a new wavelet. An extremely simplified model takes the outgoing wave pattern shown in figure 10-9 and generate the backwards propagating waves by assuming that the outward propagating waves are reflected off a concentric spherical reflector. These reflected waves then propagate back towards the rotating dipole. This makes another pair of Archimedes spirals that in a static image are the mirror image of figure 10-9. They have the same rotational direction when viewed from the perspective of figure 10-9, but they are propagating inward.

When the outgoing waves and incoming waves are added together we obtain an interference pattern shown in Figure 10-10. This is a cross-section view of the equatorial plane of the external volume of a rotar. This also depicts an instant in time. The actual pattern is rotating at the same rate as the rotating dipole (the Compton frequency). For an electron, this image would rotate about 1.24×10^{20} revolutions per second. This is currently the best representation of an isolated rotar such as an isolated electron. We are assuming a stationary frame of reference for Figure 10-10 (no de Broglie waves superimposed). Note that there is a 180 degree phase change at the destructive interference bar (black bar) that goes across the center of this figure. This phase change can be seen because there is a reversal of color (yellow to blue or blue to yellow) at this region of destructive interference.

Even though this figure was made using some questionable simplifications, it is a reasonable first attempt. The amplitude of the waves should drop off with a $1/r^2$ decrease in amplitude from the center. For illustration purposes, this figure depicts uniform radial wave amplitude. The reader should mentally adjust for the radial decrease in amplitude.

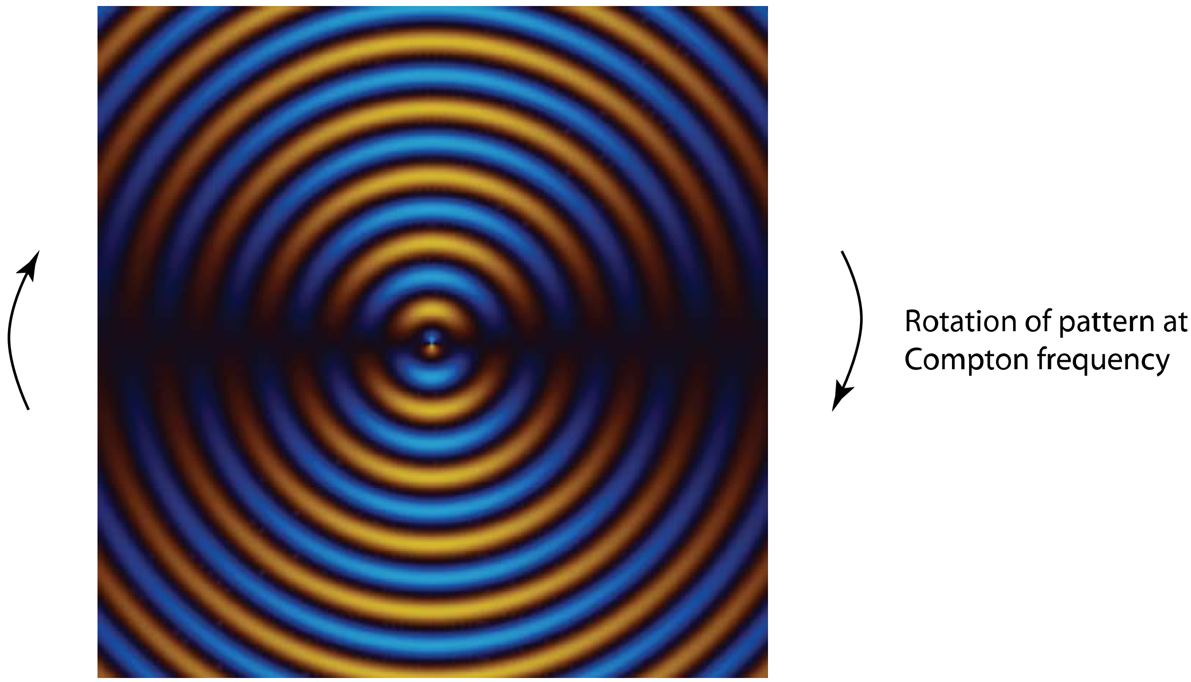

FIGURE 10-10 Interference pattern obtained by adding outward and inward propagating Archimedes spiral waves. (stationary frame of reference)

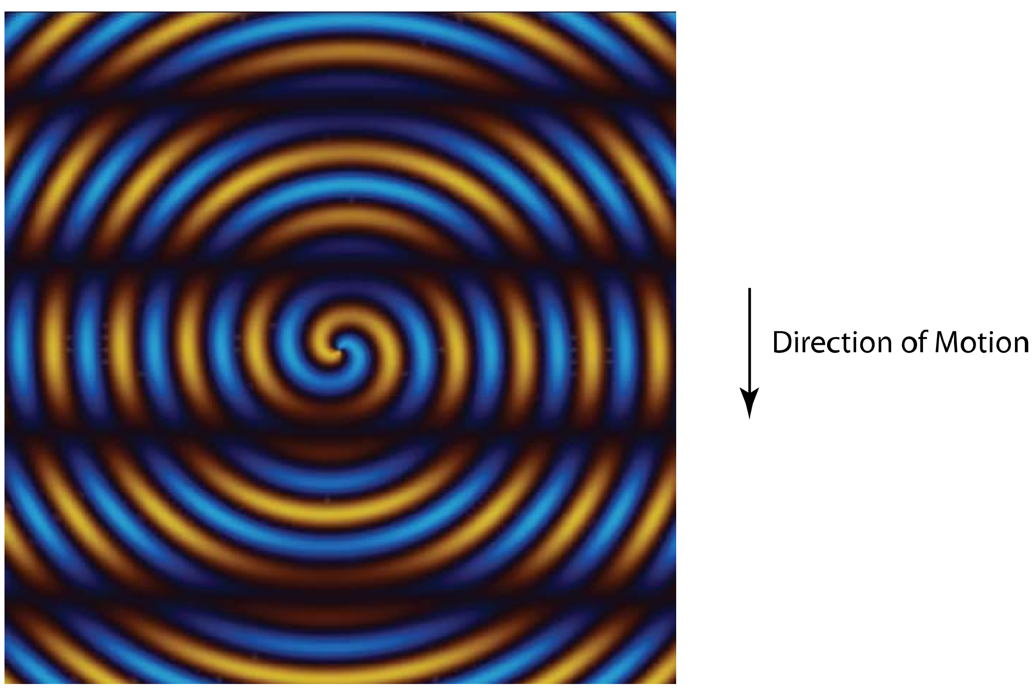

FIGURE 10-11 Interference pattern obtained by viewing Fig 10-10 from moving frame of reference

Conservation of Angular Momentum: Figure 10-10 looks similar to a rotating disk, but this is the wrong interpretation. There is no violation of the conservation of angular momentum as this pattern enlarges. This is best explained by returning to figure 10-9. We will assume that all of the energy and angular momentum starts off in the region designated “rotating dipole lobes”. If some energy leaves this region, its outward propagation follows the Archimedes spiral pattern shown in figure 10-9. This is the pattern that maintains constant total angular momentum.

Proving this statement would represent a substantial diversion, but one brief point supports this contention. Figure 10-9 shows an arrow drawn perpendicular to the Archimedes spiral in the far field of the spiral pattern. In the limit of the far field the projection of this perpendicular line back towards the center results in the projected line being tangent to the imaginary circle with radius of R_q. This implies a conservation of the angular momentum for energy that leaves this circle. The pattern shown in figure 10-10 is a super position of two Archimedes spiral patterns, both of which can be shown to individually exhibit conservation of angular momentum. The rotating pattern in figure 10-10 has a tangential speed faster than the speed of light for any radial distance greater than $r = R_q$. This is permitted because this is just an interference effect that can move faster than the speed of light.

In Figure 10-11 we are looking at this same pattern of figure 10-10 from a moving frame of reference. To obtain this picture we added together the Doppler shifter outgoing and incoming wave patterns. This is similar to adding together Figures 10-3 and 10-4 to get figure 10-5. To obtain figure 10-11 we added together Doppler shifted outgoing and incoming Archimedes spirals rather than the concentric circles. Like figure 10-5, Figure 10-11 is a snap-shot of a moving interference pattern. The interference pattern would be moving faster than the speed of light as previously explained for Figure 10-5. In fact, the de Broglie wavelength and translation speed is the same whether we model a monopole source or a dipole source provided that we assume the same Compton frequency.

Figure 10-11 is actually a large spiral pattern, but the spiral characteristic is only obvious near the center of the figure. The exact center of figure 10-11 that is the initiation of the spiral is not an accurate illustration of the pattern that would be produced by a rotar. Figure 10-9 illustrates that the spiral does not extend to the exact center. Instead, there is a transition to the quantum volume that is represented by a circle with radius R_q. Figure 10-11 was drawn with the two spirals (inward and outward propagating) extending all the way to the center. Therefore, a more realistic version of figure 10-11 would have a transition to black over the center ~ $1/\pi$ wavelength.

Compton Scattering: In 1905 Albert Einstein’s published a paper on the photoelectric effect. This paper suggested that light exhibits particle-like properties. At the time light was considered to be only a wave phenomenon. In the early 1920’s, the particle-like properties of light was still being debated. However, debate effectively ended with the observation by Arthur Compton of the scattering of x-ray photons by electrons (called Compton scattering). The scattered x-ray photons exhibit a decrease in frequency that is a function of scattering angle. The individual electrons also exhibit recoil when they scatter an x-ray photon. The decrease in the frequency of the scattered photon corresponds to the energy transferred to the recoiling electron. A simple Doppler shift of waves reflecting off the moving electron does not correspond to the correct frequency shift. All of this is perfectly explained by the model that assumes that photons are particles with energy that is a function of frequency. When a photon (point particle) collides with an electron (point particle) there is momentum transfer and energy transfer between these particles. The interaction is nicely described by Compton's equations and he received the 1927 Nobel Prize in physics for this work.

The physics community has universally adopted the wave-particle photon model. Photons clearly have wave properties, but Compton scattering, the photoelectric effect and other experiments also seem to require a particle explanation. The wave-particle description of both photons and particles works well, but the conceptual understanding of this has puzzled generations of physics students.

Schrodinger Article on the Compton Effect: Since this book proposes that fundamental particles are dipole waves in spacetime, it would be helpful to support this contention by offering a plausible explanation for Compton scattering using the proposed spacetime based model of both electrons and photons. As I was working on this explanation, I assumed that no one had been successful in proposing a purely wave based explanation for Compton scattering. To my surprise, I discovered that in 1927 Erwin Schrodinger had published a technical paper titled "The Compton Effect"[2]. This article is available in Schrodinger's book "Wave Mechanics" which has had multiple editions in English. Schrodinger did not conceive of waves in spacetime or a rotar model, but he did propose a plausible wave explanation for Compton scattering. His proposed explanation involved an electron's de Broglie waves interacting with light waves to produce the correct scatter characteristics for both the light and the electron. In this article, Schrodinger used some antiquated terminology such as the phrase "an ether wave" to describe light, but his point is valid. A brief description of his concept will be given here.

Schrodinger looked at the collision as if it was a continuous process. In this case four waves are present and continuously interacting. These four waves are 1) the electron's de Broglie wave before the interaction 2) the electron's de Broglie wave after the interaction 3) the light wave before the interaction and 4) the light wave after the interaction. Schrodinger found that the two superimposed de Broglie waves combined to make a wave that he called a "wave of electrical density". This combined wave had the perfect periodicity to reflect the incident light beam and create a reflected beam with the correct frequency shift and scatter angle. The two

[2] Annalen der Physik (4), vol 82

superimposed light waves (incident and scattered) produce an interference pattern that matches the interference pattern produced by the two superimposed de Broglie waves.

Schrodinger made an analogy between Compton scattering and light interacting with sound waves (Brillouin scattering). Sound waves produce a periodic change in the index of refraction of an acoustic medium. Light waves propagating in an acoustic medium can reflect off the sound wave which produces periodic changes in the index of refraction. The maximum reflection is obtained if the following equation is satisfied: $\lambda \approx 2\Lambda \sin\theta$

Where: $\lambda =$ light wavelength, $\Lambda =$ acoustic wavelength and $\theta =$ the angle between the light propagation direction and a plane parallel to the acoustic waves.

This equation would be exact if the acoustic wave was stationary. Since the acoustic wave has a speed much less than the speed of light, the condition of a stationary acoustic wave is approximately met. However, relativistic corrections would be required if the sound wave propagated at a significant fraction of the speed of light. The equation corresponds to the Bragg law (first order) and becomes exact when the acoustic waves are stationary. When the acoustic speed of sound is taken into consideration, then it appears as if the light waves are reflecting off a moving multi layer dielectric mirror. There is a frequency shift in the reflected light and the angle of incidence does not equal the angle of reflection because the mirror is moving.

Schrodinger considered the superposition of the two sets of an electron's de Broglie waves (before and after the interaction) to result in a "wave of electrical density" that could interact with light. Here are Schrodinger's translated words:

> "According to the hypothesis of wave mechanics, which up to now has proven trustworthy, it is not the ψ-function itself, but the square of the absolute value that is given a physical meaning, namely, density of electricity. A single ψ-wave therefore produces a density distribution which is constant in both space and time. If however, we superimpose two such waves,… we see that a 'wave of electrical density' arises from the combination…"
>
> Now it is this density wave that takes the place of the sound wave of Brillouin's paper. If we assume that a light wave is reflected from it as from a moving mirror, (subject to the fulfillment of Bragg's law) then we shall show that our four waves (two ψ-waves and the incident and reflected light waves) stand exactly in the Compton relationship….
>
> As all the four waves are invariant with respect to Lorentz transformation, we can bring the density wave to rest by means of such a transformation…. Bragg's

relationship holds exactly if λ denotes the wavelength of the light wave, Λ that of the density wave and θ the glancing angle. It can be put in the form: $2h\lambda/sin\theta = h/\Lambda$"

Vector Diagrams: I will elaborate on Schrodinger's point that it is possible to bring the two interacting de Broglie waves into a stationary frame of reference by a Lorentz transformation. Normally Compton scattering involves an incident photon striking a stationary electron. The momentum transfer produces a recoiling (moving) electron and reduces the energy of the scattered photon compared to the incident photon.

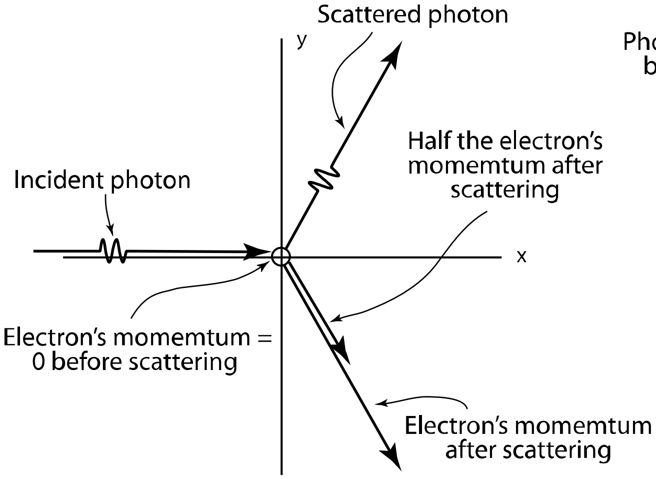

FIGURE 10-12 Compton scattering vector diagram (stationary electron before scattering)

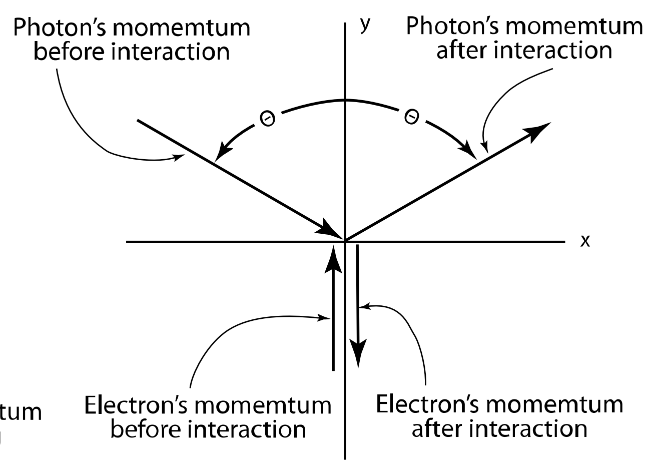

FIGURE 10-13 Compton scattering vector diagram in the frame of reference that gives zero energy transfer (moving electron before scattering)

Figure 10-12 shows a vector diagram that depicts this normal Compton scattering condition. This diagram shows the momentum vector of both the incident and the scattered photons. It also shows the electrons momentum vector after the Compton scattering. All of these are commonly included in Compton scattering diagrams, but figure 10-12 includes two additional features. First, the electron's momentum before scattering is designated (momentum = 0). Secondly, there is a momentum vector designated "half the electron's momentum after scattering". This vector should be superimposed on the parallel vector but it has been displaced slightly for clarity.

The reason for the additional designations of the electron's momentum before scattering and half the electron's momentum after scattering is that these designations will help explain the frame of reference used for Figure 10-13. In figure 10-13, we adopt a frame of reference that is required to have the electron moving with the opposite momentum as the vector designated "half the electron's momentum after scattering". If the scattered electron's velocity is non relativistic, then the moving frame of reference is simply half the scattered electron's speed and the opposite vector direction as shown in figure 10-13. In this frame of reference, the electron is moving at velocity +v before scattering and is moving at velocity –v after the scattering (the same speed but opposite direction). This is the frame of reference described by Schrodinger as the Lorentz transformation that "brings the density wave to rest". The superposition of the electron's de Broglie waves before and after the interaction results in a stationary (but oscillating) de Broglie wave pattern.

It is very easy to analyze Compton scattering from this frame of reference. There is momentum transfer between the photon and the electron, but there is no energy transferred. In this zero energy transfer frame of reference, the electron momentum moving towards the origin (before scattering the photon) is the same magnitude but opposite direction as the electron momentum moving away from the origin (after scattering the photon). The reversal in direction is the momentum transferred to the photon. The superposition of the two sets of the electron's de Broglie waves produces a stationary standing wave pattern (density wave) with periodicity of $\Lambda_d = \hbar/mv$. This stationary wave pattern effectively reflects a photon without any change in frequency. Also, the angle of incidence equals the angle of reflection – just like reflection from a stationary mirror.

All Compton scattering events involving an initially stationary electron can be looked at as a special case of the zero energy transfer Compton scattering where the frame of reference has been adjusted (Lorentz transformation) so that the electron is initially stationary. Once we understand a scattering event in this simplest frame of reference, we can easily switch back to the commonly used frame of reference depicted in figure 10-12. The frequency shift and angle change is simply the result of reflecting off a moving multi-layer dielectric mirror.

Figure 10-5 shows a rotar model in a moving frame of reference. This figure depicts an instant in time. The large black horizontal fringes are moving in the direction of translation at a velocity of $w_d = c^2/v$. This says that the interference fringes are always moving faster than the speed of light. When we superimpose two rotar models moving at the same speed but in opposite directions, we again obtain an instantaneous picture similar to figure 10-5. However, the superposition of opposite moving waves results in the de Broglie waves becoming stationary. This can be visualized as the high frequency waves (yellow and blue waves) in figure 10-5 being standing waves which are oscillating at a frequency of approximately 10^{20} Hz.

ψ Function: The envelope of these waves is a wave that is proposed to be Schrodinger's ψ function. Squaring this gives the probability of finding the electron in areas of greatest oscillation amplitude. Schrodinger calls these areas of greatest oscillation "waves of electrical density". Since these waves are proposed to be dipole waves in spacetime oscillating at the electron's Compton frequency, it is easy to see why the square of these waves represents the probability of "finding" an electron.

Schrodinger argues that when light interacts with stationary ψ-waves (de Broglie waves) they represent the equivalent of a density variation that can reflect light. Once again, his translated words are:

> "A single ψ-wave therefore produces a density distribution which is constant in both space and time. If however, we superimpose two such waves,… we see that a 'wave of electrical density' arises from the combination…"
>
> Now it is this density wave that takes the place of the sound wave of Brillouin's paper. If we assume that a light wave is reflected from it as from a moving mirror, (subject to the fulfillment of Bragg's law) then we shall show that our four waves (two ψ-waves and the incident and reflected light waves) stand exactly in the Compton relationship."

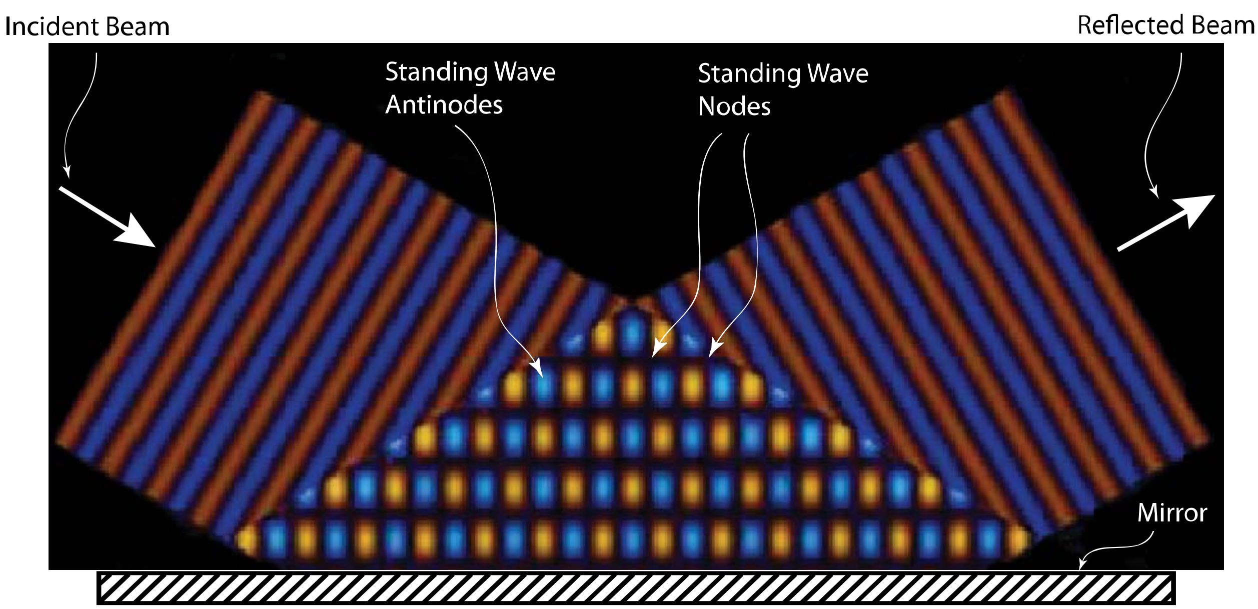

FIGURE 10-14 Standing wave pattern produced by the reflection of a beam of light off a mirror

More will be said about the physical explanation of the Ψ function in chapter 12. For now we will attempt to illustrate Schrodinger's idea of Compton scattering with the next two figures. Figure 10-14 sets the stage by illustrating the wave properties of light reflecting off a mirror (frozen in time). The beam of waves enters from the left, reflects off the mirror and leaves to the right. The area of overlap between the incident and reflected beams is the area where a standing wave pattern is created. This standing wave pattern has standing wave nulls which in this figure are horizontal bands parallel to the mirror surface where there is no electric field oscillation. The antinode bands are also illustrated and these are regions of maximum electric field oscillation. For example, if the light wave is linearly polarized with the electric field vector oscillating perpendicular to the plane of the illustration, then the blue regions might be considered regions where the electric field momentarily is pointing towards the reader and the yellow regions might be considered regions where the electric field vector is momentarily pointing away from the reader. If time was allowed to progress forward, these blue and yellow regions in the standing wave would move from left to right. The node planes would remain unchanged.

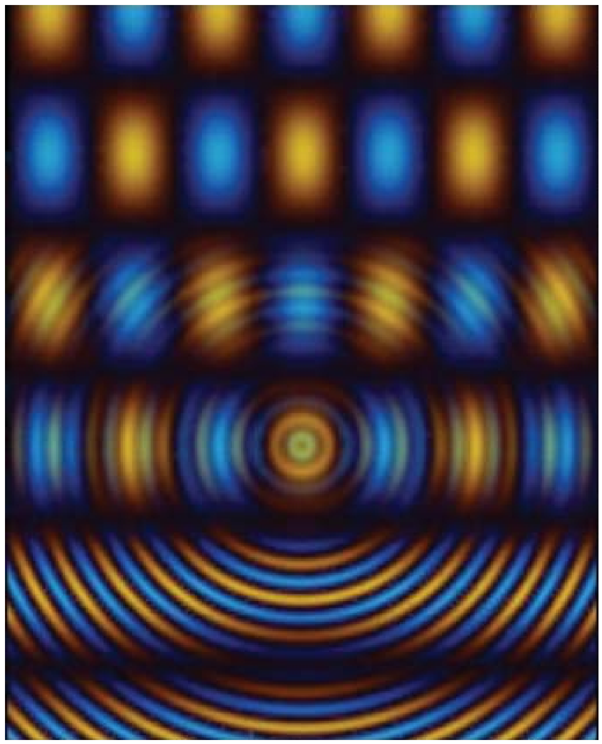

FIGURE 10-15 The superposition of 4 wave patterns produce this representation of Compton scattering. These 4 wave patterns are: 1) the incident light, 2) the scattered light, 3) the electron wave pattern before interaction, 4) the electron wave pattern after interaction.

Now figure 10-15 represents the combination of figures 10-14 and 10-5. In this case only the standing wave portion of figure 10-14 is illustrated, so the reader must imagine that the incident beam is coming in from the upper left and the reflected beam is leaving to the upper right. Also the lower portion of figure 10-15 represents the superposition of an electron before and after the scattering. We are using the zero energy transfer frame of reference, so the de Broglie wave pattern would appear stationary. The conditions that produce Compton scattering result in a perfect match between the spacing of the standing wave antinodes of the light beam and the standing wave antinodes of the electron. It is as if the light beam is reflecting off a multi layer dielectric reflector.

If we moved to a different frame of reference where we would perceive some energy transfer between the light and the electron, then the angle of incidence would not equal the angle of reflection and the wavelength of the reflected beam would be different than the wavelength of the incident beam. In the above description, some artistic license has been taken both in the illustration and the choice of words. We should really be talking about the scatter of a single photon from a single electron. The wave amplitude should not be uniform and numerous other corrections.

This spacetime wave explanation of Compton scattering is proposed to actually be better than the particle based explanation because several quantum mechanical mysteries are also explained by the spacetime wave explanation. For example, the spacetime wave explanation has the wave model of an electron going from its initial velocity to its final velocity without accelerating through all the intermediate velocities. An explanation of Compton scattering involving the standard point particle model of an electron would seem to imply that the electron undergoes acceleration as it transitions through intermediate velocities. This concept of intermediate velocities is not consistent with the quantum mechanical description.

Also, Schrodinger indicated that his ψ function had no physical meaning; it only gained physical meaning when it was squared to give the probability of finding a particle. I have given a proposed physical meaning to the ψ function. It is the wave envelope shown in figure 10-7 and depicted in figure 10-5. The envelope (ψ function) is undetectable because it is an interference effect with nodes and antinodes of dipole waves in spacetime with an interference pattern that propagates faster than the speed of light. Only when there is an interaction between two such envelopes of waves does the propagation slow down to a speed less than the speed of light (as depicted in figure 10-15). Squaring this then gives the probability of "finding the particle".

Plausibility, Not Proof: To successfully complete this Compton scattering analysis, it would be necessary to show that this superposition of the electron's waves in spacetime (two different velocities) produces a periodic change in the proper speed of light. Furthermore, it would also be necessary to characterize a photon using waves in spacetime and show that the combination of these models produces the correct scatter probability.

While I have proposed explanations that contain the elements required in this explanation, I cannot conclusively show that the effects on the speed of light are sufficient to accomplish Compton scattering. It is hoped that others might be able to complete this task. Schrodinger has shown that a wave explanation of Compton scattering is plausible. I show that the rotar model in a moving frame of reference is plausibly equivalent to Schrodinger's ψ-function waves. Therefore, this will be declared a successful plausibility test even though it is a long way from being conclusively proven.

Double Slit Experiment: Another plausibility test of the rotar model is to see if this model produces a diffraction pattern characteristic of sending an electron (or other particle) through a double slit. The diffraction pattern produced by sending a stream of electrons through a double slit has long been offered as proof that an electron exhibits wave-particle duality. Even before working on the ideas expressed in this book, I always found the implications of the double slit diffraction experiment to be a problem for the wave-particle duality "explanation". If an electron is also a point particle, then the point particle must have passed through only one of the two slits. Even if some wave properties of the particle explored the other slit, it seems as if the diffraction pattern should imply an unequal illumination of the two slits. A large inequality of illumination should greatly reduce the visibility of the diffraction nulls. Instead, the diffraction pattern produced by electrons implies that the electron possesses only wave properties as it passes through both slits equally and simultaneously. I find it far easier to conceptually understand how the rotar model of an electron can possess particle-like properties than understand the contradictions of wave-particle duality. Imagine an electron as a unit of quantized angular momentum with a specific rotational frequency existing in a sea of vacuum energy. With this model it is possible to see how this quantized angular momentum could possibly reassemble itself on the other side of a double slit. It would have passed through both slits and would exhibit the double slit diffraction pattern.

The following explanation will continue to use an electron as an example, but this also applies to composite particles such as neutrons or molecules. The reasoning about neutrons and other composite particles will be discussed later in the chapter about hadrons.

The diffraction pattern produced by light of wavelength λ passing through a single slit of width d_1 produces a well-known single slit diffraction pattern. The single slit intensity profile can be calculated from the Fraunhofer diffraction integral. In general, the double slit diffraction pattern can be thought of as a superposition of the single slit diffraction pattern on the diffraction pattern for two coherent narrow $(< \lambda)$ line sources of light separated by the double slit separation distance d_2.

Here we are only going to do a greatly simplified version that can illustrate some interpretations of the wave patterns that will be obtained in a double slit simulation. In this simplification, we start with the model of a moving rotar such as shown in figure 10-5. Symmetrical portions of the external volume of a rotar are presumed to pass through both slits symmetrically and become two new sources of waves. For simplification the emission pattern from each slit is spherical. An actual slit width would introduce an additional intensity distribution superimposed on this spherical emission pattern. The key difference between this model and a standard double slit experiment with light is that the waves emanating from both slits in this model have the bidirectional propagation characteristics (de Broglie waves) of a moving rotar. This means that we are interfering 4 sets of waves (2 counter propagating waves from each slit).

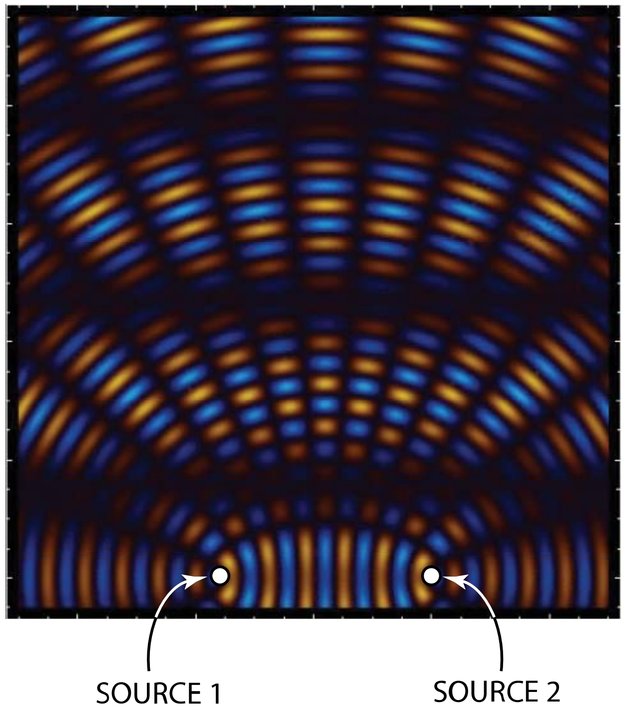

FIGURE 10-16 Illustration used to explain effects produced when a rotar encounters a double slit

Figure 10-16 shows the result of the coherent interaction of these 4 waves. The two slits are identified as "source 1" and "source 2". The resultant interference pattern is similar to what might be expected from light passing through double slits, but there are some key differences. First, the three dark horizontal bands are the result of the de Broglie waves and are similar to the bands shown in figure 10-5. These bands would be moving at faster than the speed of light $(w_m = c^2/v)$ and would not be in the pattern produced by light. Secondly, the blue and yellow wave representations would be alternating color (dipole polarity) at the electron's Compton frequency. Third, these blue and yellow wave representations would be propagating away from the slits at the electron's propagation speed $(u_d = v)$ and not at the speed of light as would occur with light. Fourth, it is impossible to detect the fine wave pattern represented by the blue and yellow waves. These have displacement amplitudes less than Planck length/time and are undetectable as discrete waves. They are at the electron's Compton frequency and the square of the time averaged waves represent the probability of "finding" the electron.

When a moving electron encounters a double slit, it no longer is an isolated electron. The model must change to reflect the changed boundary conditions. Parts of the quantized wave that is the electron pass through both slits and parts of the electron encounter the matter (other waves in spacetime) that forms the blocking areas. Whether or not the electron (rotar) reforms on the other side of the double slit is a probability. Even though most of the dipole wave is blocked (perhaps 99%), apparently the remaining 1% has a probability of reconstructing the entire dipole wave on the other side of the double slit. If it does reform, it has new characteristics imposed by the interaction with the matter (waves) that surrounds the double slit openings. There are new boundary conditions that are expressed as the radial interference pattern shown in Figure 10-16.

Oscillating Component of Gravity: Most of this chapter was spent describing the part of the external volume associated with the oscillating and non-oscillating components associated with the electric field. Chapters 6 and 8 were spent on gravity which is actually describing the non-oscillating strain in spacetime caused by spacetime being a nonlinear medium for dipole waves in spacetime. The remaining component is the proposed oscillating component of gravity. Today, this is an extremely weak effect because the amplitude of this oscillating component is $H_g = H_\beta^2/\mathcal{N}^2 = L_p^2/r^2$. Obviously, L_p^2/r^2 is an extremely small number for any value of r encountered today. However, at the beginning of the Big Bang this oscillating component of gravity was very important. It converted the starting condition of the universe (Planck spacetime) into the form of vacuum energy that we have today (superfluid dipole waves that lack angular momentum). This will be discussed further in chapters 13 and 14 which deal with cosmology.

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Chapter 11

Photons

Photons: In chapter 9 we examined the simplified case of photons confined to a reflecting cavity. When we reduced the dimensions of the cavity to the minimum size that would support electromagnetic radiation of a particular wavelength, we called this condition "maximum confinement". Equations for the electric and magnetic field were developed for this maximum confinement condition. In this chapter we will develop a model of a freely propagating photon. This model will be incomplete, but hopefully this attempt at developing such a model will encourage others to improve on this model.

It is commonly argued that photons cannot just be waves because the photo-electric effect demonstrates that all the energy of a photon is transferred to a single electron in an absorbing atom. This concentration of energy can eject an electron from the surface of the photo-electric material. The reasoning is that if a photon was a wave, then the wave would distribute the photon's energy evenly over a surface and no single electron would receive the energy required to eject an electron from a surface.   This reasoning assumes that the waves of a photon are similar to either a sound wave or perhaps a wave in the ether. A sound wave in air for example produces an oscillating displacement of many molecules. When a sound wave in air strikes a solid surface, it is really many individual molecules striking the surface independently. The energy of the sound wave is distributed over the surface. Similarly, if light is imagined as a wave in an omnipresent fluid called the ether, then waves in the ether would be evenly distributed over a surface and an electron would not be ejected from the surface.

However, since a photon has quantized angular momentum, it is impossible to distribute quantized angular momentum to multiple locations. All the quantized angular momentum (and energy) is deposited at a single location. This does not require a particle explanation; it only requires quantization of angular momentum. Furthermore, the photo-electric effect is low energy Compton scattering.   In chapter 10 it was shown that Compton scattering has a plausible wave explanation. Even though the photoelectric material has a surface work function, the basic Compton scatter wave interaction is the same. The wave characteristics of the photon and the electron can eject the electron from the surface.

How Big Is a Photon? The standard explanation for a photon's properties is to claim that a photon exhibits "wave-particle duality". Of course, this is not a conceptually understandable explanation; it is merely a name. In a double slit experiment, a photon seems to have the ability to pass through both slits simultaneously. This implies that a photon has a physical width. A photon also seems to have a physical length that is a function of the photon's spectral width. For example, a rubidium atom has a spectral line called the D_1 transition. When a rubidium atom goes through this transition, it emits a photon over about 26 ns. This implies that this photon has a length of about 8 meters. Furthermore, the spectral line width of this rubidium transition has a bandwidth that also implies a wave packet with this physical length using a Fourier transform. This is not just an 8 meter uncertainty in the location of the photon; it is an actual wave that is 8 meters long. The hyper fine transition of cesium 133 that is used in atomic clocks emits at a microwave frequency of about 9.2×10^9 Hz. This emission frequency is stable to better than one part in 10^{13}. This implies that the emitted photon is continuously emitted over about 1000 seconds and the length of the photon is about 3×10^{11} m. At the opposite extreme, the record for the shortest pulse of laser light (in terms of approaching the theoretical limit) is a mere 1.3 cycles per pulse. The current record for the shortest pulse of laser light is about 8×10^{-17} seconds but that pulse contained several cycles and harmonics of a short wavelength.

The emission of a photon by an atom is often depicted as if it is an instantaneous event. However, this is known to be incorrect[1] because there is a time dependence of the wave function in a quantum transition. Experimental measurements have been made of samples undergoing spectroscopic transitions. These experiments confirm that there are no instantaneous quantum jumps. Instead, the electric and magnetic properties undergo a smooth and continuous transition occurring over the lifetime of an excited state.

There is a very good paper titled "How a Photon is Created or Absorbed"[2] that is also available online[3]. This online version has two good animations showing the oscillations of a hydrogen atom during the emission of a photon. This paper shows that there is an often ignored transition period required for the emission or absorption of energy in a transition between energy levels. There are numerous experimental observations that confirm that photons are emitted or absorbed over a time period corresponding to the inverse bandwidth. Quoting from the above article:

> The first experimental measurements of bulk samples undergoing spectroscopic transitions were obtained from nuclear magnetic resonance observations of the transition nutation effect[4] and spin echoes[5],[6] using coherent radiation produced by a single radio frequency oscillator. More recently, the analogous transition nutation effect[7],[8] and so called "photon echoes"[9],[10],[11] have been observed in molecular

[1] Macomber, J. D. *The Dynamics of Spectroscopic Transition;* John Wiley and Sons: New York, 1976.
[2] Henderson, G *J. Chem. Educ.* **1979**, *56*, 631-634
[3] http://jchemed.chem.wisc.edu/JCEWWW/Articles/DynaPub/DynaPub.html
[4] Torrey, H. C. *Phys. Rev.* **76**, 1059 (1949).
[5] Hahn, E. L. *Phys. Rev.* **77**, 297 (l950).
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[9] Kurnit, N. A.; Abella, I. D.; Hartmann, S. R. *Phys. Rev. Lett.* **13**, 567 (1964).
[10] Abella, I. D.; Kurnit, N. A.; Hartmann, S. R. *Phys. Rev.* **141**, 391 (1966).

spectra using pulsed coherent laser radiation. These experiments confirm that there is no "quantum jumps" in the non-stationary state; rather there are smooth, continuous periodic changes in the magnetic and electrical properties of the system undergoing a transition.

An electron bound in an atom possesses less energy than an isolated electron. For example, 13.6 eV of energy is released when an isolated electron combines with a proton to form a hydrogen atom in the ground state. The binding energy can be considered to be a negative form of energy which means that binding releases energy and breaking a bond requires energy. The rotar model of fundamental particles says that an isolated electron is a rotating dipole in spacetime with a rotational frequency of about 1.24×10^{20} Hz. When an electron and proton combine to form a hydrogen atom in the ground state, a photon is released with a frequency of about 3.3×10^{15} Hz (~13.6 eV). According to the rotar model, the energy released when a hydrogen atom forms comes from the electron losing energy and reducing its Compton frequency by about 3.3×10^{15} Hz. The oscillations of the electron cloud shown in the above animation can be thought of as the interaction between the electron in two different energy states (two different frequencies) interfering with itself. These oscillations create waves in spacetime that remove this energy at the frequency of the oscillations. These waves are proposed to be the photon.

In chapter 9 it was shown that a photon was not an energy packet traveling THROUGH spacetime, but a wave traveling IN the medium of spacetime. Now we will develop the model of a photon further based on waves propagating within the vacuum fluctuations of spacetime. These waves will be shown to be distributed over a substantial volume of spacetime. Clearly such a structure cannot be visualized as a point particle. It only exhibits particle-like properties because it possesses quantized angular momentum combined with the property of unity. This combination gives waves in spacetime with quantized spin the ability to act as a unit and transfer their energy and quantized spin to a single rotar. The name "photon" is not really appropriate since the suffix "on" was coined specifically to imply particle properties. However, the name "photon" is flexible enough that it can adjust to a quantized wave explanation. Therefore no attempt will be made to replace the word "photon".

Vacuum Energy Versus the Ether: The ether was once believed to be an omnipresent fluid with a single frame of reference that served as the propagation medium for light waves. The concept of the ether implied that it should be possible to detect evidence of the earth's motion relative to the ether. This relative motion would produce a shift in interference fringes in the Michelson Morley experiment. This and numerous more recent experiments have confirmed that there is no evidence that any such relative motion exists. With this experimental evidence, the concept of the ether has been abandoned. This background makes the following seem like a radical proposal:

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[11] Hartmann, S. A. *Sci. Amer*. **218**, 32 (1968).

Electromagnetic radiation is a wave disturbance with quantized angular momentum that propagates in the medium of the vacuum fluctuations of spacetime.

This sounds like I am merely substituting the term "vacuum fluctuations" for ether. However, there is a big difference. The properties of the vacuum fluctuations are such that it is impossible to detect any motion relative to these fluctuations. Recall that vacuum energy (vacuum fluctuations) is a sea of dipole waves in spacetime that lack angular momentum. These waves are already propagating at the speed of light. Every part of a wave becomes the source of a new wavelet so spacetime becomes a sea of dipole wave distortions that are rearranging themselves at the speed of light. As previously explained, these chaotic waves that lack angular momentum make the quantum mechanical version of a vacuum. They are responsible for the appearance of virtual particle pairs, the uncertainty principle, the Casimir effect, the Lamb shift, etc.

It is impossible to detect motion relative to these waves in spacetime. Chapter 7 discussed the subject of spectral energy density in vacuum energy. That discussion is repeated here because it takes on new meaning when applied to detecting motion relative to vacuum energy.

> In quantum field theory, spacetime is visualized as consisting of fields. Every point in spacetime is treated like a quantized harmonic oscillator. The lowest quantum mechanical energy level of each oscillator is $E = ½\, \hbar\omega$. This concept leads to a spectral energy density $\rho(\omega)d\omega$ that is:
>
> $$\rho(\omega)d\omega = k\left(\frac{\hbar\omega^3}{c^3}\right)d\omega$$
>
> If spacetime is filled with overlapping dipole waves in spacetime that are capable of forming the equivalent of virtual particle pairs at all frequencies (not just frequencies corresponding to fundamental particles), then the spectral energy density would be this same equation.
>
> This spectrum with its ω^3 dependence of spectral energy density is unique in as much as motion through this spectral distribution does not produce a detectable Doppler shift. It is a Lorentz invariant random field. Any particular spectral component undergoes a Doppler shift, but other components compensate so that all components taken together do not exhibit a Doppler shift. It should also be noted that neither cosmological expansion nor gravity alters this spectrum.[12]

[12] Puthoff, H.E. Phys. Rev. A Volume 40, p.4857, 1989 Errata in Phys. Rev A volume 44, p. 3385, 1991 See also New Scientist, volume 124, p.36, Dec. 2, 1989

Therefore, vacuum energy has completely different properties than the ether which is thought of as an omnipresent fluid which has a specific frame of reference. It is impossible to detect motion relative to the vacuum energy. It is made of dipole wavelets that are continuously forming new wavelets and propagating at the speed of light. Vacuum energy has no definable frame of reference. The experiments attempting to detect the ether neither prove nor disprove the proposal that electromagnetic radiation propagates in vacuum energy.

Previously it was speculated that vacuum energy is similar to a super fluid. The super fluid vacuum fluctuations of spacetime do not possess angular momentum on the large scale. Any angular momentum is isolated into quantized units. The fundamental particles are isolated into rotars with angular momentum of ½ ħ. The bosons such as photons have angular momentum of ħ. These quantized angular momentum disturbances in spacetime, are not confined to a specific location like the rotar model. Instead the quantized angular momentum of a photon is distributed into an expanding wave that will be described in this chapter. When a photon is absorbed, the disturbance with quantized angular momentum would collapse and transfer the angular momentum to the absorbing body (rotars).

A Photon Is Not a Dipole Wave in Spacetime: A photon cannot be a quantized dipole wave in spacetime. A dipole wave creates an oscillating rate of time gradient. A rate of time gradient is capable of accelerating any matter, even a neutral particle such as a neutron. To prevent a violation of the conservation of momentum, dipole waves in spacetime are limited to a maximum displacement of spacetime of Planck length and Planck time as previously described. A focused laser beam would easily violate this restriction. Recall that rotars have this quantum mechanical limit of Planck length and Planck time. Therefore, the maximum energy density for a dipole wave in spacetime is equal to the energy density of the quantum volume of a rotar (U_q). This knowledge can be converted to a maximum intensity ($\mathcal{I}$) for a dipole wave in spacetime with reduced wavelength $ƛ$ since $\mathcal{I} = Uc$ for radiation propagating at the speed of light. From previous calculations of rotars, we know that the energy density in the quantum volume of a rotar is: $U_q = \hbar c/ƛ^4$. This energy density then sets an upper limit to the maximum intensity that could be achieved at the focus of a laser beam if photons were dipole waves in spacetime. Using $\mathcal{I} = Uc$, the maximum intensity of electromagnetic radiation that would violate the conservation of momentum if photons were dipole waves in spacetime is: $\mathcal{I}_{\max} = \hbar c^2/ƛ^4$.

The maximum intensity allowable for a laser beam with a wavelength of about 10^{-6} m (reduced wavelength $ƛ \approx 1.6 \times 10^{-7}$ m) would be about 10^{10} w/m² (10^4 w/cm²). Intensities in excess of 10^{20} w/cm² have been achieved at the focus of a pulsed laser at this approximate wavelength, so a photon is definitely not a propagating dipole wave in spacetime. A model will be developed that is a wave in the space dimensions of spacetime without affecting the rate of time. Gravitational waves can also have displacement amplitude that exceeds dynamic Planck length L_p because they also do not cause a displacement of the rate of time. (They also are not dipole waves in spacetime.)

Waves in Vacuum Energy: So far we have talked about waves in the abstract. What are the waves of a photon made of? They are not propagating dipole waves in spacetime but the proposed answer is that they are a propagating disturbance in the dipole waves that form vacuum energy. In chapter 9 the proposal was made that an electric field is a strain in spacetime where the proper speed of light is slightly different for opposite directions. This produces the unsymmetrical effects associated with propagation in the positive or negative electric field direction. This results in the one way distance between points being slightly different for opposite polarity directions. For example, if there is an electric field present, then the time required to go from point A to point B is longer than the time required to go from point B to point A. However, the round trip time is the same as expected from the speed of light. This means that there is no change in proper volume and no change in the rate of time. A single photon in maximum confinement had a difference in path length over a distance of $\lambda\!\!\!^-$ of L_p and n photons in maximum confinement produced a path length difference of: $\sqrt{n}L_p$. This explains why it is impossible to measure the wave properties of a single photon but it is possible to measure the wave properties of many photons (for example, the electric field of a radio wave).

The model of a single photon would be a wave possessing quantized angular momentum that propagates in vacuum energy. The dipole waves that form vacuum energy cannot possess angular momentum, so a disturbance carrying quantized angular momentum would be like a propagating phase transition that causes a specific frequency and volume to momentarily lose its superfluid properties. Such a wave would momentarily be giving a distributed angular momentum to vacuum energy. Apparently this disturbance is a transverse wave that possesses the polarization characteristics we normally associate with a photon. Such a wave in vacuum energy would propagate at the speed of light for all frames of reference. Furthermore, the impedance of free space (Z_o) associated with electromagnetic radiation is equitable to the impedance of spacetime $Z_o/\eta^2 = 4\pi Z_s = 4\pi c^3/G$.

Electron-Positron Annihilation Thought Experiment: We are going to develop the photon model further using a thought experiment. In this thought experiment we will look at the two entangled photons produced by annihilation of an electron-positron pair. This might seem like an exotic way of producing a pair of photons, but it actually is the simplest case to examine because unlike atomic emission or Compton scattering, no particles remain after the annihilation to carry away momentum.

We are assuming that we start with an electron-positron pair with antiparallel spin. This form of positronium typically has a lifetime of about 10^{-10} seconds and usually decays into two entangled photons with antiparallel spins. We will assume this normal two photon decay.

These two gamma ray photons have opposite spins and opposite momentum vectors. However, the spins and momentum vectors are only defined when the first photon is detected. Each photon has 511,000 eV of energy, so the frequency and wavelength of each photon matches the Compton frequency and Compton wavelength of the annihilated rotars.

The conventional picture of this annihilation is the emission of two photons which have both particle and wave properties. The particle properties imply a packet of energy that can be found somewhere within the uncertainty volume defined by the decay time and spin orientation of the electron-positron pair. This conventional picture has the two entangled photons with opposite momentum, but the momentum directions are not set until the first photon is absorbed. At that moment the momentum and polarization of the second entangled photon has been determined. One counter intuitive part of this model is that the information about momentum and polarization must somehow be communicated to the surviving photon when the first of the two entangled photons is absorbed.

Even if the two entangled photons are separated by a distance of one light-year, they still somehow are in instantaneous communication. If one of the photons happens to interact with a polarizer of any orientation or ellipticity, the other photon instantly becomes the orthogonal polarization. Many logical questions arise from this picture. How do the two photons keep track of each other? What type of communication signal is sent out when one photon encounters a polarizer? How does this communication happen faster than the speed of light? I propose that the reason that this explanation is impossible to conceptually understand is because it is the wrong picture of a photon.

Electron-Positron Annihilation – The Quantized Wave Model: We will now restate this interaction using the photon and rotar models that incorporate distributed waves in spacetime. Suppose that we use the rotar model of an electron and a positron with opposite (antiparallel) spins that are initially far apart compared to distance R_q. Both rotars have a Compton angular frequency of about 7.76 x 10^{20} s^{-1} or a frequency of 1.23 x 10^{20} Hz. If these two rotars move towards each other, it means that they would both perceive the other to be Doppler shifted and the two frequencies would not be exactly the same. Since these two rotars are going to eventually emit two entangled photons of the same frequency, we will presume that the formation of positronium includes some type of synchronization of these two frequencies.

What will happen when we bring together an electron and a positron? It appears as if this interaction destabilizes both rotars. The rotar model of an isolated electron proposes that an electron is stable because there is a type of resonance between the electron's rotating dipole wave and the surrounding vacuum energy. Recall that the electron has a quantum amplitude of $H_\beta \approx 4.18 \times 10^{-23}$. This dimensionless number is also the electron's frequency, energy, mass, inverse quantum radius, etc. in Planck units. This frequency and amplitude achieves a resonance in vacuum energy that cancels the loss of power and produces constructive interference with the rotating dipole core.

The lifetime of positronium with antiparallel spins has been calculated[13] from QED as: $\boldsymbol{\tau} = 2\hbar/m_e c^2\alpha^5 = 2/\omega_c\alpha^5 \approx 1.25 \times 10^{-10}$ s. This calculated lifetime agrees with experimentally measured lifetime. The annihilation of positronium with antiparallel spins usually produces two entangled gamma ray photons. These two photons have the same frequency, wavelength and energy as the electron and positron in the rest frame. Since the electron-positron pair had antiparallel spins, the two entangled photons also have a combined spin of zero.

Photon Model of Annihilation: Now the model of this annihilation using waves in spacetime will be presented. The electron and positron both have a Compton angular frequency of 7.76×10^{20} s^{-1}. When these two rotars annihilate each other the stabilization mechanism with vacuum energy is destroyed. The cancellation wave formed in vacuum energy no longer prevents the dissipation of the electron's and positron's energy. Waves in spacetime at the electron/positron Compton frequency propagate away from the site of the annihilation at the speed of light. These propagating waves are two entangled photons that result from the annihilation. The waves are propagating in the medium of the vacuum fluctuations that are an essential characteristic of spacetime. As previously determined, the impedance and bulk modulus encountered by these waves corresponds to the impedance of spacetime $(Z_s = c^3/G)$ and the bulk modulus of spacetime $K_s = F_p/\lambda\!\!\!^{-2}$. The speed of this wave propagation is equal to c which was previously calculated from the interactive energy density of spacetime and the impedance of spacetime.

Figure 11-1 shows this annihilation event. At the center of this figure, a small volume of space is labeled as the location of the annihilation of the electron-positron pair. This figure shows the results of this annihilation some time after the annihilation takes place. This is a cross-sectional view of the waves in spacetime that are the two entangled photons. Symmetrically around the annihilation volume there is now a spherical shell of waves in spacetime with the radius increasing at the speed of light.

The waves in this shell have an angular frequency of 7.76×10^{20} s^{-1} which is also the electron's Compton angular frequency. Since there is no frequency change between the electron/positron and the photons emitted, the annihilation event can be considered merely the destabilization of the vacuum energy cancelation waves that were keeping the electron's energy confined. The time required for annihilation was 1.25×10^{-10} s so this amounts to about 1.5×10^{10} cycles (wavelengths) forming a shell of waves with a thickness of about 3.8 cm. Figure 11-1 shows multiple concentric circles to convey the idea that the expanding shell contains many

[13] http://arxiv.org/PS_cache/hep-ph/pdf/0310/0310099v1.pdf

wavelengths. Also the entangled spherical shell of waves has zero net spin since this example assumed that the electron and positron had antiparallel spin.

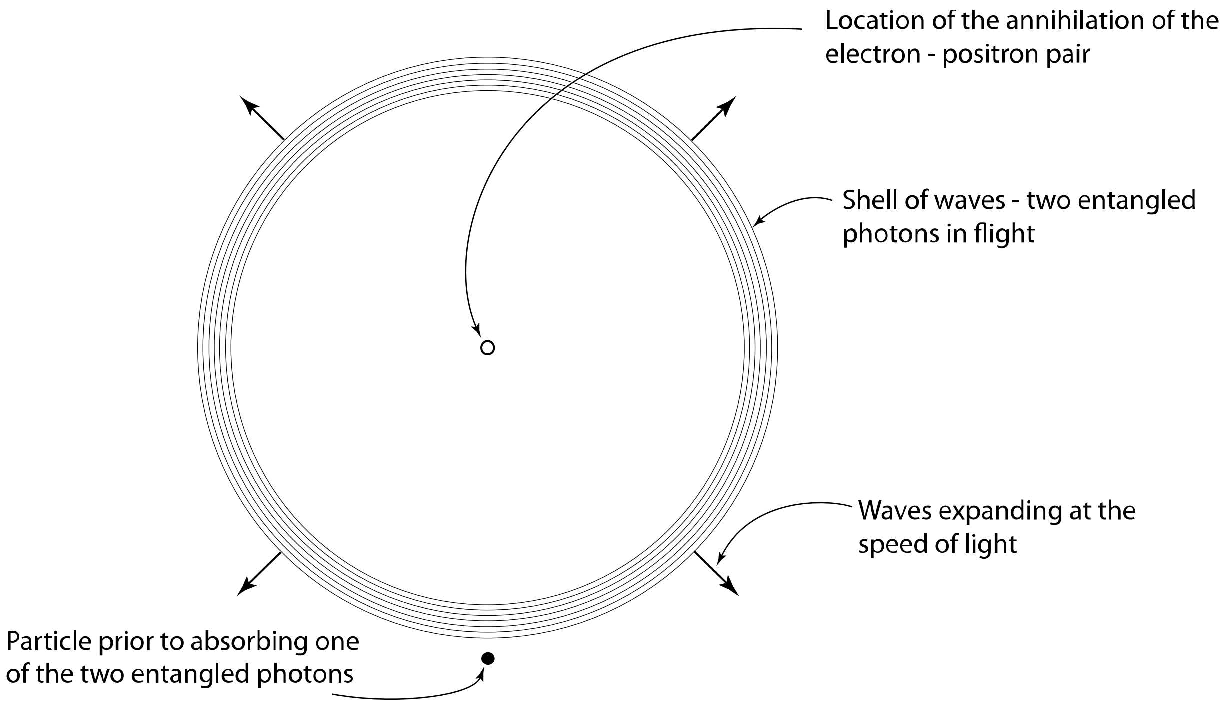

FIGURE 11-1 Concentric circles represent the waves in spacetime that form the two entangled photons produced by the annihilation of an electron-positron pair.

Entanglement: Suppose that the spherical shell of two entangled photons (propagating in the vacuum fluctuations of spacetime) expands into what might be called "empty space" to a radius of one light-year. Really this space is filled with a sea of vacuum energy and the waves are a disturbance in this vacuum energy. At this point, suppose that a small portion of the wave shell encounters an absorbing object that we will generically call an absorbing particle. It could be an atom or other group of rotars. To make the absorption interesting, we will presume that the absorbing material has a strong absorption preference for clockwise circular polarization at the frequency of the two entangled photons. This absorbing material is illustrated in figure 11-1 as a point labeled "particle prior to absorbing one of the two entangled photons". The absorbing particle (or group of rotars) is capable of absorbing quantized angular momentum of ħ. However, the spherical shell of waves is two entangled photons that were generated when the electron and positron (both spacetime dipoles) were annihilated. The absorbing material cannot interact with only a small percentage of the quantized wave. The quantized angular momentum transferred must be either ħ or nothing.

Now it gets interesting. Any interaction must be with a complete photon (quantized energy and angular momentum). In this case, this means that the interaction is between the absorbing material and one of the two entangled photons that together made up the entire spherical wavefront, one light-year in radius. The interaction cannot be with both photons because the two photons have a total spin of zero. There appears to be a prohibition against energy transfer without an accompanying spin transfer.

If there is absorption, then the proposed property of unity causes one of the two entangled photons to collapse. All of the energy (511,000 eV), all the angular momentum (ħ of clockwise circular polarization) and all the momentum (~ 2.7 x 10^{-22} kg m/s) of the single photon is deposited into the absorbing material. Even if the absorption happens over a finite absorption time that is comparable to a finite emission time (for example, several nanoseconds), the entire quantized wave energy, distributed over one light-year radius, must collapse in this short time.

The details of how photons are proposed to collapse will be discussed later when we deal with the eventual absorption of the second of the two entangled photons. The collapse of the first of the two entangled photons removes from the spherical shell all of the wave characteristics necessary to make a circularly polarized photon with clockwise angular momentum. This includes not only spin and energy, but the collapse also imparts momentum of ~ 2.7 x 10^{-22} kg m/s. with an accurately defined momentum vector that will be discussed later.

What remains in the spherical shell of waves are proposed to be all the characteristics required to make a photon with the orthogonal polarization (counterclockwise spin) and the opposite momentum vector which is not quite precisely defined. This implies that the second photon can only impart the opposite momentum and opposite circular polarization when it is eventually absorbed. The photon that was absorbed must be the inverse of the photon that remains since the two entangled photons originally formed a uniform amplitude shell of waves. Therefore, to obtain a description of both photons we will examine the remaining photon.

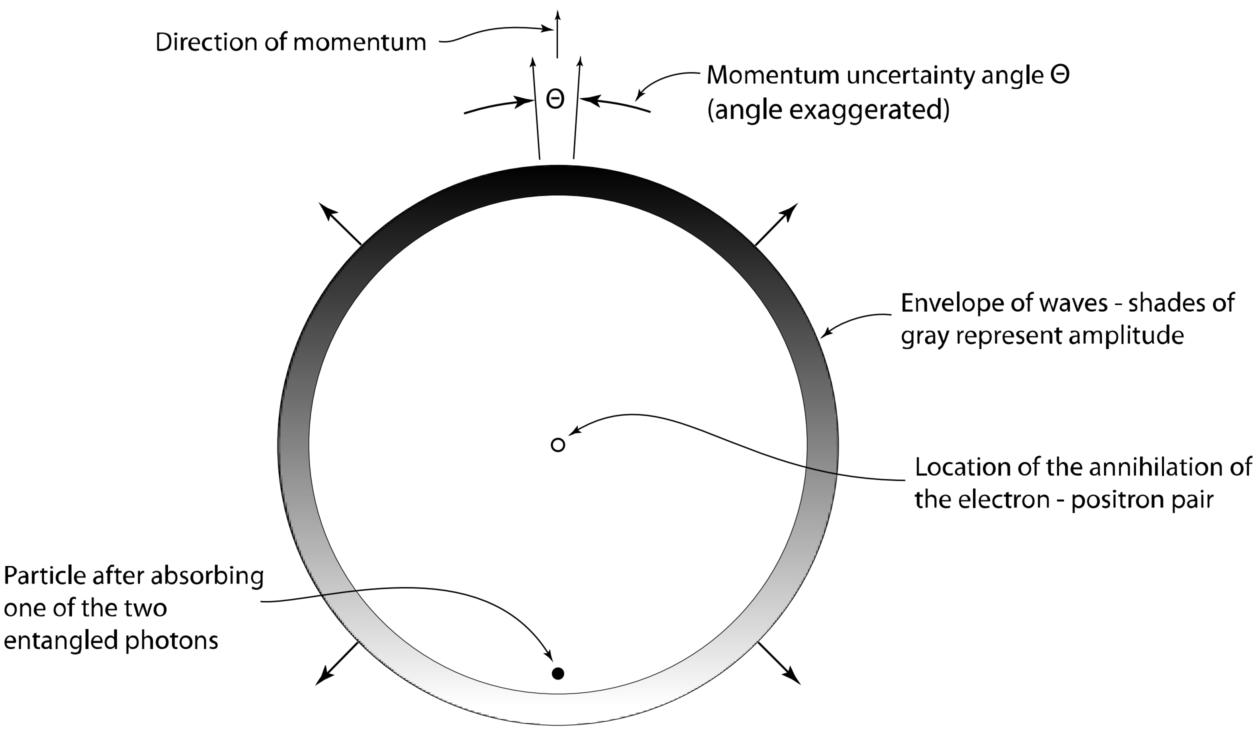

FIGURE 11-2 Amplitude distribution (shades of gray) of the surviving photon. This is a picture shortly after the other entangled photon was absorbed by the particle shown.

Single Photon Model: Figure 11-2 shows the proposed model of the surviving photon after the other entangled photon previously discussed was absorbed and collapsed into the absorbing particle. In other words, figure 11-2 shows a slightly later time than figure 11-1. In figure 11-2 the envelope of waves has expanded past the particle that absorbed the other entangled photon. This particle is shown near the bottom of the figure. Compare the placement of this particle to the placement shown in figure 11-1.

The major visible difference between figures 11-1 and 11-2 is that the circle representing the envelope of waves is now shown with different shading ranging from black (highest amplitude) at the top of the figure through shades of gray to white (lowest amplitude) at the bottom of the figure. The waves are still present but the waves are not shown in figure 11-2 because the emphasis in 11-2 is the amplitude of these waves.

The amplitude distribution for the waves in the remaining photon is proposed to be the same as the amplitude distribution of the wavelets in the Huygens-Fresnel-Kirchhoff principle. Recall that the Huygens-Fresnel principle accurately models diffraction of an optical wave by assuming that all points on an advancing wavefront become the source of a new wave called a wavelet. A new wavefront is formed by coherently adding together these secondary waves, including their phases. This principle was perfected by Gustav Kirchhoff when he added an amplitude distribution to the waves that formed each new wavelet that prevented backwards propagation towards the source and improved the accuracy. Previously the wavelets were merely considered to be limited to the forward hemisphere. This arbitrary limitation worked well for most applications, but Kirchhoff's addition perfected the principle for all cases. The amplitude distribution formulated by Kirchhoff is called the obliquity factor $K(\theta)$. It can be expressed either in Cartesian or spherical coordinates. The spherical coordinate representation is: $K(\theta) = \cos^2(\theta/2)$.

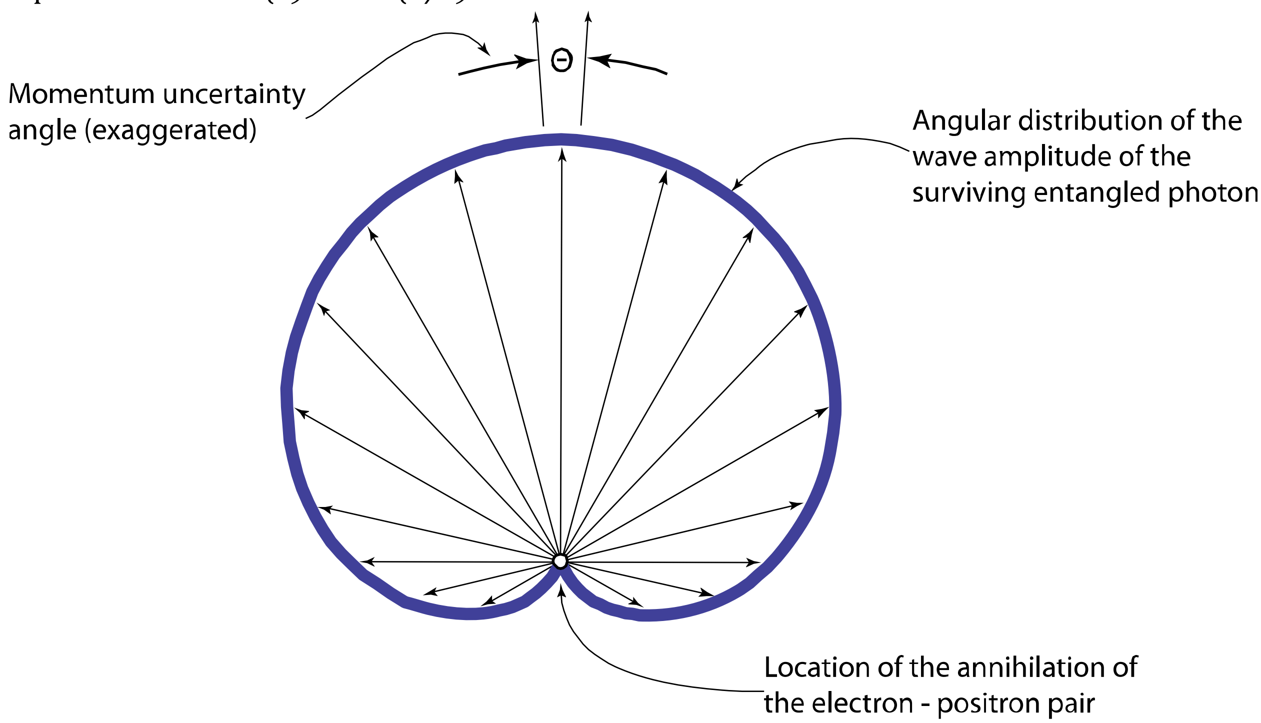

FIGURE 11-3 Amplitude distribution (graphical representation) of the surviving photon

A single photon is proposed to have the same amplitude distribution as the wavelets required for the Huygens-Fresnel-Kirchhoff principle. The shading of the envelope of waves in figure 11-2 has this distribution. However, figure 11-3 is a graphical representation of the amplitude distribution of the surviving photon. The absorbed photon would have had the inverse of this amplitude distribution which is the same as inverting figure 11-3. Adding these two distributions together produces the uniform distribution of the original entangled pair of photons $(\sin^2(\theta/2) + \cos^2(\theta/2) = 1)$.

Photon's Momentum: We are now going to return to figure 11-2 to address the question of the momentum of a single photon. Recall that the thought experiment that generated this figure presumed that the two entangled photons expanded in a vacuum to the radius of one light year when finally one of the two photons was absorbed by the particle shown in figure 11-2. These assumptions mean that the momentum vector for the surviving photon must be very well defined. The original annihilation of the electron/positron pair had an uncertainty volume that can be calculated knowing the mass of the electron/positron pair (~ 1.82×10^{-30} kg) and the lifetime (~1.25×10^{-10} s) to give an emission uncertainty radius

$\Delta x = \sqrt{\hbar t/2m} \approx 6 \times 10^{-8}$ m. Also the particle that absorbed the first photon could have been part of a detector that could specify the location of the absorption to a radius much smaller than the 6×10^{-8} m uncertainty of the emission. Therefore the uncertainty in the emission dominates and we can ignore the uncertainty in defining the absorption location.

Since these two uncertainty volumes are separated by one light year (~ 10^{16} m), this means that that the momentum vector uncertainty angle of the single photon in this example is about 6×10^{-24} radians (6×10^{-8} m/10^{16} m). The surviving photon must have the opposite momentum, so at the moment the first photon is absorbed, we know a great deal about the allowed volume where the second photon can possibly be absorbed in the future. The reason for this exercise is that the model of a single photon must be capable of this momentum accuracy.

In figure 11-2 the envelope of waves should be pictured as being one light year in radius. This figure also shows an angular spread designated "momentum uncertainty angle" which for this example is about 6×10^{-24} radians. How is it possible for this wave structure to possess this narrow a momentum uncertainty? Just looking at the figure, it seems as if the surviving single photon could be absorbed by an absorbing particle located in almost any direction around the expanding shell of waves (except perhaps the zero amplitude direction). The requirement of a well defined momentum helps us define the model and helps to define the way that photons collapse.

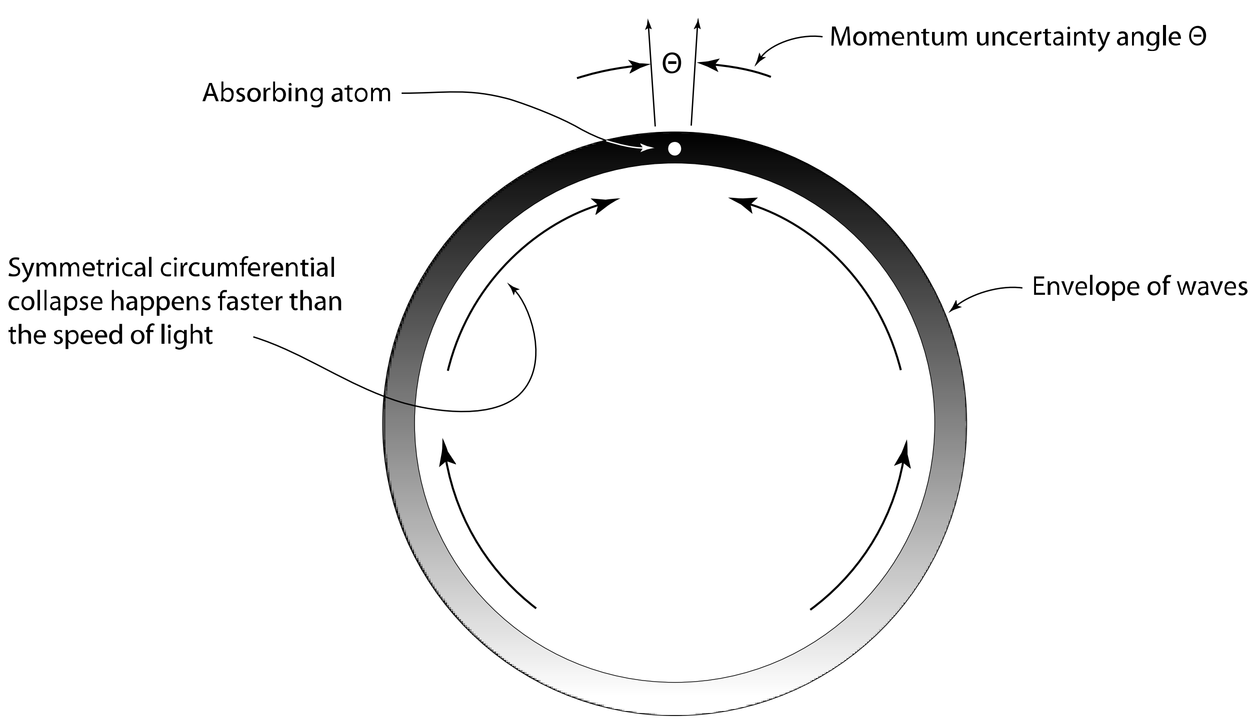

FIGURE 11-4 The collapse of a photon on an atom

Collapse of a Single Photon: Figure 11-4 shows the eventual absorption of the surviving photon. The absorbing body is designated and it must lie within the volume limited in width by the momentum uncertainty angle. Also the absorbing body must be located within the thickness of the envelope of waves during the absorption. The collapse of the single photon's energy and angular momentum is depicted by the arrows shown in figure 11-4. These arrows indicate that the collapse proceeds along the circumferential route defined by the envelope of waves.

This has a great deal of appeal. The momentum transferred to the absorbing body can only have a radial vector relative to the emission uncertainty volume. It would be a violation of the conservation of momentum for there to be a tangential vector component that is larger than the uncertainty limit. This means that the only volume of the photon's wave structure capable of interacting with matter is restricted to the small volume bounded by the momentum uncertainty angle. This is the only volume where the collapse is sufficiently symmetrical to prevent the transfer of substantial transverse momentum. There must be offsetting transverse momentum components on either side of the absorbing body so that the collapse is balanced and results in the correct net momentum.

Next, we are going to examine whether the photon structure proposed here is capable of collapsing to a volume as small as would be required to satisfy the momentum uncertainty angle which is about 6×10^{-24} radians. If the second photon was absorbed shortly after the time of the first photon absorption, then the shell of waves would be about the same size which was postulated to be 1 light year in radius ($\sim 10^{16}$ m in radius). The waves are distributed over a diameter of about 2 light years ($\sim 2 \times 10^{16}$ m) and the wavelength produced by the annihilation of an electron/positron pair is $\lambda \approx 2.4 \times 10^{-12}$ m. If we merely calculate the diffraction limit of this combination of aperture size and wavelength we obtain a λ/D uncertainty angle (divergence angle) of 2.4×10^{-28} radians. Therefore this wave structure can easily satisfy the requirement of collapsing to a volume equivalent to 6×10^{-24} radians uncertainty. In fact, this photon model should always collapse to an area about one wavelength in circumference.

Limits on Absorption: The portion of the single photon that lies outside the momentum uncertainty volume cannot interact with matter. A speculative answer says that these waves can pass through matter without being absorbed or affected. In the figures 11-1 to 11-4 we carefully avoided the question of the waves encountering other matter by postulating propagation in an empty vacuum. However, the waves external to the momentum uncertainty angle may merely pass through matter without any interaction. Recall that matter is made of rotars that are just empty spacetime that is very slightly strained. (roughly 1 part in 10^{20} for an up quark). If a disturbance in vacuum energy is incapable of transferring angular momentum because it is outside of the momentum uncertainty volume, then this portion of a photon should be more inert than a neutrino and should easily pass through matter.

Unity Connection: The circumferential collapse shown in figure 11-4 is the proposed property of unity at work. This proposed property permits faster than the speed of light communication and collapse within a single quantized wave in spacetime. In chapter 14 a speculative mechanism will be proposed for faster than the speed of light communication within a single quantized wave. However, superluminal communication is an experimentally established property of entanglement and it is quite reasonable that a single photon would also possess this same capability even if an explanation is not currently available. The superluminal collapse of a photon shown in figure 11-4 is symmetrically balanced and does not involve the transfer of any information or external momentum. The momentum that is transferred is entirely within the single photon. While the collapse is faster than the speed of light, it is not instantaneous. It probably requires a time of at least $2\pi/\omega$ which is a minimum of one cycle of the photon.

It is also clear that there is no mystery how the photon model can carry angular momentum. The shell of waves must be pictured as a 3 dimension spherical shell. The waves that make up a circularly polarized photon would have a phase progression that circulates the spherical shell at a frequency equal to the photon's frequency. The spatial distribution of this shell of waves makes it easy to see how it is possible for this photon model to carry angular momentum and transfer the angular momentum when the wave structure collapses. It is not clear how the conventional model of a photon transfers angular momentum.

Photon Emission from a Single Atom: In the thought experiment involving the annihilation of an electron/positron pair there was no remaining matter to remove momentum and complicate the analysis. We will next address the emission of a photon by a single atom. If a proton and an electron combined to form a hydrogen atom, the energy of the photon emitted would be about 13.6 eV. The emission of this energy would cause the hydrogen atom to recoil with a velocity of about 4 m/s. Hypothetically, it is possible to determine the direction of the photon's momentum by monitoring the motion of the electron and proton prior to forming the hydrogen atom and by monitoring the recoil of the hydrogen atom after the emission of the photon. There is uncertainty in making these measurements, but the accuracy in determining the direction of the photon's momentum increases with time. The photon has the opposite momentum of the recoiling hydrogen atom. The further the recoiling hydrogen atom travels before its position is detected, the more accurate that the momentum vector of the recoiling hydrogen atom can be determined.

The photon is carrying the opposite momentum vector as the recoiling hydrogen atom to within the limits of the uncertainty principle. I claim that not only does our ability to measure the momentum vector of the recoiling hydrogen atom improve with time, but there is continued interaction between the external volume of the recoiling hydrogen atom and the photon even after the photon has been emitted. This interaction reduces the momentum uncertainty angle of the expanding photon over time to coincide with the improved ability to measure the recoil momentum vector of the hydrogen atom.

Recall that a hypothetical rotar formed shortly after the Big Bang and undisturbed since then, would have an external volume that extends virtually to the particle horizon of the universe. The waves in the external volume have the Compton frequency of the rotar, so when there is a loss of energy, an adjustment in the frequency of the waves in the external volume must be made. The "news" that a hydrogen atom was formed with less total energy than the component parts progresses into the external volume of the electron and quarks at the speed of light. This "news" exactly corresponded to the expanding shell of waves that forms the emitted photon. As discussed below, the waves in the rotar's external volume continue to make a very small but important contribution to the photon as the photon expands at the speed of light into the external volume. The uncertainty in the momentum of the photon decreases with time (distance) the same as the uncertainty in the recoil momentum of the atom decreases with time.

Compton Scattering Revisited: A hydrogen atom made of 4 rotars (1 electron and 3 quarks) is too complicated to analyze the interaction between the expanding photon and the external volume of the rotars that form the hydrogen atom. Therefore we will switch back to Compton scattering between a single electron and a single photon. This interaction was previously examined using the series of figures from 10-12 to 10-15. Figure 10-15 is the super position of 4 waves. The waves at the top of this figure represent the photon's waves before and after the scattering. The waves at the bottom of the figure represent the electron's waves before and after the scattering. The middle portion of the figure shows both pairs of waves interacting.

Because of the standing waves in the electron's external volume this interaction continues to occur long after we think that the scattering event has happened. Picture the electron (rotar) as having diminishing standing waves in its external volume that extend a long way from the location of the scattering. The "news" that the rotar has undergone acceleration propagates into these surrounding standing waves at the speed of light. There is a spherical shell that is expanding at the speed of light where the overlap of the before interaction and after interaction waves overlap. Within this expanding shell of overlapping waves, the fringe pattern shown at the top of figure 10-15 still exists, but at greatly reduced amplitude. This is superimposed on the photon's waves which are also spreading away from the scattering site at the speed of light. The interaction between these overlapping waves continues to make successively finer adjustments to the photon's momentum. This explains how the uncertainty of the photon's momentum can improve over time, just like we reasoned by looking at the recoil of a hydrogen atom.

In all of this, the electron does not undergo a gradual acceleration as might be expected for a classical particle that is changing its momentum. Instead, the wave model of the scattered rotar changes from the wave pattern of the rotar before the scattering to the wave pattern of the rotar after the scattering without undergoing the intermediate velocities. Similarly, a hydrogen atom would not gradually accelerate to 4 m/s as it emits a 13.6 eV photon. The "before" wave pattern fades as the "after" wave pattern comes into existence.

From the uncertainty principle we know that a decrease in the momentum uncertainty (Δp) must be accompanied by an increase in the position uncertainty Δx. When we think of a point particle photon, then the physical interpretation of Δx is different than when we think of a single photon as a shell of waves with a large radius. To accommodate this improvement in our knowledge of the photon's momentum (decreased Δp), it is necessary for the radius of the photon to increase with time (increased Δx). This requirement fits perfectly with the proposed photon model because the radius of the photon's shell of waves increases with time.

Recoil from Coherent Emission: In the above examples, it was repeatedly emphasized that they described the properties of a single photon. The characteristics of photons change dramatically when they congregate into coherent beams. We are going to ease into a discussion of a beam of light made of many photons with the following preliminary thought experiment.

Suppose that we have a rotating electrically charged dipole. This imagined electrically charged dipole is made of a positive charge and a negative charge physically separated by a short rod. For example, imagine an electron and a positron separated by a rod 1 mm long and rotating about a perpendicular axis at the center of the rod at a frequency of 10^{10} Hz. Even though it would be virtually impossible to have this electrical dipole mechanically rotate at this frequency, in the thought experiment there is no such limitation. We would expect to see the emission of microwave electromagnetic radiation (10^{10} Hz) in a classical rotating dipole emission pattern from this rotating dipole. This pattern has emission in all directions, but the intensity of emission is twice as strong along the rotation axis as the intensity in the equatorial plane. However, near the equatorial plane there are more ster-radians for emission so all emission directions are important. The symmetrical radiation pattern around the axis of a mechanically rotating dipole is really the result of the emission of many incoherent photons. This symmetrical emission pattern does not produce recoil in any particular direction.

Now suppose that we have a trillion such rotating dipoles distributed over a spherical volume with radius about 1000 times larger than the microwave emission wavelength. The dipoles are therefore distributed in a way that individual dipoles are separated from their nearest neighbor by much less than one wavelength but the group is much larger than a wavelength. If the rotating dipoles are all rotating incoherently, they emit incoherent radiation in all directions. Since the emission is symmetrically balanced, there is no net recoil direction felt by individual rotating dipoles.

However, if all dipoles are rotating coherently (same frequency, parallel rotation axis and controllable phase) the radiation from the group of rotating dipoles can be controlled. For example, the microwave radiation can be made into a diffraction limited beam that can be steered in any direction. This directional control depends entirely on the ability to adjust the phase of individual dipoles in the group so that the multiple emissions add constructively in the desired emission direction.

Now let's think about the recoil felt by each mechanically rotating dipole from the emission of radiation. If only one dipole is mechanically rotating, the emission of multiple photons (photons) is symmetrical and no specific recoil direction is felt by the single rotating dipole. However, when the multiple rotating dipoles are properly phased to constructively interfere in a particular direction, then each rotating dipole must feel a force in the opposite direction as the emitted beam. We would say that this force is the momentum recoil required for conservation of momentum. However, each rotating dipole is just interacting with the local EM field generated by the coherent addition of spherical waves generated by other rotating dipoles. The collimation and directionality of the emitted beam is achieved by the group interaction. The point is that the emission direction and the recoil direction are the result of the coherent addition of properly phased rotating dipoles.

Huygens-Fresnel-Kirchhoff Principle: At this point the analysis converts to a classic example of the Huygens-Fresnel-Kirchhoff principle. With this principle, each point on a wavefront becomes the source of a new wavelet that emits into the amplitude distribution formulated by Kirchhoff: $\cos^2(\theta/2)$. This is exactly the same emission pattern as a photon with its momentum vector aligned with the beam vector. Therefore each cycle of the coherent photon emission is identical to the wavelet that would be formed at the location of the emitting rotating dipole. The Huygens-Fresnel-Kirchhoff principle describes amplitude addition and how intensity is proportional to the square of amplitude. Therefore, the individual photon joins the beam as if it was merely a series of new wavelets. The only difference is that in the Huygens-Fresnel-Kirchhoff principle the total energy of the beam remains constant while the emission of a coherent photon increases the total amplitude and energy of the beam.

It is a short step from mechanically rotating dipoles to many atoms in an excited state in a laser gain medium. The propagation of a laser beam is well described by the Huygens-Fresnel-Kirchhoff principle. Each point on the laser beam becomes a new wavelet and the beam evolves by coherent addition of successive generations of wavelets. When a laser beam passes through a laser gain medium, it interacts with atoms in an excited state. The interaction not only stimulates the emission of photons with the proper frequency and phase, but the interaction also imparts the correct recoil to the atoms so that the photons are emitted with the correct momentum vector. The addition of new photons to the laser beam then corresponds to the wavelet addition of the Huygens-Fresnel-Kirchhoff principle.

All other cases of photon emission into volumes where the radiation is more chaotic than a laser beam are still well described by the Huygens-Fresnel-Kirchhoff principle. Also it is reassuring that this model has the waves explore all possible paths, just like the modeling of QED.

Beam of Light: How can this model of a photon be reconciled with the concept of a well behaved beam of light that can be easily reflected off mirrors and brought to a focus? A beam of laser light does not seem to have any of the properties of a spherical shell of waves just described. To answer this, it is necessary to first remember that even a single photon has only a narrow momentum uncertainty angle set by the recoil felt by the emitting atom. Second, a beam of light contains many photons. For example, a 1 mw HeNe laser beam contains about 3 x 10^{15} photons per second. Multiple photons, such as a laser beam, together achieve the familiar beam of light. Even though each individual photon is propagating into a spherical shell of waves (with a specific momentum uncertainty angle), the other photons in the beam are adding constructively in the beam volume and destructively everywhere else. The final intensity is amplitude squared, so combining this with the momentum uncertainty angle of each photon, it is easy to produce a well behaved beam when many photons are present. The diffraction properties are well characterized by the Huygens-Fresnel-Kirchhoff principle and the photons explore every possible path between two points as required by the path integral.

The mechanism of reflection of a photon off a mirror needs to be developed further. Apparently many electrons (rotars) on the surface of the mirror are able to respond simultaneously to a photon. If there is absorption, then the quantized angular momentum of the photon is transferred to a single atom. However, metallic reflection appears to involve multiple electrons responding in a way that these surface electrons become the source of new spacetime waves. This is a subject that needs further work.

In chapter 9 an experiment was proposed that involved a radio wave in a maximum confinement cavity. This cavity has surfaces that are metallic reflectors. The electrons in these surfaces are not just reflecting the photons, they can be thought of as simultaneously absorbing photons from the cavity and creating new photons that are emitted into the cavity. Therefore this experiment avoids questions about whether the photon's amplitude (distortion of spacetime) is distributed over a much larger volume of space. It might be argued that some of the distortion extends ½ λ outside the cavity, but the continuous absorption and emission avoids the problem of the distribution extending far from the cavity.

Why Is there No Amplitude Dependence In a Photon's Energy?   One of the mysteries of quantum mechanics is contained in the photon's energy equation $E = \hbar\omega$.   Why does this equation only contain the frequency term ω? From classical physics it seems as if the energy in a wave should also contain an amplitude term. To answer this question, two important considerations must be taken into account. First is the concept that this is a packet of energy with quantized angular momentum. Therefore when it is emitted or absorbed, there is the transfer of a specific amount of angular momentum. Recall that this enforcement of quantized angular momentum occurs because the sea of dipole waves that is the vacuum fluctuations of spacetime has superfluid properties. Any angular momentum introduced into the "sea" is quarantined into quantized angular momentum packets. As the waves spread out, they still are a quantized unit and subject to the previously discussed property of "unity". It is possible to analyze the wave and energy properties assuming a "maximum confinement" volume of $ƛ^3$. It is also possible to assume that the total energy will remain constant as the quantized wave fills a volume larger than $ƛ^3$.

Second, the maximum displacement of spacetime allowed for a dipole wave in spacetime is subject to the previously discussed Planck length/time limitation. While a photon is not technically a dipole wave in spacetime, it is produced and absorbed by dipole waves in spacetime. A single photon inherits this Planck length/time limitation. As previously shown, multiple photons can exceed this limit. The strain amplitude of a single photon in maximum confinement is $H = L_p/ƛ$. The important point here is that all photons have the same displacement of spacetime ($\Delta L = L_p$) in maximum confinement volume of $ƛ^3$. Therefore, since this displacement amplitude is the same for all photons under these conditions, it is possible to see how the amplitude term might not be necessary to specify the energy of a single photon.

To actually show this cancelation of the amplitude term we will use the following wave amplitude equation and substitutions:

$E = H^2\omega^2 ZV/c$ set: $H = L_p/ƛ$, $\omega = c/ƛ$, $Z = Z_s = c^3/G$ and $V = ƛ^3$

$$E = \left(\frac{\hbar G}{c^3 ƛ^2}\right)\omega^2\left(\frac{c^3}{G}\right)\left(\frac{ƛ^3}{c}\right) = \hbar\omega$$

Therefore, the combination of quantized angular momentum/energy and the standardized displacement $\Delta L = L_p$ results in the amplitude term not appearing in the equation $E = \hbar\omega$.

Angular Momentum of a Linearly Polarized Photon: It is possible to experimentally demonstrate that circularly polarized light possesses angular momentum. For example, the mineral mica is optically birefringent. A thin sheet of mica of a particular thickness can have the ability to reverse the direction of rotation of circularly polarized light. Another way of saying this is that mica can form a half wave plate. If a very small piece of mica is suspended with low friction, (for example in a liquid) then shining a circularly polarized laser beam at the mica chip will cause the mica to rotate. The photon's angular momentum is being reversed by the mica. This transfers angular momentum from the photons to the mica and causes the mica to rotate. A small absorbing mass can also be made to rotate.

All photons should possess angular momentum, but it is not obvious how linearly polarized photons can possess angular momentum. The following thought experiment can demonstrate that a linearly polarized photon does possess a type of angular momentum known as "orbital angular momentum". Suppose that a small rod has a positive charge at one end and a negative charge at the opposite end. If this rod is rapidly rotated around an axis perpendicular to the rod's length, then this rotating charged rod is a rotating dipole. We normally encounter oscillating dipoles, but rotating dipoles also emit electromagnetic radiation with a radiation pattern that is well understood (the classical rotation dipole emission pattern). For example, photons emitted parallel to the axis of rotation are circularly polarized and photons emitted in the plane of rotation (the equatorial plane) are linearly polarized. Intermediate emission angles would be elliptically polarized. The emission frequency is equal to the rotational frequency. For this example, we will imagine a rotation frequency of 10^{10} Hz which would emit a microwave wavelength of about 3 cm.

It is easy to prove that the circularly polarized photons emitted from the poles are carrying away angular momentum and therefore they are removing angular momentum form the rotating rod. However, what about the linearly polarized photons emitted from the equatorial plane? These photons are carrying away energy which implies that their emission also retards the rotation (removes angular momentum). If the linearly polarized photons were not also removing angular momentum, this would be a violation of the conservation of energy. For energy to be removed from the rotating rod it is necessary to remove angular momentum from the rod. If the linearly polarized photons were not removing the correct angular momentum, there would be a mismatch between the amount of photon energy emitted and the amount of energy removed from the rotating rod. Therefore, how is the emission of each linearly polarized photon removing $\hbar$ of angular momentum with the correct angular momentum spin direction to retard the rotation of the rod?

Figure 10-9 from the last chapter can be reinterpreted in a way that illustrates this problem. What is labeled as "rotating dipole lobes" in figure 10-9 can be reinterpreted as the rotating charges propagating around a circle. The rotating rod is not shown, but it can be imagined as connecting the two charges (lobes). This figure was drawn to illustrate dipole waves in spacetime propagating at the speed of light around a circle. Since we are now using it to illustrate a positive and negative charge, we will temporarily assume speed of light propagation for these charges. While this is not realistic for the tips of a rotating rod, speed of light propagation is the simplest example. The modifications necessary for a slower tip speed will be discussed later.

A rotating dipole has a spherical emission pattern, so figure 10-9 is a cross-section of this emission pattern along the equatorial plane. The electromagnetic radiation emitted in this cross-section plane is linearly polarized with the plane of polarization parallel to the equatorial plane.

One point of this figure is to illustrate that the wave fronts emitted in the equatorial plane are not concentric circles. Instead, the wavefronts form an Archimedes spiral. The arrows labeled "perpendicular to the wavefront" do not extend back to the axis of rotation (the center of rotation). Instead, these perpendicular projections are tangent to the circle that is one radian in radius (one wavelength in circumference).

We will now switch from a rotating rod to a rotating carbon monoxide molecule. In this molecule the carbon atom is positively charged and the oxygen atom is negatively charged. This molecule does rotate at specific "rotational" frequencies and emit photons. While elliptical polarization is possible, we will only discuss circularly polarized and linearly polarized photons. The molecule is not rotating with a tip speed equal to the speed of light. The smaller source produces a "near field" emission that includes a phase shift within about one wavelength of the molecule (not illustrated in figure 10-9). However, the point is that at a distance greater than about one wavelength the equatorial plane wavefront is the spiral pattern depicted in figure 10-9 even if the rotating dipole is much smaller than illustrated.

If the wavefronts were concentric circles, then these wavefronts would not be carrying away any angular momentum. However, since the wavefronts are an Archimedes spiral, then they possess what is known as "orbital angular momentum". This type of angular momentum is well known in laser research. Lasers can emit radiation into modes where the photons possess "orbital angular momentum". The wavefront of the emitted beam is actually helical as it propagates. All photons, even linearly polarized photons, carry at least $\hbar$ of angular momentum. Integer multiples of $\hbar$ are also possible. The emission of a photon always imparts angular momentum to the source which might be an atom or molecule. The emitted photon's angular momentum can either be in the form of a circularly polarized photon or a wavefront carrying orbital angular momentum.

The propagating photon model discussed in this chapter is distributed over a large volume. It is easy to see how this model of a photon can be carrying orbital angular momentum even if the photon is linearly polarized. When this model of a photon is absorbed, the wavefront collapses as previously discussed. The orbital angular momentum is transferred to the absorbing entity such as an atom. The conventional model of a photon possesses "wave-particle duality". There is no way to make "wave-particle duality" into a conceptually understandable model. Therefore, the idea that a photon with wave-particle duality also possesses angular momentum hardly registers any objection. Adding angular momentum to this incomprehensible description just adds one more level of mystery. When we say that the universe is only spacetime, we are held to a higher standard. Suddenly, all the mysteries of physics have the potential of being modeled and understood. This book is the first step in an exciting journey. If the universe is only spacetime, then everything must have a conceptually understandable explanation (accessible to the human intellect).

Chapter 12

Bound Electrons, Quarks, and Neutrinos

Bound Rotars: One of the early quantum mechanical lessons for students is the so called "particle in a box". In this exercise, students calculate what would happen if a particle was placed in a small cavity surrounded by impenetrable walls (an infinite energy well). There are no such cavities, but if there were the particle's quantum mechanical properties would be exhibited. The particle can only possess a few specific positive energies corresponding to a few specific kinetic energies. Furthermore, the particle can never be stationary within the cavity (never have zero kinetic energy). In this example, the particle confined to a box (an infinite energy well) possesses more energy than an isolated particle that is not confined.

This is a perfect example to support the quantized wave model of particles, but the reason for bringing up the particle in a box exercise now is to make a point about bound particles. This lesson creates the erroneous impression that bound particles in nature can also possess a positive binding energy. The particle in a box exercise describes what would happen if a particle is surrounded by walls that are always repelling the particle. In nature, particles are bound by attraction, not confined by repelling walls. Electrons in an atom are bound by attraction to the nucleus. Attraction also binds quarks in a hadron or gravitational attraction binds a planet to a star. These are all examples of negative binding energy (lower total energy than the unbound component parts). From this, the following statement can be made:

Rotars bound by attraction always possess less energy than the same rotar when it is isolated. Attraction binding energy can be thought of as negative energy. Energy is emitted when rotars combine.

We will start with a gravitational example. In chapter #3 we determined that a particle has more internal energy in zero gravity than when the particle is in gravity. ($E_o = \Gamma E_g$). Gravitational potential energy is a negative value that is referenced to zero at infinite distance. Suppose an observer using a zero gravity clock monitors the Compton frequency of the rotar as the rotar is restrained and slowly lowered towards a large mass. Gravitational energy is removed by the restraining mechanism as the rotar is slowly lowered into stronger gravity. The Compton frequency ω_c of the lowered rotar, measured by a zero gravity clock, decreases as gravity increases and more energy is removed. This decrease in frequency is not noticeable locally because of the gravitational dilation of time. Locally, a slow clock is used to monitor a slow Compton frequency. The point is that gravitational bonding energy is negative energy. The Compton frequency of a gravitationally bound rotar is lower than the same rotar not gravitationally bound when both frequencies are measured using a clock running at zero gravity rate of time.

For another example, an electron and a proton release a 13.6 eV photon when they become electromagnetically bound together to form a hydrogen atom with the electron in the lowest energy level. This released energy represents the negative binding energy of the hydrogen atom. It is possible to go one step deeper in understanding this negative binding energy. An isolated electron has a Compton frequency of about 1.24 x 10^{20} Hz and the sum of the Compton frequencies of the three quarks that form a proton is about 2.27 x 10^{23} Hz. When an electron and a proton are bound together to form a hydrogen atom, the sum of all the Compton frequencies is about 3.3 x 10^{15} Hz less than the when the electron and proton were isolated. This difference of 3.3 x 10^{15} Hz is the frequency of the 13.6 eV photon released when the hydrogen atom formed. Therefore it is possible to see the difference in energy when an electron and proton are bound to form a hydrogen atom. (To be perfect, this example needs to also account for the small amount of kinetic energy carried away by the hydrogen atom as it recoils from emitting the photon.)

A more extreme example is the bonding of an electron to a uranium nucleus which has been stripped of all electrons. This bonding is so strong that the bonding energy is equivalent to about ¼ the mass/energy of an electron. The energy lost when this bonding first takes place is removed by the emission of a gamma ray photon. Isolated particles are more energetic than bound particles. This concept will later be applied to bound quarks with some surprising implications.

The standard model considers the electromagnetic force to be transferred between point particles by the exchange of virtual photons. This raises interesting questions. Where does the loss of energy occur when an electron is bound to a proton? It is not sufficient to say that there is a reduction in the electric field. The virtual photons ARE the electric field. Do the virtual photons that supposedly bond oppositely charged particles possess negative energy? What is the wavelength of a virtual photon? These questions are introduced to raise some doubts about virtual photons and the generally accepted explanations.

The rotar model proposed here has no trouble answering these questions. There are no virtual photon messenger particles. There are fluctuations of spacetime that can be considered virtual photon pairs, but these are not the messenger particles that are supposedly exchanged by charged particles. All rotars possess an "external volume" of waves previously discussed. The external volumes of interacting rotars overlap. Two oppositely charged rotars interact in a way that decreases the Compton rotational frequency of each rotar (ω_c is reduced). The location of the lost energy is easy to identify. Also the overlapping external volumes affect the pressure exerted on opposite sides of a rotar by vacuum energy. This pressure difference causes a migration of the rotational path of each rotar towards the oppositely charged rotar with each rotation. We consider this migration to be electromagnetic attraction. When an electron and proton are in free fall from a wide separation, their initial attraction is exhibited by the kinetic energy of the motion towards each other. In this phase, there is no energy lost and no reduction in frequency. The decrease in Compton frequency due to weak bonding is offset by the frequency increase associated with the rotar's kinetic energy. Only when this kinetic energy is removed by the release of a photon is the negative energy bond made.

Electrons Bound in Atoms: In the Bohr model of a hydrogen atom, the electron's 1s orbital (the lowest energy level) is described as having a radius of $a_o = \hbar c/E_e\alpha \approx 5.3 \times 10^{-11}$ m. Also the orbital angular momentum of the electron's 1s orbital is $\hbar$ according to the Bohr model. The combination of this radius size and this angular momentum corresponds to the electron having velocity of $v = \alpha c$ (about 137 times slower than the speed of light). The de Broglie wavelength for an electron at this velocity is $\lambda_d = 2\pi a_o$. This means that the de Broglie wavelength equals the circumference of this Bohr orbit. This is an appealing picture, but according to quantum mechanics, none of these Bohr atom conclusions are correct.

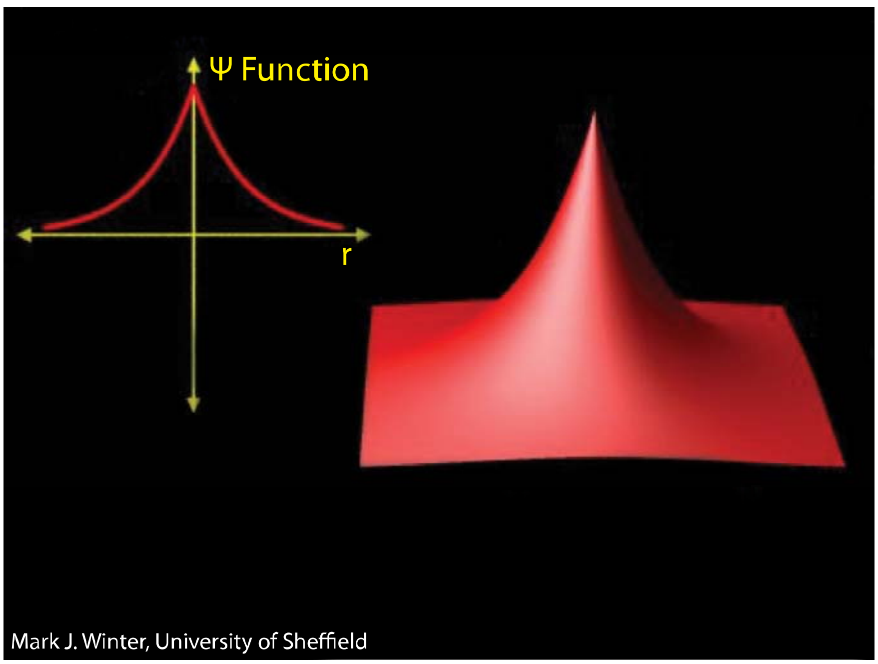

FIGURE 12-1 Plot of the 1s wave function of an Atomic Orbital

Figure 12-1[1] shows the graph and the 3 dimensional plot representing the ψ function of the 1s orbital of an electron in a hydrogen atom. Squaring this ψ function gives the probability of finding the electron. In each case, the peak corresponds to the location of the proton in the hydrogen atom. The closer we probe to the proton, the higher the probability of locating the electron. This plot, obtained from the Schrodinger equation, looks nothing like what might be

[1] Mark J. Winter http://winter.group.shef.ac.uk/orbitron/

expected from the Bohr model. There is no orbit with radius a_o. There is no de Broglie wavelength correspondence and the 1s orbit has no orbital angular momentum. The only angular momentum of this orbital is the ½ $\hbar$ angular momentum of the electron.

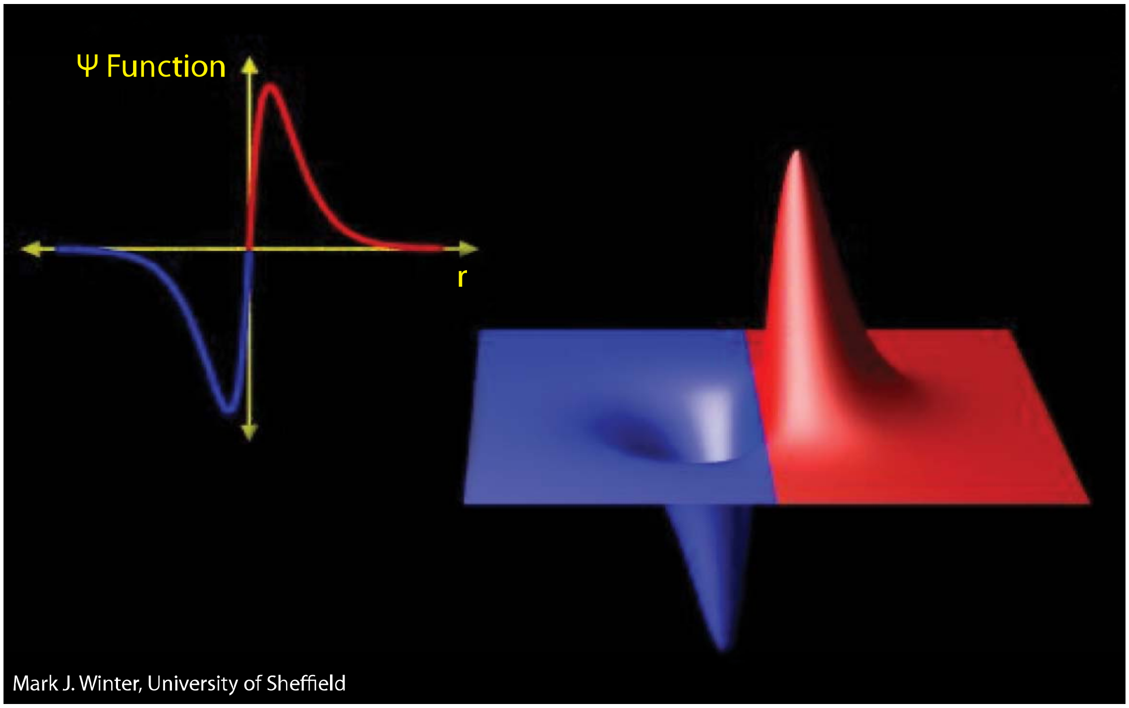

FIGURE 12-2 Plot of the $2p_x$ wave function of an Atomic Orbital

Figure 12-2 is similar to figure 12-1 except figure 12-2 shows the Ψ function and probability of finding an electron that is in the 2p orbital of a hydrogen atom. To understand these figures in terms of the spacetime wave model of rotars, it is necessary to examine the Ψ function.

Ψ Function: It is an axiom of quantum mechanics that the ψ function has no physical significance; only the square of the ψ function can be physically interpreted as representing the probability of finding a particle. It is proposed here that the spacetime wave model of rotars does give a physical meaning to the Ψ function. This physical meaning is easiest to explain by returning to the hypothetical example of a "particle in a box".

The "particle in a box" thought experiment is an idealized thought experiment since there are no cavities surrounded by impenetrable walls creating an infinite energy well. Assuming such a cavity, the quantum mechanical properties of a particle (rotar) trapped inside would be revealed.

In order for the rotar to meet these boundary conditions imposed by the walls, it is necessary for the rotar to possess slightly more energy than an isolated rotar. Recall that attraction bonding involves a loss of energy and hypothetical repulsive bonding, such as a particle in a box, requires a gain in energy. In order for the rotar to achieve zero amplitude at the two 100% reflectors of the box, it is necessary for two spacetime wave frequencies to be present rather than the single Compton frequency of an isolated rotar.

Figure 12-3 shows the conventional depiction of one possible Ψ function of a particle trapped in a small box with impenetrable walls. Different resonant modes are possible, so a three lobe resonance is chosen for ease of illustration. Note that the Ψ function represented in figure 12-3 has both positive and negative values (above and below the zero line). Quantum mechanics does not give a physical meaning to the Ψ function. Only the square of the Ψ function can be physically interpreted as the probability of finding a particle. The rotar model goes against this convention and gives a physical meaning to the Ψ function.

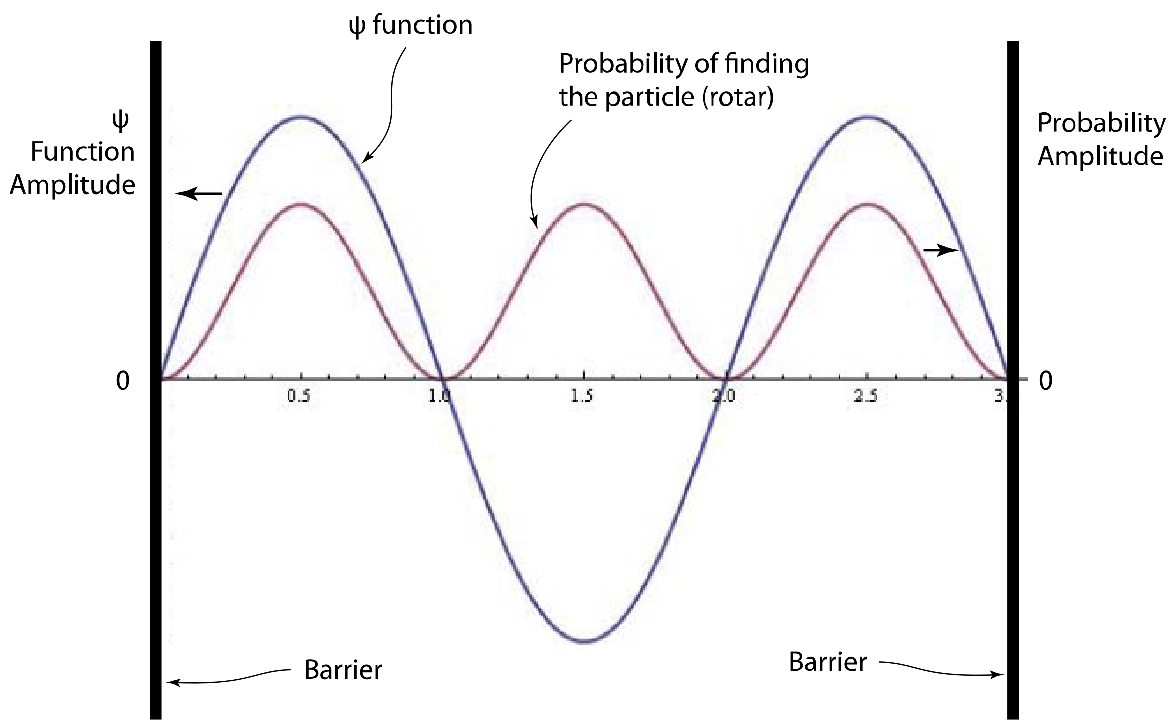

FIGURE 12-3 ψ function of a particle in a box (conventional model)

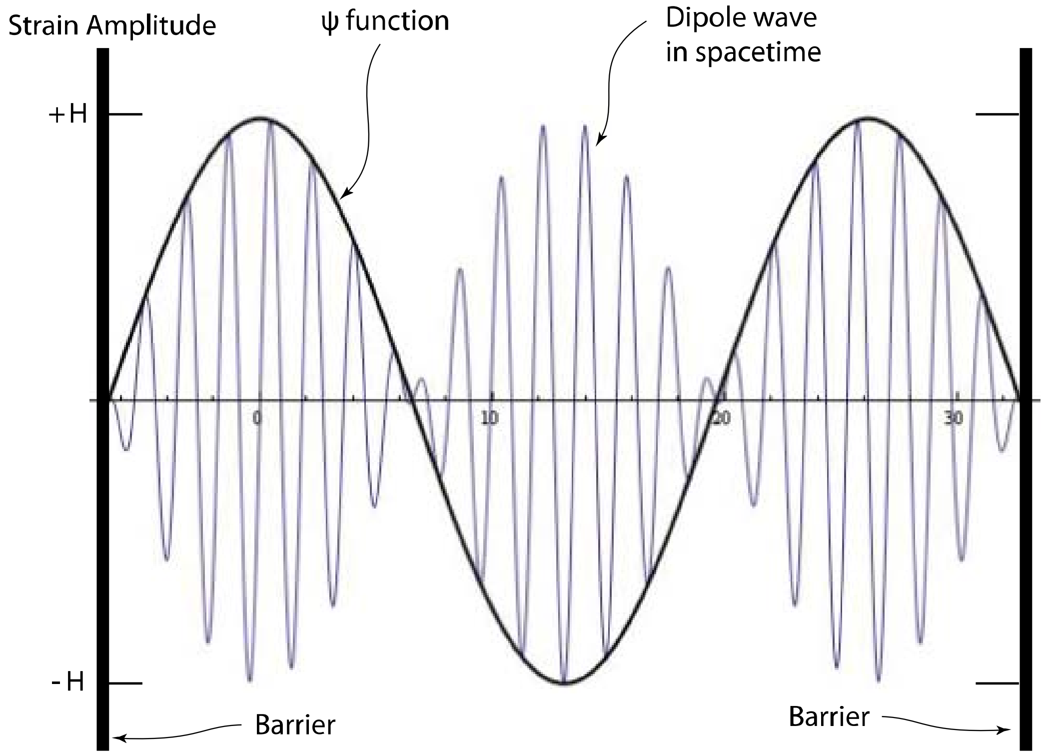

FIGURE 12-4 Spacetime wave model of the ψ function of a particle (rotar) in a box

The ψ function of a bound rotar is the wave envelope of the waves in spacetime that form the rotar.

Figure 12-4 shows the spacetime wave interpretation of the Ψ function of a particle in a box. We will reinterpret the particle in a box to a rotar trapped between two hypothetical barriers that are 100% reflectors for waves in spacetime. The box is essentially a repulsive type of confinement. Placing a rotar in a repulsive confinement requires that energy be added to the rotar in excess of the energy that a rotar would have if it was isolated. This added energy shows up in the rotar having two frequencies that together average more than the Compton frequency of an isolated rotar.

Placing a rotar in such a cavity changes the rotar's boundary conditions compared to an isolated rotar. In order for the rotar to meet the condition of zero amplitude at each of the two 100% reflectors, the rotar must possess two frequencies that are both propagating to the left and right in figure 12-4. These two frequencies traveling both directions produce the "stationary" standing wave pattern shown in this figure. This pattern looks similar to the de Broglie waves previously shown. However, de Broglie waves have the wave envelope moving faster than the speed of light while the wave envelope shown in figure 12-4 is stationary in the sense that its nodes and antinodes do not move.

Next, we will return back to the hydrogen atom that has its electron in the 1s orbital depicted in figure 12-1. The electron and proton are bound together by attraction. The electron lost 13.6 eV energy when it went from being an isolated electron to being an electron bound in the 1s orbital of a hydrogen atom. (The quarks that form the proton also lost a small amount of energy, but this is negligible and will be ignored.) New frequencies were introduced to the electron in this binding process so that the average frequency of the electron is less than the Compton frequency of an isolated electron. All the orbitals of an electron in a hydrogen atom have a wave structure that involves two or more frequencies with fractional amounts of energy compared to $E = \hbar\omega$. The total of the energy is equal to the electron's energy in isolation minus the energy lost to form the hydrogen atom in the designated orbital. Orbital angular momentum also has a wave explanation that involves waves of slightly different frequencies propagating in opposite rotational directions around the proton. This is analogous to the waves having a rotating frame of reference.

While the Bohr atom model has been replaced by the quantum mechanical model, the point is that the superposition of counter propagating waves in spacetime traveling at the speed of light can achieve the desired orbital angular momentum. It is proposed that it is going to be possible to combine the spacetime wave model with the quantum mechanical atomic model to give a conceptually understandable model of an atom. The mechanism that eliminates energy loss from an atom is unknown, but presumably it is similar to the mechanism proposed for stabilizing isolated rotars.

This explanation leaves a lot of questions unanswered. Perhaps the most obvious: Is there still a rotating dipole quantum volume buried somewhere within the bound electron's lobes? The electron retains its ½ $\hbar$ angular momentum in addition to orbital angular momentum present in most atomic orbitals. Further insights clearly will involve the marriage of quantum mechanics and improved versions of the spacetime wave theory of rotars. The difference in the spectrum of hydrogen and deuterium is due to the difference in the amount of nutation the two different mass nuclei experience. This seems to indicate that the electron retains a substantial amount of concentrated inertia within the electron cloud that is causing the nucleus to nutate.

Hadrons and Quarks

Background: The standard model of particles depicts hadrons as being made of low energy quarks. Currently, an up quark is thought to have energy in the range between 1.5 and 3.3 MeV. A down quark's energy is currently thought to be in the range of 3.5 to 6 MeV. Since a proton has energy of about 938 MeV, this means that the standard model has only about 1% of a proton's mass/energy is provided by the rest mass of the quarks. The current thinking is that about 99% of a proton's energy is from the energy of gluons that bind the quarks together and from the kinetic energy of the quarks.

The spacetime wave model of a hadron is more complex than either an isolated rotar or an electron bound in a hydrogen atom. A proton, for example, has three fundamental rotars (quarks) that are dipole waves in spacetime possessing quantized angular momentum. These three quarks are strongly interacting both with each other and also interacting with the surrounding sea of vacuum fluctuations (dipole waves) that lack angular momentum. We are in the position of trying to interpret experimental observations and seeing if they are plausibly compatible with the proposed wave theory of matter. Some characteristics of gluons will also be examined.

We will start by examining binding energy in general. Then we will attempt to apply this idea to quarks bound into hadrons. The standard model says that a proton is approximately 100 times more energetic than its component quarks. This implies that the binding energy provided by gluons is a large <u>positive</u> binding energy. Also, according to the standard model, the quarks would be massless without the existence of a Higgs field with its energy density of about 10^{46} J/m^3. Furthermore, the Higgs field is only one of many different fields required by the standard model.

Intrinsic Energy of Quarks: The low intrinsic energies of up and down quarks (between 1.5 and 6 MeV) in the standard model is incompatible with the wave theory of matter proposed here. For example, a rotating spacetime dipole with energy of 2.4 MeV would have a quantum radius of $R_q \approx 8 \times 10^{-14}$ m. This single quark is about 100 times larger than the experimentally measured radius of a proton. Even if there is a relativistic length contraction, the transverse dimensions remain unchanged. Clearly the idea of low energy up and down quarks is incompatible with the wave model presented here.

The proposed alternative (explained below) is that up and down quarks are intrinsically high energy rotating dipoles that are strongly bound together when they form hadrons. There are no isolated first or second generation quarks because they simply do not attain stability as isolated rotars. (The top quark will be discussed later). Attempting to remove quarks from a hadron against the strong force increases the quark's energy (Compton frequency) until a new meson is formed. When new mesons are formed, the binding force between former components of the split hadron decreases to near zero. Single first or second generation quarks are never produced.

However, to illustrate the concepts, we will imagine what it would be like if isolated quarks were allowed. It is proposed here (justified later) that if isolated up and down quarks existed, they would be rotating dipoles with energy substantially greater than 400 MeV. If up and down quarks existed as isolated rotars, then they would shed energy when they bond to form a proton or neutron. Hadrons come into existence already formed since this is the lowest energy state and the only form that has stability. However, it is informative to imagine the steps that would occur if a hadron was formed from isolated quarks.

Energy Well: There is always an energy well when two or more rotars are bound together by attraction. Energy is lost when the bound state is formed by attraction compared to the hypothetical unbound state. For example, a photon is emitted when a proton captures an electron to form a hydrogen atom. This is lost energy compared to the unbound state. Another example is gravitational bonding. When distributed mass comes together to form a planet or star, the gravitational energy must be converted to heat and radiated away. This lost energy is the negative gravitational binding energy.

What change takes place when a rotar, such as an electron, goes from an isolated state to a bound state?

1) It loses energy through some form of energy emission.
2) This lowers the rotar's Compton angular frequency ω_c.
3) The strain amplitude H_β of the rotar decreases.
4) The quantum radius R_q increases.
5) The boundary conditions are changed compared to an isolated rotar. This changes the energy distribution from the isolated rotar model. Apparently an electron bound in an atom becomes a larger cloud-like energy distribution.

It is the usual convention in physics to consider binding energy as positive energy. However, it should be remembered that this is just a convention. In nature, virtually all bonding is accomplished by forces which are attracting. This means that the bound state has less energy than the hypothetical unbound state.

The spacetime wave model of a hadron depicts the bound quarks (rotars) as being in a very deep energy well. This means that quarks bound together in a hadron have much less mass/energy than the same quarks would have if they could exist as isolated rotars. This concept represents a strong conflict with the standard model. As previously stated, the three quarks that form a proton supposedly account for only about 1% of a proton's mass/energy. The standard model requires that about 99% of a proton's mass/energy comes from the binding energy of the gluons and kinetic energy of the quarks. For this model to be correct, the gluon bonding would need to somehow add energy rather than remove energy. Gluon bonding does not create an energy well compared to the sum of the mass/energy of the component parts. Instead the bound state has up to 100 times more energy than the component quarks.

Energy Density and Pressure: In an earlier chapter the relationship between energy density and pressure was examined. A proton was used as an example. The proton's energy density is about 3 x 10^{35} J/m^3. This energy density implies that the quarks and gluons that form the standard proton model must have an internal pressure of at least 10^{35} kg/m^2. What force keeps the large energy density (pressure) of the proton confined? If gluons possess a large energy density, they must also be generating this pressure. What prevents gluons from merely dissipating their large energy density (pressure) until some equilibrium is reached? If fundamental particles are vibrating strings, what mechanism resists the tremendous pressure implied by this structure?

The spacetime wave model of a proton also must contend with energy traveling at the speed of light in a confined volume. This confined energy does indeed generate the high pressure just like the confined light example. An energy density of 3 x 10^{35} J/m^3 of dipole waves in spacetime would generate about 10^{35} kg/m^2 pressure. The spacetime wave model counteracts this pressure by proposing that the few frequencies and configurations that are stable achieve stability by interacting with the pressure of the vacuum fluctuations (waves in spacetime) that fill the universe. In the chapters on cosmology (13 & 14) the energy density and pressure of vacuum energy will be estimated. It will be shown that vacuum energy has much more energy density (pressure) than the minimum required to stabilize the rotar model of all known fundamental particles.

Binding Energy of Nucleons: While it is very difficult to make energy and force measurements inside a proton or neutron, we can obtain a hint of what is going on by looking at the binding that occurs between nucleons. According to the standard model, gluons are also responsible for the binding of nucleons, (the residual strong force). Do the gluons increase or decrease the total energy when we go from unbound nucleons to bound nucleons?

The answer is obvious. A helium atom (^{4}He) has less mass/energy than 2 deuterium atoms. The binding energy of nucleons is a negative form of energy (energy reduction compared to the sum of the unbound components). There is a decrease in mass (loss of energy) when hydrogen nuclei fuse to form nuclei of heavier atoms. At first it might appear that ^{235}U and other heavy atoms are an exception to this rule, but this is incorrect. The strongest bound atomic nucleolus is ^{56}Fe with a binding energy of 8.79 MeV per nucleon. ^{235}U has a binding energy of 7.79 MeV per nucleon and this is comparable to the binding energy per nucleon of carbon or nitrogen. Breaking ^{235}U apart releases energy because the two lighter nuclei formed have a greater binding energy per nucleon than ^{235}U. A greater binding energy means that excess energy must be released upon formation. The point is that even ^{235}U has less mass/energy than the energy of the protons, neutrons and electrons that form the uranium atom. Binding energy between nucleons is negative energy. Similarly, quarks bound into hadrons must have less energy than the total energy of the hypothetical isolated quarks. We never get to do this experiment because isolated quarks are so energetic that they do not exist in isolation.

Energy of Bound Quarks: The working proposal is that all the energy of a proton is contained in its three bound quark rotars (rotating dipole waves in spacetime). The role of gluons, color force, etc. will be addressed later. Furthermore, it is proposed that the binding energy is so great that the bound quarks have much less energy than they would as hypothetical isolated rotars. We will first survey the hadrons that are made of only up and down quarks to compare the energy of the up and down quarks under various bound conditions. The nucleons (protons and neutrons) have almost the same energy ~938 MeV. If we assume that all this energy can be traced to the energy of 3 rotating spacetime dipoles (3 quarks) then the implication is that up and down quarks have about the same energy. There are different proportions of up and down quarks, yet approximately the same total energy. We will assume that bound up and down quarks in a nucleon has energy of about 313 MeV (~ $^1/_3$ of the total).

There are two other families of hadrons that consist of only up and down quarks. These are the pi mesons (pions) and the delta baryons. The delta baryons have spin of J = $^3/_2$ rather than the spin of ½ for the nucleons. There are 4 delta baryons. These are:

Δ^{++} (uuu); Δ^{+} (uud); Δ^{o} (udd) and Δ^{-} (ddd).

These all have about the same energy (1,232 MeV) therefore the up and down quarks bound in this hadron have energy of about $^1/_3$ of this value: ~ 411 MeV.

The pions consist of a quark and an anti-quark such as an up quark and an anti-down quark. The net spin of the pions is zero (counter rotating dipoles). The energy of the pions is 139.5 MeV for the two charged pions (π^+ and π^-) and about 135 MeV for the neutral pion (π^o). This means that the up and down quarks in a pion have average energy of about 70 MeV for the charged pions (π^+ and π^-) and about 68 MeV for a neutral pion π^o.

Therefore we have examples where up and down quarks have energy ranging from 411 MeV to 68 MeV. The standard model deals with this difference by assuming that an isolated up or down quark has energy of only a few MeV. The extra energy required to reach 68 MeV, 313 MeV or 411 MeV is assumed to be predominately in the energy of the gluons.

Energy of a Hypothetical Isolated Quark: The spacetime wave model offers a different answer. It says that an isolated rotar up or down quark would have energy substantially greater than 411 MeV. When quarks are bound into a hadron, the bonds are so strong that a large percentage of the hypothetical isolated energy is lost. It would be radiated away if it was possible to do this experiment. The difference between the 68 MeV, 313 MeV or 411 MeV reflects different amounts of negative binding energy.

The binding energy per nucleon in ^{56}Fe represents approximately 1% of a proton's energy. An electron bound to a uranium atom's nucleolus stripped of all other electrons has a binding energy that is about 25% of an isolated electron's energy. In order for an electron to attach to a stripped uranium atom nucleolus, it has to emit a gamma ray photon to shed about 25% of the electron's energy.

It is proposed that the binding energy of quarks in a hadron is much greater than these examples. To illustrate this concept, we will choose an energy substantially larger than 411 MeV for the energy of a hypothetical unbound up or down quark. For illustration, we will use the number of about 600 MeV for the energy of isolated up and down quarks. With this assumption, an isolated up or down quark would lose about 1/3 of its energy when it forms a delta baryon (411 MeV). It would lose about ½ of its energy when it forms a nucleon (313 MeV) and it would lose about 89% of its energy when it forms a neutral pi meson (68 MeV).

Electron vs. Proton Size: Before proceeding too far, it is desirable to do a calculation to see if the ideas proposed here are plausible. We will attempt to calculate the size of a proton. However, first it is necessary to recognize why a proton has a measurable size and an electron does not. A proton has a measurable size because a proton is made up of 3 fundamental rotars. The three quarks of a proton do not respond to a high energy collision as a single quantized unit. The property of unity only exists within a single quantized wave (rotar). A collision with a proton involves speed of light communication of forces between the three quarks of a proton. This means that the proton exhibits a physical size in a collision even though this size does not exhibit a hard boundary.

When an electron collides with one of the three quarks in a proton, it appears as if there is a collision between two point particles. The reason is the same as previously explained for a collision between two electrons. Both the electron and the quark are quantized rotating dipoles in spacetime. In a direct hit, they both convert the kinetic energy of the colliding electron to internal energy of the rotating dipole. This happens faster than the speed of light because preserving the quantized angular momentum results in the previously explained property of unity. The conversion of kinetic energy momentarily increases the Compton frequency of each rotar. In order for angular momentum to be conserved, the quantum radius R_q of each rotar momentarily decreases. The amount of decrease in size makes each rotar experimentally indistinguishable from a point particle because (as previously explained) the momentary radius is less than the resolution limit set by the uncertainty principle. The other two quarks that were part of the proton only learn about the collision through speed of light communication.

Calculation of Proton Radius: The presence of only three quantized waves means that a proton still exhibits substantial quantum mechanical properties such as no definite shape and the lack of a hard edge. Also the shape of a proton depends on the alignment of the spins of the quarks. An analysis[2] of all measurements of the proton radius concludes a most probable charge radius for a proton is: 0.877 x 10^{-15} meter $\pm$ 0.15 x 10^{-15} meter

We will do a plausibility calculation to see if the proposed rotar model of a proton gives roughly the correct size. This calculation will assume that the proton is made of 3 rotars, each with energy of 313 MeV (5 x 10^{-11} J). We must decide how these three rotating dipoles fit together. Are there voids or excessive overlaps? It is known that protons are not necessarily spherical depending on the alignment of the spins of the up and down quarks. Still, the simplest assumption is a spherical proton with quarks that are so intimately bound that the proton has three times the volume of an individual rotar quark with radius R_q. The plausibility calculation will assume this simplified model.

We will first calculate the quantum radius R_q of a rotar with energy of 5 x 10^{-11} Joule (313 MeV). Then we will increase this radius by a factor of $3^{1/3}$ to obtain the radius of a sphere with 3 times the volume of an individual rotar quark.

$R_q = \hbar c/E_i$ substitute: E_i = 313 MeV = 5 x 10^{-11} J
$R_q \approx 6.3 \times 10^{-16}$ meter radius of one quark with energy of 313 MeV
$R_q \times 3^{1/3} \approx 9 \times 10^{-16}$ meter calculated proton radius (3 quarks)

The experimentally determined radius of a proton is: 8.77 x 10^{-16} $\pm$ 1.5 x 10^{-16} meter, therefore the calculated radius of 9 x 10^{-16} meter agrees within the experimental error. This degree of accuracy is probably more than we deserve considering the crudeness of the calculation. In fact, the rotar model could be correct for charged leptons and too simplified to be applied to quarks which are tightly bound with very restrictive boundary conditions. Still, the calculation does give a reasonable answer and cannot be ignored. This calculation could easily have been off by many orders of magnitude.

It is also interesting to note that the density of the quarks in the above calculation is roughly 5.9 x 10^{17} kg/m^3. The density of the nucleus of an atom with many bound nucleons is subject to some interpretation, but is roughly 2.3 x 10^{17} kg/m^3. Therefore, the density of an atomic nucleus is roughly half the density of individual quarks. This is far different from the standard model that depicts quarks as point particles and therefore infinitely more dense than an atomic nucleolus.

Gluons: The spacetime based model of particles and forces does not use exchange virtual gluons or photons to accomplish the transfer of the strong or electromagnetic forces. These exchange particles are simply not required to explain the forces. The virtual particle pairs that are present in vacuum energy have an explanation based of dipole waves in spacetime. The pressure exerted by the vacuum energy desntiy is a critical component of all force explanations.

[2] http://arxiv.org/abs/hep-ph/0008137v1

There just are no exchange gluons or virtual photons propagating at the speed of light. The exchange of W and Z particles will be discussed below.

The standard model has 8 different types of gluons providing the strong force. While two opposing repulsive forces can easily accommodate the resultant force encountered in separation, a single attractive force needs to be given unusual properties to achieve the same net force curve. The gluon bonding needs to explain 1) no force at the asymptotic freedom separation distance 2) a strong repulsive force if the quarks are forced closer together and 3) an increasing attractive force as the quarks are separated. The explanation of point #3 is that the gluons become increasingly confined into a "flux tube" extending between the quarks as the quarks are separated. Since this implies energy density propagating at the speed of light, the gluons should be generating a high pressure which should both create a repulsive force for the quarks and quickly dissipate the gluon energy. The model of gluons has been adjusted to accommodate these difficulties, but it is proposed that a much simpler rotar and vacuum energy based model can be developed to agree with experiments.

The numerous experiments that are currently interpreted as implying 8 types of gluons are proposed to have a wave based explanation within the complex wave structure of hadrons. For example, there might be internal resonances or phase shifts that are currently interpreted as characteristics of gluons. Gluons have never been directly observed but three jet events in energetic collisions are interpreted as indirect evidence of gluons. It is proposed that as the wave based model is developed further, there will be alternative wave based explanations of the experimental observations that will eliminate the need for gluons. The color charge characteristics currently associated with the 8 types of gluons will have to be incorporated into the wave based model of the quark and vacuum energy interaction.

Removal of a Quark from a Hadron: In chapter 7 there was a discussion of the asymptotic freedom of quarks bound in a hadron. There it was stated that the strong force is actually an interaction of two forces. At distance R_q the two interaction quarks are deflecting each other's circulating power so they are repelling each other with the maximum force $F_m = P_c/c = \mathbb{P}_q R_q^2$. However, this would also interfere with the pressure exerted by vacuum energy. The maximum interference would produce a total loss of pressure over one side of a rotar with area of kR_q^2. Then there would be unbalanced force exerted by vacuum energy $F_m = \mathbb{P}_q R_q^2$. The force exerted by vacuum energy/pressure on the opposite side of the rotar would attempt to push the two rotars towards each other and would appear to be attraction between rotars. It is proposed that an isolated meson achieves equilibrium where the two opposing force vectors can both equal approximately the maximum force F_m at separation distance R_q. This is the asymptotic freedom state of hadrons.

For example, an attempt to remove a rotar from a hadron (increase the separation beyond R_q) results in an opposing force that rapidly approaches the maximum force. This is the strong force which appears to be attraction. It is possible to get a rough idea of the effect of attempting to remove a quark from a hadron using the rotar model. For example, we will calculate the maximum force that an up or down quark can generate if we attempt to remove it from a proton (assuming no change in frequency). For the internal energy E_i of the bound quark we will use the 313 MeV ($E_i \approx 5 \times 10^{-11}$ J) previously calculated approximate energy of a quark bound in a proton. Substituting this into $F_m = P_c/c = E_i^2/\hbar c$ we obtain $F_m \approx 80{,}000$ N.

While this is the correct maximum force, it is an oversimplification to assume that any attempted displacement of two quarks immediately starts off with this maximum force. The quarks in a hadron are in a type of equilibrium (asymptotic freedom) if they are not being acted upon by an outside force that is attempting to separate the quarks. Imagine partial overlap of the two or three similar energy rotars, so that each rotar is deflecting the circulating power of the other rotar(s). This generates a repulsive force attempting to separate the rotars. The magnitude of this force is roughly equal to the maximum force F_m of the similar energy rotars.

As previously explained, the rotars are also being forced together by the unbalanced pressure exerted by vacuum energy. The vacuum energy is only exerting pressure on the “outside” hemisphere of the quarks. This is a repulsive force exerted by vacuum energy that is attempting to force the two rotars together. In fact, only frequencies and configurations which achieve this balance are sufficiently stable to be considered as hadrons. The magnitude of the force exerted by vacuum energy is also approximately equal to the rotar’s maximum force F_m. For hadrons an equilibrium separation is found where the opposing forces balance. The force attempting to separate the two rotars is offset by the vacuum energy force attempting to force the rotars together. This is the equilibrium separation distance that exhibits asymptotic freedom.

Therefore, if a collision is attempting to separate a quark from a hadron, the force resisting removal of a quark starts at near zero and grows until enough work has been done to form a pion or other meson. It only takes about 140 MeV or 2.2×10^{-11} J to form a new pion. To put this in perspective, it would take a displacement of 2.8×10^{-16} m against an 80,000 N force to do enough work to generate a new pion. Since the force starts near zero and increases with distance, the actual displacement required would be somewhat greater than this. For example, a linear increase in force up to 80,000 N would require about 6×10^{-16} m displacement to form a pion. What we call the strong force is proposed to be the resultant force, the difference between the two manifestations of the maximum force.

As the two quarks are being separated, but before a pion is formed, the energy expended to separate the quarks is being stored as a higher Compton frequency (higher ω_c) in the quarks. This higher frequency can be thought of as getting closer to the Compton frequency of a hypothetical 600 MeV isolated up quark used as an example. This frequency increase with separation distance then increases ω in $F_m = \hbar\omega^2/c$. However, this equation also implies a separation distance that is not being met as the two quarks are being separated. This makes the force versus distance more complex.

When we attempt to separate an electron and a proton that are initially stationary in space (not formed into a hydrogen atom), the electrostatic force resisting removal starts off at a maximum and drops with $1/r^2$. The graph of force versus distance for the removal of a quark from a hadron is unknown. However, experiments seem to indicate that the force required for removal of a quark from a hadron starts at zero and increases with distance, then perhaps levels off to a constant force near the point where a new meson is formed. The force then drops to near zero when the new meson is formed. Such a graph can be reconciled with the model proposed here. However, no justification will be offered since everything, including the graph, is too speculative.

The force between nucleons (the nucleon-nucleon force) reacts differently to separation compared to the force characteristics when two quarks are separated in a hadron. The nucleon-nucleon force has been estimated to drop off over a distance of roughly 1.3 x 10^{-15} meters. This is roughly twice the 6.3 x 10^{-16} m radius of the rotar model of up and down quarks calculated earlier in this chapter. It is quite reasonable that this would be the scale over which forces diminish for a rotar based model of a proton or neutron.

Interactions Required for Stability: As explained previously with charged leptons, the biggest challenge for waves in spacetime to achieve stability is to somehow prevent energy dissipation. Without some offsetting factor, the waves will have an amplitude distribution of L_p/r. This just means that the waves dissipate back into the other waves in spacetime in a time of $1/\omega_c$ which is roughly in the range of 10^{-25} to 10^{-20} seconds. The few combinations of angular momentum, frequency, amplitude, etc. that achieve stability are the rare exception. These conditions that form stable hadrons exhibit qualities not present in a random combination of waves in spacetime.

Somehow two or three quarks acting together can find stability where individual quarks do not. Do the hadrons that find stability achieve this stability by exhibiting the standing wave properties of a single unit? It is possible to answer this question by looking at the diffraction pattern of neutrons passing through a crystal. The diffraction pattern produced by a neutron (3 quarks) implies a de Broglie wavelength that is characteristic of the neutron's total mass $(\lambda_d = h/mv)$ rather than the mass of the three individual quarks with approximately one third this total mass.

Apparently the stability condition required for vacuum energy to stabilize a neutron results in frequency summation in the external volume. In other words, the 3 quarks present in the neutron lose their individuality at the boundary of the neutron. Externally, the vacuum energy stabilizes a neutron by treating it as a single unit. The standing waves generated in the vacuum energy apparently are equivalent to a Compton frequency characteristic of the entire energy of the neutron. The de Broglie waves generated by a neutron imply a single wavelength of the bidirectional standing waves in the neutron's external volume. Besides neutrons, larger composite particles such as alpha particles and even entire molecules exhibit diffraction patterns characteristic of the total energy. An improved rotar model should address the issue of frequency summation further.

Formation of the First Hadrons: The formation of rotars in the Big Bang was previously described as a trial and error process where a few combinations of angular momentum, frequency, and amplitude condensed out of the chaotic energetic waves in spacetime present in the early stages of the Big Bang. It is now proposed that besides single rotating spacetime dipoles, nature also found a few combinations of rotating dipoles that could achieve stability. These also condensed out of the energetic waves in spacetime as already formed hadrons. The source of the angular momentum required to form quarks, leptons and photons will be addressed in chapters 13 and 14. It will be shown that even the starting condition of the universe (Planck spacetime) must have possessed quantized angular momentum.

Presumably the first hadrons that condensed out of the energetic waves in spacetime created by the Big Bang were highly energetic hadrons made from generation III and II quarks. The probable sequence that eventually arrives at the dominance of protons and neutrons in the universe today will have to be developed by others.

W and Z Bosons: So far this analysis has not mentioned W^+, W^- and Z bosons. There is clearly a large body of experimental observations that support these particles in the standard model. However, like gluons, it is proposed that these bosons have a wave explanation. W and Z particles have $\hbar$ spin characteristic which is normally associated with a boson. However W and Z particles also have rest mass which is normally associated with a fermion (spin ½ $\hbar$). Clearly this is more complicated than previously encountered with other fermions or bosons.

Is there any other case discussed in this book where a boson (spin $\hbar$) possesses rest mass? The answer is: yes. In the first chapter we discussed the case of photons confined in a reflecting box. Photons have $\hbar$ spin yet when they are confined in some way they are forced to have a specific frame of reference and they acquire rest mass. In fact, it was pointed out that any time a photon has energy of $E \neq pc$, the photon will have rest mass. When a photon is confined between two reflectors it can be thought of as propagating in both directions simultaneously. Since momentum is a vector, the two vectors cancel and $p = 0$. This condition gives the photon rest mass even though the photon is a boson. Therefore even a photon propagating through glass is propagating at less than the speed of light in a vacuum and $E \neq pc$.

The point of this example is that bosons, with spin $\hbar$, can have rest mass if they interact with fermions (rotars) in a way that results in $E \neq pc$. Apparently spacetime and the hadron structure must have a type of resonance that occurs at 1.22 x 10^{26} s^{-1} (W boson 80,38 GeV) and 1.39 x 10^{26} s^{-1} (Z boson 91.19 GeV). Apparently spacetime and the hadron structure must have a type of resonance that occurs at 1.22 x 10^{26} s^{-1} (W boson 80,38 GeV) and 1.39 x 10^{26} s^{-1} (Z boson 91.19 GeV).

Imagine two quarks acting something like mirrors momentarily confining a W or Z boson. With Compton wavelengths of 1.54 x 10^{-17} m and 1.36 x 10^{-17} m (W and Z respectively) these are the size range that plausibly could interact with the rotar structure of hadrons. The W and Z bosons would have a standing wave structure which would look like standing waves interacting with the wave structure of the two quarks. This would give these W or Z bosons rest mass and the short range properties normally associated with the weak force. This is not a complete explanation, but it does show how the spacetime model of forces and particles can accommodate W and Z bosons. Hopefully others will analyze this further.

Neutrinos

Neutrino Introduction: Neutrinos are the least understood of the “fundamental particles”. While a lot has been learned in recent years, we still don't conclusively know whether the electron neutrino possess rest mass or not. However, it seems very likely that all three neutrinos possess rest mass. Previously the standard model considered neutrinos to be massless particles but the phenomenon known as neutrino flavor oscillation indicates that neutrinos possess a small rest mass. The spacetime wave model of the universe can accommodate either neutrinos that have a small rest mass or massless neutrinos. However, this latter possibility is considered so unlikely that it will not be discussed further here.

One advantage of the starting assumption (the universe is only spacetime) is that it is so restrictive that it greatly narrows the possibilities for physical models. All particles that exhibit rest mass are proposed to possess this mass because they are spacetime waves with quantized angular momentum. These waves are propagating at the speed of light but they are restricted to a confined volume of space. This implies that they have a rest frame of reference where their waves in spacetime are circulating at the speed of light in a closed loop. This model also implies that there is a rotating rate of time gradient at the center of the quantum volume of the rotar. Before describing the most likely neutrino model, we will first review the known characteristics of neutrinos.

Background: There are three types or "flavors" of neutrinos (electron neutrinos, muon neutrinos and tau neutrinos). Experiments prove that neutrinos can change from one type of neutrino to another type of neutrino as a neutrino propagates through space. This "neutrino flavor oscillation" is interpreted as indicating that neutrinos must have some rest mass. The reasoning is that anything traveling at the speed of light cannot experience time and therefore neutrino flavor oscillation implies that neutrinos must be traveling at less than the speed of light. The upper limit for the average rest mass of the three types of neutrinos has been estimated at less than 0.67 eV in one analysis[3] and less than 0.4 eV in another analysis.

However, currently there is a slight doubt that neutrinos have rest mass. This slight doubt arises because of the following: 1) neutrinos have never been observed in a rest frame and 2) within experimental error, all neutrinos have left-handed helicities (spin direction) and all antineutrinos have right handed helicities. This last observation gives support to the idea that neutrinos are traveling at the speed of light. If they are not traveling at the speed of light, then hypothetically, it would be possible to move faster than a neutrino and convert a left handed neutrino into a right handed antineutrino. An anti-neutrino in one frame of reference would be a neutrino in another frame of reference. This predicament is usually overcome by assuming that neutrinos must have some additional property that distinguishes a neutrino from an antineutrino.

Modeling a Neutrino with Rest Mass: The spacetime wave model can accommodate neutrinos either having rest mass or being a "massless particle". However, we will only examine the spacetime wave model of a neutrino with rest mass and presume that the mass/energy is less than 0.67 eV. This maximum mass/energy implies that an isolated neutrino in its rest frame has a Compton frequency of less than 1.6×10^{14} Hz and a quantum radius larger than 3×10^{-7} m. This large size and low frequency for rotars would seem to present a problem for the rotar model that can be illustrated with an example. A muon decays into an electron, an electron antineutrino and a muon neutrino. The muon has a quantum radius of about 1.9×10^{-15} m and a Compton frequency of about 2.6×10^{22} Hz. If neutrinos have rest mass, how is it possible for the decay of a muon to produce neutrinos that are about 10^8 times larger radius than the muon? ($\sim 10^{-7}$ m compared to $\sim 10^{-15}$ m)

This apparent incompatibility occurs because we are erroneously comparing the size and frequency of isolated rotars in a rest frame when we should be looking at these characteristics when rotars are in the very close proximity to other rotars at the moment of decay. Recall that when an electron collides with a proton or another electron, there is a moment when all the kinetic energy of the electron is converted to internal energy of the electron. This momentarily increases the electron's Compton frequency and momentarily contracts its quantum radius. A 50GeV electron collision causes the electron to momentarily decrease its quantum radius by a factor of about 100,000 and increase its frequency by the same factor.

[3] http://www.iop.org/EJ/abstract/1475-7516/2006/06/019

If a neutrino has rest mass, it is proposed that a neutrino created in a particle decay (a muon decay for example) is initially created in the high energy, compressed condition characteristic of a collision. This extra energy is converted to the ultra-relativistic velocities of the three decay products produced by the muon decay. This can be seen from the following example: Suppose that we imagine reversing the decay process. The decay products consisting of an electron, an electron antineutrino and a muon neutrino would reverse directions and produce a collision that forms a muon. This collision would be highly relativistic and momentarily return the three decay products to their energetic, compressed state present when the muon initially decayed. In fact, the sum of the frequencies of the three decay products in the compressed state (before separation) would equal the muon's Compton frequency. In this explanation, the neutrinos would not develop the large size and lower frequency until they separate from the other rotars and each is viewed in its rest frame.

Almost all the quantized angular momentum in the universe is contained in neutrinos and photons. All the other leptons and quarks together contain less than one part in 10^8 compared to quantized angular momentum of photons and neutrinos. This makes neutrinos an important consideration when examining the evolution of the universe. Therefore, neutrinos will be discussed again in chapters 13 and 14 on cosmology.

Chapter 13

Cosmology I – Planck Spacetime

Introductory Note: The next two chapters will often use the term "particle" rather than "rotar" because the wave structure is not usually required for cosmological explanations. Also astrophysicists usually refer to the "density" of the universe – a term which combines both energy and matter. This book presents a wave based model of the universe which is more accurately described by the term "energy density of the universe".

The Cosmic Microwave Background (CMB): The precise measurement of the CMB has had a profound impact on cosmology. The Wilkinson Microwave Anisotropic Probe (WMAP) has mapped the full sky distribution of the CMB to a resolution of 0.2°. The age of the universe has been determined to be 13.73 billion years ± 1%. Also the universe has been determined to not have any large scale curvature. It is "flat" to a measurement accuracy of less than 1%.[1,2]

Analysis of the data from WMAP has also determined that about 380,000 years after the Big Bang, the energy in the universe was 10% neutrinos, 15% photons, 12% ordinary matter (baryonic matter), and 63% dark matter. For comparison the percentages quoted for today are: 4.6 % ± 0.1% ordinary matter, 23.3% ± 1.3% dark matter and 72.1% ± 1.5% dark energy.

The 15% energy that was photon energy at 380,000 years has today been redshifted by a factor of about 1080. This has reduced the current energy content of these CMB photons to an almost insignificant percentage (~ 0.01%) of the total energy in the universe. Similarly, neutrinos and other relativistic particles have also lost momentum (kinetic energy) due to the redshift. Therefore, over 20% of the total observable energy present in the universe at an age of 380,000 has disappeared. If we extrapolate back further, the universe was radiation dominated and almost all the observable energy present in the early universe has disappeared (observable energy excludes vacuum energy). The question about what has happened to this observable energy will be discussed later

It can be shown that the energy that was present in ordinary matter and dark matter at 380,000 years is still approximately present in the universe today. The percentages look different because of the addition of dark energy and the subtraction of the energy in photons and neutrinos. Dark energy has never been observed, but it is required by the currently accepted cosmological model. The need for dark energy will also be discussed later.

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[1] http://lambda.gsfc.nasa.gov/product/map/dr4/pub_papers/sevenyear/cosmology/wmap_7yr_cosmology.pdf
[2] Astrophysical Journal Supplement 180: 225-245 February 2009

The measurement of the CMB has also shown that the universe does have a preferred frame of reference. From any given location, the cosmic microwave background only appears isotropic from a particular frame of reference called the CMB rest frame. For example, the sun appears to be moving at about 369 km/s in the direction of the Virgo constellation relative to the CMB as seen from the sun's location. This relative motion produces a Doppler shift in the CMB that shows up as a redshift in the CMB in one direction and a blue shift in the CMB in the opposite direction (dipole anisotropy). This anisotropy is subtracted from CMB pictures to produce the uniform CMB pictures commonly exhibited showing only small temperature variations. Each location in the universe has a unique frame of reference that is stationary relative to the CMB.

Comoving Coordinates: The perspective of a unique CMB rest frame at each location has led to the concept that the universe can be modeled as having a "comoving coordinate system". This is a coordinate grid that expands with the Hubble expansion of the universe. Each point on this grid is in the CBM rest frame for that location. This is also called the "comoving frame". A comoving observer is the only observer that will see the universe (including the CMB) as isotropic. Galaxies are nearly in the comoving frame, so any velocity they have relative to the comoving frame is their "peculiar velocity".

At any given instant, all points in the CMB rest frame are experiencing the same rate of time if local gravitational disturbances are ignored. Another way of saying this is that on the scale where the universe is homogeneous (about 300 million light years), all points in the comoving frame are experiencing the comoving coordinate's cosmological time.

Comoving distance χ is the proper distance between two points (both in the comoving frame) at the present instant of comoving time. While comoving distance corresponds to proper distance at the present instant, comoving distance is imagined to remain at a fixed value of χ over time. In the past or future the proper distance between these two points changes with the Hubble flow but the comoving distance is a fixed designation on an expanding coordinate system. The cosmic "scale factor (a)" is a function of time and usually designated as: $a(t)$. This scale factor quantifies the relative expansion of the universe between two moments in time. The term l_t is proper distance between the two points at a different time (different ages of the universe). The relationship between these terms is:

$$\chi = l_\tau a(t)$$

The current scale of the comoving coordinate system is designated "a_o" and usually set to equal one $(a_o = 1)$.

The Λ-CDM Cosmological Model: Λ-CDM is an abbreviation for Lambda-Cold Dark Matter. This is currently considered to be the standard Big Bang model. In 1929 when Edwin Hubble discovered the redshift of galaxies (he called them nebula), the initial interpretation was that these were Doppler shifts due to relative motion of galaxies expanding into a preexisting void. Hubble proposed that there was a linear relationship between velocity and distance. The current interpretation is that the redshift is due to a cosmological expansion of the universe where space itself is being continuously created everywhere. One difference between Hubble's concept (a preexisting void) and cosmological expansion is that cosmological expansion is currently believed to be able to produce separation velocities that exceed the speed of light. Observations strongly support the general relativistic interpretation of a cosmological expansion over the special relativity interpretation of mass expanding into a preexisting void.

A detailed description of the Λ-CDM model will not be given here. However, there are several physical interpretations and predictions of this model that will be described to establish the current perspective of cosmologists. The favored Λ-CDM model is usually designated as: $\Omega_M = 0.3$ and $\Omega_\Lambda = 0.7$ with the Hubble parameter
$\mathcal{H} \approx 70.8$ km/s/Mpc = 2.29×10^{-18} m/s/m (in MKS units)

The matter density parameter $\Omega_M = 0.3$ represents that all forms of matter makes up approximately 30% of the critical density of the universe and the cosmological constant density parameter $\Omega_\Lambda = 0.7$ indicates that dark energy makes up about 70% of the critical density of the universe. Dark energy is the hypothetical energy that expands the universe and is associated with Einstein's cosmological constant Λ.

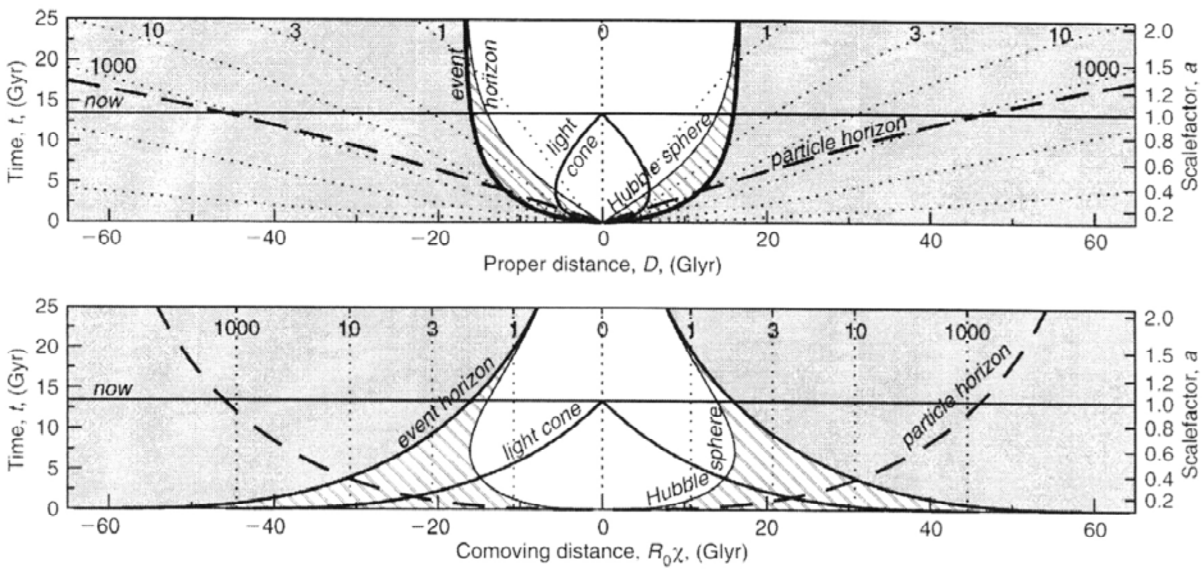

FIGURE 13-1 Spacetime diagrams showing some of the features of the Λ - CDM model of the expanding universe.

(From Davis and Lineweaver, Astronomical Society of Australia, 2004, 21, 97-109)

Figure 13-1 is taken from a very good article titled "Expanding Confusion: Common Misconceptions of Cosmological Horizons and Superluminal Expansion of the Universe"[3] Figure 13-1 is two spacetime diagrams that plot time versus proper distance D on the top panel and time versus comoving distance on the bottom panel. The panels are drawn from the perspective of an observer located at the intersection of the "now' line (13.7 billion years after the Big Bang) and the distance = 0 line. The lower panel has vertical world lines for objects currently with various redshifts ($z =$ 0, 1, 3 etc.) because the comoving distance χ does not change over time. The proper distance changes over time but the comoving distance is a coordinate distance that expands with the comoving coordinate system. The two panels offer different perspectives and the following description applies to both panels.

The dashed line labeled "particle horizon" crosses the 13.7 billion year "now" line at about 46 billion light years. It is to be understood that even though a signal from the most distant source currently reaching us, called the particle horizon, has been traveling at the speed of light for 13.7 billion years, the current distance to that source is larger than 13.7 billion light years. This is because the cosmic expansion of the universe has continued to increase the volume of the universe and the distance between points after the speed of light signal has passed any location.

Next we will look at the line labeled "Hubble sphere". Currently the boundary of the Hubble sphere is 13.7 billion light years from us. This is the distance where space itself is supposedly receding from us at a velocity equal to the speed of light (concept examined later). According to the Λ-CDM model, the space beyond the Hubble sphere is receding from us faster than the speed of light. This gives rise to an "event horizon".

The line labeled "event horizon" represents the furthest distance that we can receive current information. For example, according to the Λ-CDM model, galaxies that we currently observe as having a redshift of $z =$ 1.8 are currently crossing our event horizon. This means that light being emitted by these galaxies today will never reach us because of the accelerating expansion of the universe. All galaxies with redshifts greater than 1.8 have already crossed our event horizon and will disappear from view sometime within the next 14 billion years (larger redshifts disappear sooner).

According to the Λ-CDM model eventually the Hubble sphere and the event horizon will be approximately the same distance. In the distant future the universe will have an event horizon at a constant proper distance of about 17 billion light years. Galaxies will continue to disappear from view as they are carried by cosmological expansion beyond this distance. Eventually only the gravitationally bound galaxies will remain visible. If the concept of accelerating expansion of the universe is carried to its logical conclusion, we would end with the "Big Rip" where

[3] T. M. Davis; C. H. Lineweaver; *Publications of the Astronomical Society of Australia* 2004, **21**, 97-109.

expanding spacetime eventually tears apart our galaxy, then our solar system and eventually even atoms.

Spacetime Transformation Model: We are about to start the description of an alternative cosmological model that will be referred to as the "spacetime transformation model". This model will be more fully explained in the next chapter, but key parts of the model will be presented in this chapter. Initially, these key parts will be explained using the familiar concepts and terminology of the current Big Bang model. However, in the next chapter the Big Bang will be explained with the concept that spacetime is undergoing a transformation. This transformation explains the observed increase in the proper volume of the universe and explains the formation of fundamental particles from 4 dimensional spacetime. It will be shown that this alternative model gives the same cosmological redshift but it eliminates the need for dark energy and makes different predictions about the future of the universe.

When explaining the spacetime transformation model, the initiation of the transformation (the beginning of time) will be referred to as the "Big Bang". This is a highly descriptive term that is being adapted to express the start of a transformation of one form of spacetime to another. This was accompanied by a tremendous increase in proper volume, so the term "Big Bang" is still applicable.

The Expanding Volume of the Universe: If the universe is only spacetime, how does spacetime create new volume? Today, a lot of attention is being paid to the apparent acceleration of the expansion of the universe. While this is an important question, it is not possible to answer this question until we first understand how <u>any</u> new proper volume is created in the universe. If the expansion of the universe is imagined as mass/energy expanding into a preexisting void, then momentum would continue this expansion and there would be no mystery. However, the Λ-CDM model of cosmology says that the universe is undergoing a cosmological expansion. This expansion is the result of new volume continuously being created everywhere in the universe. This new volume is indistinguishable from previously existing volume. Therefore, the new volume must also contain vacuum energy with energy density of more than 10^{112} J/m^3. All the energy in the observable universe is less than 10^{71} Joules. Therefore even a cubic nanometer (10^{-27} m^3) of vacuum contains more energy in the form of vacuum energy than the total observable energy in the universe.

It would appear that there are only three choices to explain this discrepancy. Either 1) vacuum energy is canceled by some other equally vast offsetting effect; 2) a vast amount of new vacuum energy is being continuously added to the universe to maintain a specific vacuum energy density or 3) a fixed amount of vacuum energy is being distributed over an increasing volume which vastly decreases the energy density of vacuum energy as the universe expands. All of these alternatives are unappealing. The spacetime transformation model of the universe proposed later will offer a fourth, more appealing explanation.

The addition of new volume to the universe is not some subtle effect that is taking place in remote parts of the universe between galaxies. It is possible to illustrate the scale of cosmic expansion using our own solar system as an example. Suppose that we consider a spherical volume with the radius of Neptune's orbit (radius ≈ 4.5 x 10^{12} m). This solar system size spherical volume would contain all the major planets and have a volume of about 3.8 x 10^{38} m^3. Calculating from the Hubble parameter ($\mathcal{H} \approx 2.29 \times 10^{-18}$ s^{-1}), this volume would increase by about 10^{21} m^3 each second if the spherical volume expanded proportional to the Hubble expansion of the universe. To put this expansion in perspective, this solar system size volume is adding the equivalent of about earth's volume (1.08 x 10^{21} m^3) every second. We do not notice any change in the volume of the solar system or the Milky Way galaxy because these objects are gravitationally bound. The addition of new volume becomes obvious when distance (proper light travel time) is measured between galaxies that are not gravitationally bound together. Only after we have a plausible explanation for the creation of this new volume everywhere in the universe, can we seriously address the question about the nonlinearity in this creation process (accelerating expansion).

The new volume is also spacetime so a rephrasing of the question is: How does spacetime rearrange itself to give the appearance that it is creating new volume? If the universe is only spacetime, and if the universe appears to be expanding, then the properties of spacetime must be changing with time. Something must be changing because today it takes a longer time for light to travel between two galaxies than it did a billion years ago (assuming each galaxy is at rest relative to the CMB).

Proper Volume: What examples do we have of spacetime adjusting itself in a way that changes proper volume? In the example of the Shapiro experiment, the sun's gravity changed the spacetime between the earth and the sun in a way that increased the proper radial distance by about 7.5 km compared to the radial distance that would be expected from Euclidian geometry. This increase in radial distance increased the volume within a sphere that is 1 astronomical unit (1 AU) in radius by $\Delta V \approx 3.46 \times 10^{26}$ m^3 (previously calculated). This non-Euclidian increase in proper volume is more than 300,000 times the earth's volume. This volume increase was accompanied with a decrease in the rate of time.

Also, the rotar model has two lobes where the properties of spacetime are slightly distorted. The slow time lobe has a rate of time that loses 1 unit of Planck time in a time period of $1/\omega_c$. That slow time lobe has a volume that is larger than what would be expected from Euclidian geometry. The fast time lobe has less proper volume than would be expected from Euclidian geometry. Again it appears as if there is an inverse relationship between proper volume and the rate of time.

Near the end of chapter 2 it was shown that the standard solution to the Schwarzschild equation has a 4 dimensional volume that is independent of the gravitational gamma Γ because the change in the time dimension offsets the change in the radial spatial dimension. In all these examples, there is an interconnection between the rate of time, the coordinate speed of light and proper volume. We will explore the following idea:

New proper volume is created when the rate of time decreases.

It is proposed that spacetime is able to exchange the absolute rate of time for proper volume. This concept is implied in the following equation:

$\frac{dt}{d\tau} = \frac{dL_R}{dR} = \Gamma$ note inverse relationship between dτ and dL_R

While dL_R/dR applies to the radial direction in the Schwarzschild coordinate system, the above equation also can be interpreted as showing an inverse relationship between the rate of proper time and proper volume even when applied to the entire universe. We see the proper volume of the universe increasing, but proving that this is coupled with a decreasing rate of time is more difficult. An absolute proof that the rate of time is slowing in the universe would require the comparison to a hypothetical coordinate clock outside of the universe. This is an impossible experiment, so instead we will start with several thought experiments.

Cavity Thought Experiments: First we will imagine a spherical shell with mass m and internal radius *r*. We will place this spherical shell in space where it is in an inertial frame of reference. If the spherical shell has mass, then on the outside surface of this spherical shell we would experience a gravitational acceleration accompanied by the standard time dilation and gravitational effect on volume. Inside this spherical shell, there would be no gravitational acceleration and we could consider this flat spacetime. However, the escape velocity from the shell is greater if we start from inside the shell compared to starting from the outside surface. Even though there is flat spacetime, inside the spherical shell we still have the gravitational effects that are a function of escape velocity and scale with Γ. This point was also made in chapter 2 with examples using a cavity and the Andromeda galaxy. The gravitational effect on the rate of time, the coordinate velocity of light and on proper volume remains even when there is no gravitational acceleration. However, only the gravitational effect on the rate of time is easy to experimentally see so we will temporally concentrate on the gravitational effect on the rate of time.

Background Gravitational Gamma Γ: Previously we defined the gravitational gamma Γ and a closely related concept, the gravitational magnitude β. These were defined as follows:

$\Gamma \equiv \frac{dt}{d\tau} = \frac{1}{\sqrt{1-\left(\frac{2Gm}{c^2R}\right)}} = 1/\sqrt{1 - v_e^2/c^2} = \frac{1}{1-\beta}$ Γ = gravitational gamma

$\beta \equiv 1 - \frac{d\tau}{dt} = 1 - \sqrt{1 - \frac{2Gm}{c^2R}} = 1 - \frac{1}{\Gamma}$ β = gravitational magnitude

$\Gamma \approx 1 + \beta$ and $\beta \approx \frac{Gm}{c^2r}$ approximations valid only in weak gravity

Inside a cavity uniformly surrounded by mass m, there is a gravitational effect, but the gravitational gamma definition $\Gamma = \frac{1}{\sqrt{1-\left(\frac{2Gm}{c^2R}\right)}}$ needs to be reinterpreted. This equation presumes an isolated mass in an otherwise empty universe. The interior of a spherical shell does not meet this assumption. However, the definition of Γ that incorporates escape velocity v_e is easily definable: $\Gamma = 1/\sqrt{1 - v_e^2/c^2}$. For example, a cavity at the center of the earth would have an escape velocity about 22% greater than the escape velocity starting from the earth's surface (assuming a uniform density approximation and ignoring air friction).

The other alternative definition for the gravitational gamma (stationary frame) also works for a cavity surrounded by mass: $\Gamma = dt/d\tau$. In this case, we define a coordinate clock far from the source of gravity with a rate of time dt and a clock in the cavity with rate of time $d\tau$. Actually, the definition $\Gamma = dt/d\tau$ is preferable because it is also applicable to the entire universe.

The reason for discussing cavities surrounded by mass is that our location in the universe has similarities to a cavity surrounded by mass. In fact, the universe is something like being surrounded by a shell that is increasing in mass every second. What would it be like to be inside a shell that is increasing its mass? (assuming inertial frame of reference) The rate of time would be slowing down and the coordinate speed of light would be slowing down, but we would not be able to directly detect these changes unless we had communication to an outside standard. However, it is proposed that we would notice something strange was happening. A careful experiment would reveal that light was undergoing a slight redshift. The wavelength of light propagating inside the cavity would increase with propagation time. A proof of this contention will be given in the next chapter to explain the redshift observed in the universe.

We often make the assumption that a location in space far from the earth and sun can be considered to be a location with zero gravity. It is true that there might be negligible gravitational acceleration, but we are still surrounded by all the mass/energy within the particle horizon for our location in the universe. We know from observations of the Cosmic Microwave Background (WMAP satellite) that the universe is flat spacetime with only a 0.4% margin of error. This suggests that the universe extends infinitely beyond our particle horizon. However, only the mass/energy within our particle horizon can have any influence on us. The mass/energy within our particle horizon exerts a background gravitational effect which must have greatly slowed down both the rate of time and the coordinate speed of light compared to a hypothetical empty universe. We will use a new name to discuss this subject.

Background Gravitational Gamma of the Universe Γ_u: The name "background gravitational gamma of the universe" and the symbol Γ_u will be used to represent the concept that the universe possesses a gravitational effect that produces no acceleration but affects the rate of time, proper volume and many other physical properties. With background gamma there is distributed mass/energy in all directions so we do not meet the Schwarzschild assumption of a single mass in an otherwise empty universe. However, the definition of Γ based on the effect on the rate of time is the same: $\Gamma_u = dt/d\tau_u$ where $d\tau_u$ is the rate of time is the rate of time in a frame of reference that is stationary relative to the cosmic microwave background (CMB) and far from localized sources of gravity. In this case dt is the coordinate rate of time which is either the rate of time in a hypothetical empty universe where $\Gamma_u = 1$ or the rate of time at the instant the Big Bang started (when $\Gamma_u = 1$). This will be explained later.

To illustrate the concept of a background gravitational gamma, an example will be given using the Milky Way galaxy. This galaxy has a visible radius of about 50,000 light years, but dark matter is believed to extend to a radius of at least 150,000 light years. The sun's orbit is about 26,000 light years in radius around the galactic center. The galactic gravitational acceleration felt by the sun is due entirely to matter that is inside the sun's orbit. Matter and dark matter in the Milky Way galaxy that lies external to the sun's orbit does not produce any gravitational acceleration on the Sun. However, this external matter does still produce a gravitational effect in the sense that it affects the rate of time, the coordinate velocity of light, the gravitational potential, the escape velocity from the galaxy, the standard of energy, etc. In other words, this external matter is producing a significant background Γ at the sun's orbital distance.

It is interesting to estimate the background Γ of the Milky Way galaxy caused by the galaxy's mass external to the sun's 26,000 light year orbit. The total mass of the galaxy, including dark matter, is estimated at about 1.2×10^{42} kg. The mass inside the sun's orbit required to produce the required gravitational acceleration on the sun is only about 15% of this total mass of the galaxy. Therefore the mass of the Milky Way galaxy external to the sun's orbit is about 10^{42} kg. Almost all of this mass is dark matter that is spherically distributed around the Milky Way galaxy. For this calculation we will estimate that all the mass external to the sun's orbit can be simulated by a spherical shell 110,000 light years in radius with mass of 10^{42} kg. Substituting into $\beta \approx Gm/c^2r$ we obtain $\beta \approx 7 \times 10^{-7}$ (or $\Gamma \approx 1 + 7 \times 10^{-7}$). The earth's gravitational magnitude at the earth's surface is $\beta \approx 7 \times 10^{-10}$ (or $\Gamma \approx 1 + 7 \times 10^{-10}$). While neither the earth nor the Milky Way galaxy have a large effect on the absolute rate of time, the Milky Way's uniform background Γ slows down the rate of time about 1,000 times more than the earth's own gravity ($7 \times 10^{-7}/7 \times 10^{-10}$).

Extending the concept to the background gamma to the universe Γ_u, all the mass/energy within the particle horizon is creating a very large value of Γ_u. Individual stars and galaxies represent only a relatively small perturbation of curved spacetime in the flat and very large background Γ_u of the universe. (Black holes will be discussed later.) For example, if the universe had 99 % of the m/R ratio required to form a black hole, the background gravitational gamma of the universe would be: $\Gamma_u \approx 10$. Later we will attempt to calculate the actual current value of Γ_u of the universe. General relativity calculations normally ignores the background gamma of the universe which is the same as assuming that this background is $\Gamma_u = 1$. This is acceptable for all calculations involving discrete mass or even galactic clusters. However, when attempting to explain the expansion of the universe, this cannot be ignored.

Besides Γ_u, there is a related concept that is the background gravitational magnitude of the universe: β_u. The relationship between Γ_u and β_u is the same as the relationship between Γ and β. Some equations are simpler when expressed in terms of gravitational magnitude β rather than gravitational gamma Γ. The exact conversion between Γ and β is: $\beta = 1 - 1/\Gamma = 1 - d\tau/dt$. These relationships also hold for β_u. The gravitational magnitude β has a scale that ranges from 0 to 1 while the gravitational Γ has a scale that ranges from 1 to infinity

Isotropic and Homogeneous Universe: All points on the comoving coordinate system (CMB rest frame) perceive the universe to be isotropic and homogeneous. This includes the rate of time which is the same everywhere in the CMB rest frame. Since points on the comoving coordinates are expanding away from each other, what does it mean for these points to have the same rate of time at a given instant? This can be illustrated with a thought experiment. Suppose we have 3 spaceships located far from sources of gravity in intergalactic space. Each of the three spaceships is exactly stationary relative to the CMB for its location. The three spaceships are widely separated forming a straight line with the middle spaceship exactly halfway between the two outside spaceships. Suppose the two outside spaceships sent out a stable microwave signal at the 9.19 gigahertz corresponding to the frequency of their cesium atomic clocks. When the two signals reach the middle spaceship, the frequency would be slightly lower (redshifted) compared to the atomic clock on the middle spaceship due to cosmic expansion. However, the important point is that both the frequencies from the two outside spaceships would be exactly the same. The middle spaceship observes that both the outside spaceships were experiencing the same rate of time at the instant the signals left the spaceships. With relativity there can be confusion about different definitions of the term "simultaneous". Therefore, the concept of a "midpoint observer" specifies one way of defining simultaneous. The two outside spaceships are simultaneously experiencing the same rate of time according to the midpoint observer.

This means that all points on the comoving grid are experiencing the same rate of time according to midpoint observers. Therefore, this rate of time is used as coordinate rate of time in the Robertson-Walker metric. Now suppose that all three spaceships are stationary relative to each other. An extrapolation of the thought experiment shows that the even if the three spaceships are moving relative to the CMB but stationary relative to each other, the midpoint observer will still see that the outside spaceships are experiencing the same rate of time. This concept can be extended to any two points in the universe in the same frame of reference.

On the scale where the universe is homogeneous, any two points in the same frame of reference experience the same rate of time according to a midpoint observer.

No Large Scale Gravitational Acceleration: This thought experiment will be explained using the rotar model of an electron and the explanation for gravity previously developed. Suppose that we place an electron (rotar) in intergalactic space and ignore any locally generated forces. We are only interested in examining gravity on the scale larger than 300 million light years where the universe is homogeneous. We are going to test the large scale gravity of the universe using the rotar model of an electron. Recall that a rotar experiences gravitational acceleration when there is a rate of time gradient across the rotar. This causes the vacuum energy to exert an unbalanced pressure on opposite sides of the rotar. This produces a net force that is the gravitational force. The acceleration of gravity (g) was previously shown to be:

$$g = c^2\left(\frac{d\beta}{dr}\right) = -\,c^2\frac{d\left(\frac{d\tau}{dt}\right)}{dr}$$

g = gravitational acceleration

It was previously shown that the distance designated in the denominator (dr) is proper length, not coordinate length (circumferential radius) from general relativity. If there is no gradient in the rate of time, then $d(d\tau/dt)/dr = 0$ and $g = 0$. There is no gravitational acceleration when there is no gradient in the rate of time. Two points on the opposite sides of the quantum volume of a rotar can be considered to be two points in the same frame of reference. In a homogeneous and isotropic universe, the same rate of time is present on opposite sides of the rotar (according to the midpoint observer). There is no gravitational acceleration on the homogeneous scale of 300 million light years or larger. All this might seem obvious, but it implies that the universe is not struggling to expand against a gravitational force that is attempting to collapse the universe. The gravity of localized objects like stars and galaxies can curve spacetime on a local scale, but there is not a rate of time gradient in the universe on the scale where the universe is homogeneous.

If there is no large scale rate of time gradient in the universe, then there is no tendency for there to be gravitational deceleration or acceleration at this scale.

It might be argued that dark energy is currently providing something like anti-gravity. To defend this position it would have to be argued that gravity is currently producing a rate of time gradient that is attempting to collapse the universe but dark energy is producing an opposite rate of time gradient. The combination offset each other and eliminates any large scale rate of time gradient thereby eliminating large scale gravitational acceleration. However, even this argument has an obvious flaw. Dark energy only became a significant fraction of the energy in the universe roughly 7 billion years ago. It would have to be argued that prior to this time there was a large scale rate of time gradient in the universe. This is counter to the assumptions contained in the Robertson-Walker metric. It is not possible to have an isotropic universe if there is a large scale rate of time gradient. In fact, if there was a large scale rate of time gradient present when the CMB radiation was emitted, evidence of this rate of time gradient would be preserved as anisotropy in the CMB unless we happen to be located at the exact center of the rate of time gradient.

Rate of Time Gradient in a Dust Cloud: It is an axiom of general relativity that a distributed cloud of dust (no pressure) should experience a uniform gravitational collapse. If the cloud is divided into spherical volumes of successively larger radii, then a particular dust particle (the test particle) in the cloud experiences gravitational acceleration only from the gravity of dust particles within the smaller radii spheres. Mass that lies outside the spherical volume containing the test particle does not contribute to the gravitational acceleration. Enlarging the radius of the imaginary spherical volume increases the enclosed mass. The net effect is that the collapse of the dust particles happens everywhere.

However, gravitational acceleration does not happen in the abstract. To have gravitational acceleration, the cloud of dust particles must have a definable rate of time gradient. It takes a rate of time gradient of about 1.11 x 10^{-17} seconds/second/meter to produce acceleration of 1 m/s^2. It would be possible to draw a three dimensional map showing the equivalent of isobar lines within the cloud except depicting regions of constant rate of time. A dust cloud or a galaxy does have rate of time contours that can be mapped. However, the universe has (and always had) the same rate of time everywhere on the large scale addressed by the comoving coordinate system. Is it possible to propose a model of the universe that does not have a rate of time gradient on the scale of the comoving coordinate system? Furthermore, does such a model follow logically from starting the universe as Planck spacetime? These questions will be examined by starting with a thought experiment.

Dust Particle Cloud Thought Experiment: Suppose that the previously mentioned cloud of dust particles is uniformly distributed in space over a volume about the size of the earth. Also, suppose that it is possible to turn off the gravity of all the dust particles in the cloud. This is an unrealistic assumption for a cloud of dust but it will be shown that it is not unrealistic for the beginning of the universe. Therefore attempt to follow this hypothetical thought experiment. After turning off the gravity of each dust particle, the gravitational magnitude within the cloud would quickly drop to $\beta = 0$ which is equivalent to $\Gamma = 1$. The proper rate of time everywhere within the cloud would be equal to the coordinate rate of time, therefore we would start with $d\tau = dt$ or $\Gamma = dt/d\tau = 1$. There obviously would be no rate of time gradient.

Next, the gravity of all the particles is simultaneously turned on. At speed of light propagation, there would be a period of time where the proper rate of time dτ would be slowing down while the gravitational influence of successively more distant particles is becoming established. For example, it takes about 20 milliseconds for the gravity of a particle at the center of this earth size cloud to affect the rate of time of particles near the outer "surface" of the spherical cloud and vice versa. It would take about 40 ms for the most distant particles on opposite sides of the cloud to make gravitational contact. Therefore, it takes about 40 ms for the mature gravitational acceleration (mature rate of time gradient) within the cloud to become fully established. Since we are defining the gravitational gamma as $\Gamma = dt/d\tau$, we could characterize the establishment of gravity at a particular location in the cloud by referring to the value of Γ as a function of time after the gravity was turned on.

Suppose that we look just at the first few milliseconds after turning on the gravity. Also we will examine several points (test points) within the cloud that are close enough to the center of the cloud that there is not enough time to establish gravitational communication with the boundary condition that occurs at the outer surface of the cloud. In the first few milliseconds the gravitational Γ is increasing exactly the same way at each of these test points. Even though the rate of proper time is slowing (Γ is increasing), there is no gradient in the rate of proper time. This is because all the test points (and all other points far from the surface) have undergone exactly the same amount of gravitational interaction with their surrounding particles. The lack of a rate of time gradient means that there would be no gravitational acceleration attempting to collapse the cloud during the first few milliseconds after gravity is turned on in this thought experiment. There is no tendency towards gravitational collapse only during the nonequilibrium condition of an increasing value of the background Γ. Within the dust cloud there is flat spacetime while Γ is increasing. This flat spacetime does not require a "critical density". The low density of the dust cloud is vastly less than meeting the conditions of a "critical density", yet during the nonequilibrium phase of increasing Γ the dust cloud does achieve flat spacetime (no gravitational acceleration). In fact, any homogeneous density can achieve flat spacetime provided that the nonequilibrium condition of an increasing background Γ is somehow achieved.

Immature Gravity: This thought experiment describes a condition that will be called "immature gravity" or the nonequilibrium condition where the gravitational influence of distant mass/energy is in the process of being established. This is to be contrasted to the "mature gravity" condition where there has been sufficient time to establish the gravitational gradients resulting from the existence of distant boundary conditions (distant changes in density). In this example, after about 40 ms there are differences in the rate of time throughout the cloud because of different distances to the cloud boundary. The rate of time gradient produces gravitational acceleration that was previously missing. This is the mature gravity condition we normally assume when we talk about the uniform gravitational collapse that we expect from a cloud of particles. These concepts can be illustrated using the following figures.

Figure 13-2 shows a volume deep within the dust cloud. Suppose that this is a snap-shot about 1 ms after the gravity was "turned on". The circle labeled "particle horizon for point O" would have a radius of about 300,000 m which represents the speed of light gravitational contact established from point "O" after 1 ms. This horizon is actually an expanding sphere and the figure is a cross sectional representation of a moment in time. There is also another point designated "X" that is relatively close to point X compared to the particle horizon. For example, suppose point "X" is separated by 30,000 m from point "O". This separation distance is about 10% of the distance to the particle horizon after 1 ms. However, it should be noted that point "X" has a different expanding particle horizon designated by the double line circle. After 1 ms this particle horizon is also a sphere about 300,000 m in radius, but centered on point "X".

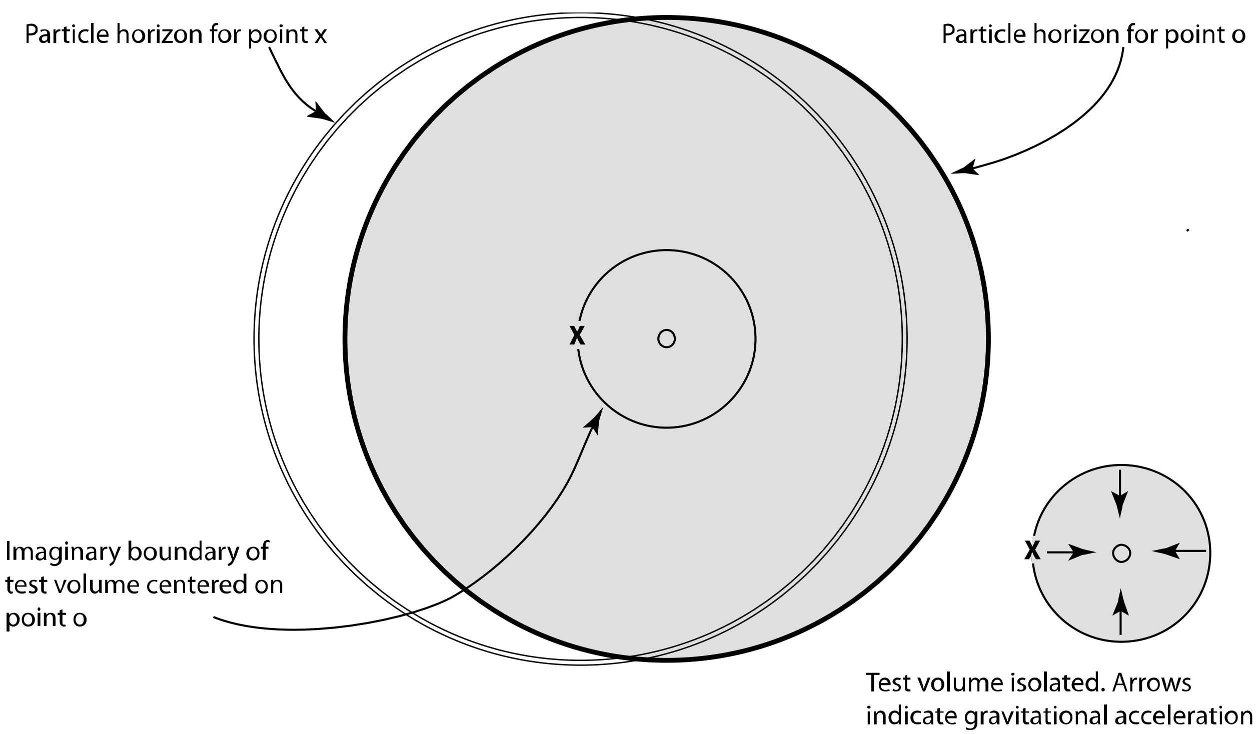

FIGURE 13-2 Observational universe as seen from point o

Figure 13-2 also shows a "test volume". This is a an imaginary sphere that is centered on point "O" and has a radius equal to the distance between point "O" and point "X" (about 30,000 m). Therefore, after 1 ms there has been enough time for the center of this 30,000 m radius spherical volume to establish gravitational contact with all the other dust particles within the test volume (0.2 ms is required for opposite edges to establish gravitational contact). Now we are going to examine the gravitational forces on dust particles within the test volume if the test volume is isolated as shown in the lower right hand corner of figure 13-2. This isolated illustration shows both points "O" and "X". If this small test volume is isolated as shown, then after 0.2 ms all particles in the test volume have sufficient time to establish gravitational contact with the boundary of the test volume. If the test volume is isolated as shown, the "mature" rate of time gradient would be established within the test volume after 0.2 ms. In this case, particles within this test volume would start to undergo a gravitational collapse and a dust particle at point X experiences a gravitational force towards point "O" as shown by the arrow.

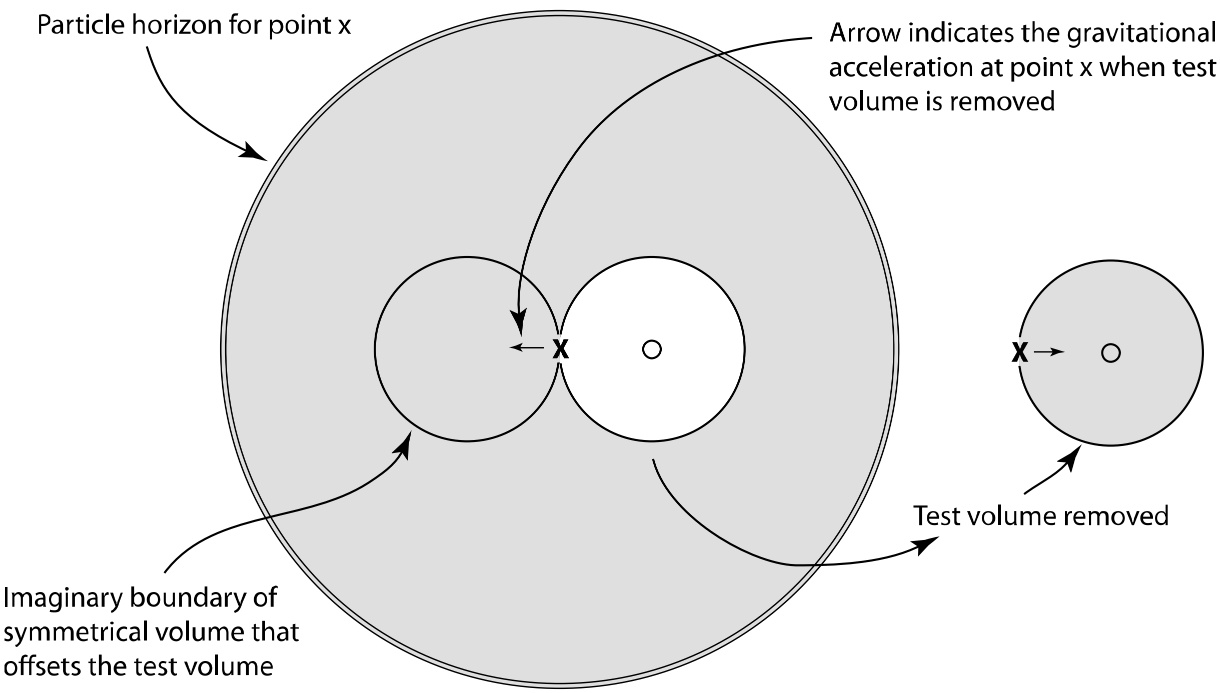

FIGURE 13-3 Observational universe as seen from point x. When test volume is removed, point x experiences a gravitational acceleration in the direction shown. When the test volume is present, there are balanced forces at point x and no net gravitational acceleration.

Figure 13-3 shows a different perspective centered on point "X". Therefore the particle horizon in figure 13-3 is a sphere centered on point X. Now we are going to examine the forces on point "X". In the previous figure, we concluded that a dust particle at point X had a force towards point "O" after 0.2 ms when the test volume was isolated. From this new perspective shown in figure 13-3, suppose that we were to physically remove the test volume as shown to the right. Now 1 ms after gravity has been "turned on" the dust particle at point X has unbalanced force from the comparable volume to its left that is designated as "the symmetrical volume that offsets the test volume". The length and direction of this arrow represents the gravitational force on a dust particle. This force arrow is pointing into the "symmetrical volume" and exactly offsets the length and direction of the force arrow pointing towards point O in the test volume. With the test volume removed, point X would experience a gravitational force in the direction of the arrow pointing to the center of the "symmetrical volume". However, if the test volume is present and point X is surrounded by a homogeneous distribution of particles, then there is no net force on a dust particle located at point X. There is also no rate of time gradient and no net gravitational acceleration.

The point of figures 13-2 and 13-3 is to illustrate that the immature gravity (increasing background Γ) creates a unique condition where there is no rate of time gradient and no tendency for gravitational collapse. Both point "O" and point "X" had their own particle horizons that were partly overlapping, but also each point had a horizon that was uniquely centered on them. This is the condition where all the gravitational forces are balanced and there is no tendency towards a gravitational collapse. Another way of saying this is that the conditions shown create a rate of time that is the same everywhere as defined by a midpoint observer at any given instant. It is ironic that the condition where there is no rate of time gradient (midpoint observer perspective) only happens in immature gravity where the rate of time is continuously decreasing relative to an outside constant rate of time.

Observable Effects of an Increasing Γ: The slowing of the rate of time when Γ is increasing would not be obvious within the cloud while it is happening because it would not be possible to compare the proper rate of time with coordinate rate of time using speed of light communication. However, it will be shown that the condition of a homogeneous increase in the background gravitational gamma would theoretically produce 1) an increase in the proper volume of the dust cloud and 2) would produce a slight redshift in radiation coming from other parts of the dust cloud. The proof for this statement will be given in the next chapter once an easier model for analysis has been introduced.

Implications of an Increasing Γ_u in the Universe: At the start of this chapter, the statement was made that before we can attempt to understand the apparent acceleration in the expansion of the universe, it is first necessary to understand why there is any expansion in the universe. It is proposed that the reason for the apparent expansion of the universe is that the background gravitational gamma Γ_u of the universe is presently increasing. Furthermore, Γ_u was always increasing over the lifetime of the universe but the rate of increase has been different during different epochs.

The purpose of the previous thought experiment is to introduce the concept of immature gravity using a model that is easier to understand than the entire universe. However, a cloud of dust starting with the gravity turned off is not a perfect analogy for the universe. The dust cloud illustrates how it is possible for there to be no rate of time gradient (midpoint observer perspective) as long as the background Γ is increasing, but the example describes a condition where there is only a minute change in Γ. Scale does matter. The change in Γ_u experienced by the universe in its first moments after gravity is "turned on" (the start of the Big Bang) compared to the dust cloud over a similar time period is a difference of more than a factor of 10^{30}. This enormous difference introduces many other differences between the universe and the cloud that will be described.

To my knowledge, no one has mathematically analyzed the implications of living in a universe where the background Γ_u is increasing as a function of the age of the universe. The Schwarzschild solution to Einstein's field equation assumed a single source of static gravity in an otherwise empty universe. The solution describes the effect on spacetime that surrounded this static source of gravity. The Friedman equation assumes a uniform distribution of matter in the universe. However, even the Friedman solution assumes a mature gravitational distribution. The standard Big Bang model also implies a mature gravitational distribution. It is proposed that this is an erroneous assumption that ultimately leads to the need to invent dark energy.

Note to the Reader: *We will divert from the dust cloud example and immature gravity for a short time to introduce additional properties of spacetime. We will then combine all these concepts to develop a model of the expanding universe.*

Energy Density of Planck Spacetime: Until now, this book has ignored numerical factors near 1. From observations and calculations, the energy density of the universe as a function of time is well known. In order for a theoretical model to be credible, it is necessary to be able to match observations. Therefore, it is necessary to introduce a missing numerical factor into the definition of Planck energy density to determine the energy density of Planck spacetime. It is necessary to carefully define the energy density of Planck spacetime because this is proposed to be the starting energy density of the universe and this value affects the evolution of the universe.

Planck energy density is defined as $U_p = c^7/\hbar G^2 \approx 4.6 \times 10^{113}$ J/m^3. This definition describes the energy density that would occur if Planck energy E_p was contained in a cube with dimensions of Planck length on a side $(U_p = E_p/l_p^3)$. This definition lacks dimensionless numerical factors. Even though the energy density of Planck spacetime is closely related to Planck energy density, they differ by a dimensionless constant. For cosmology, a more reasonable definition of energy density would be based on the volume of a sphere that is Planck length in radius rather than a cube that is Planck length on a side. The difference between these two volumes is $(4/3)\pi$.

Zero Point Energy: There is one other dimensionless numerical factor that must also be included. It is proposed that vacuum energy is equivalent to zero point energy. Zero point energy is the lowest energy that a quantum mechanical system may have. The energy of the ground state of a quantum harmonic oscillator is:

$E = ½\, \hbar\omega$ zero point energy

It is proposed that Planck spacetime was the highest zero point energy density possible. The dipole waves in spacetime can be visualized as quantum harmonic oscillators. The highest possible zero point energy density can be visualized as a quantum oscillator that is oscillating at the highest possible frequency in the smallest possible volume. The highest possible frequency is Planck angular frequency: $\omega_p = \sqrt{c^5/\hbar G}$. The zero point energy of this oscillator is:

$E = ½\, \hbar\omega_p = ½ \sqrt{\hbar c^5/G} = ½\, E_p \approx 9.78 \times 10^8$ J.

Therefore, the highest energy density of spacetime is to have this energy $(½\, E_p)$ in the volume of a sphere that is Planck length in radius. This energy density of Planck spacetime will be identified by the symbol U_{ps}.

$$U_{ps} \equiv ½\, \frac{E_p}{\left(\frac{4\pi}{3}\right) l_p^3} = \left(\frac{3}{8\pi}\right)\left(\frac{c^7}{\hbar G^2}\right) = k'\, U_p \qquad \text{where: } k' \equiv \frac{3}{8\pi}$$

$U_{ps} \approx 5.53 \times 10^{112}$ J/m^3 $\qquad$ $U_{ps} \equiv$ energy density of Planck spacetime

The correction factor $3/8\pi$ will also be used frequently and will be identified by the symbol $k' = 3/8\pi$. A sphere Planck length in radius which has spherical Planck energy density contains energy of $½\, E_p \approx 9.78 \times 10^8$ J. However, we will often round this off to about a billion Joules (10^9 J). The constant $k' = 3/8\pi$ is the conversion factor between Planck spacetime energy density U_{ps} and Planck energy density $(U_p = U_{ps}/k')$. These concepts are expressed using energy density (U) rather than mass density (ρ) because mass is a measurement of inertia. Waves in spacetime are naturally expressed in units of energy density rather than units of mass density which implies inertia.

Difference between Planck Spacetime and Vacuum Energy: Planck spacetime at the start of the Big Bang possessed the same proper energy density as vacuum energy today. Therefore, what is the difference? One of the key differences is hidden in the qualification of "proper energy density". Planck spacetime had a background gamma of the universe of $\Gamma_u = 1$ while today the value of Γ_u is an extremely large number that will be calculated later. This large value of Γ_u affects everything including the rate of time and our standard of a unit of energy. Even though one Joule today appears to be the same as one Joule a billion years ago or one Joule at the Big Bang, these are comparisons of proper values that do not take into account the effect of a different value of Γ_u. On an absolute scale of energy that compensates for the change in Γ_u, one Joule today is far less energy than one Joule when $\Gamma_u = 1$ at the start of the Big Bang (explained below).

Another difference is that vacuum energy has no quantized angular momentum (no spin) while at the start of the Big Bang 100% of the energy in Planck spacetime possessed quantized angular momentum. The lack of quantized angular momentum in vacuum energy means that this is a perfect superfluid that does not interact with our observable universe except through subtle quantum mechanical interactions. There are no fermions (half integer spin) or bosons (integer spin) in "pure" vacuum energy. We would say that vacuum energy has a temperature of absolute zero. Even though there is energy density, vacuum energy is incapable of giving kinetic energy (temperature) to particles. On the other hand, in Planck spacetime at the start of the Big Bang each of the $\frac{1}{2} E_p$ units of energy (zero point energy) possessed $\hbar$ of angular momentum. This results in the highest possible interaction with other quantized units of energy. The temperature of Planck spacetime had the highest possible temperature for zero point energy which is equal to ½ Planck temperature (½ $\mathbb{T}_p \approx 7 \times 10^{31}$ °K).

Proposed Alternative Model of the Beginning of the Universe: The alternative model proposed here starts the universe not as a singularity but as Planck spacetime with volume and finite energy density. Recall that Planck spacetime has a spherical correction factor and a zero point energy correction factor that total $3/8\pi \approx 0.12$ compared to Planck energy density. However, Planck energy density eliminates numerical factors by assuming a cubic volume. Therefore, Planck spacetime is the highest zero point energy density achievable. What is the implied rate of time (or the implied coordinate speed of light) required to achieve the highest possible energy density on an absolute scale? This question can also be stated as follows: What value of the gravitational gamma is required to achieve Planck spacetime? The highest possible energy density on an absolute scale that takes into consideration the value of Γ can only be achieved if $\Gamma = 1$. If $\Gamma > 1$ then the rate of time is slower than coordinate rate of time and the unit of energy is less than the coordinate unit of energy. The theoretical largest energy density on an absolute scale can only be achieved at the theoretical fastest rate of time which is also the fastest coordinate speed of light.

Therefore, Planck spacetime has what might seem like a contradiction. The highest possible energy density starts with a rate of time that we would expect to find in a hypothetical empty universe (no slowing of time caused by gravitational fields). If we are truly at the beginning of time, then there was no prior time for gravity to become established. There is no contradiction for $\Gamma = 1$ if this was the starting condition.

The source of Planck spacetime is an open question. Perhaps spacetime merely came into existence as Planck spacetime or perhaps this is a phase change in a repeating cycle. In either case, we assume that Planck spacetime starts with a rate of time commensurate with $\Gamma_u = 1$. This assumption means that at the start of the Big Bang the rate of proper time equaled the rate of coordinate time ($d\tau_u = dt$ at the beginning).

Extending the Dust Cloud Example: Previously we had the thought experiment involving a cloud of dust distributed in space. In this thought experiment we imagined eliminating all gravitational effects from this cloud of particles (gravity turned off). This means that we started with a background gravitational gamma of $\Gamma = 1$. Then we "turned on" gravity everywhere. The starting condition for the entire universe is proposed to be similar in some respects to this thought experiment. Planck spacetime had an energy density roughly 10^{100}

times larger than the energy density of the dust cloud but Planck spacetime was not a singularity. Planck spacetime had an extremely uniform energy density because the energy density was determined by the limitations of spacetime itself. Therefore, it is proposed that the universe started with the finite energy density of Planck spacetime. This quantifiable condition was the starting condition for the evolution of the universe.

There was no preexisting gravity present in this volume, so when time started the waves in spacetime began to distort because of the nonlinearity of spacetime. The background Γ_u of the universe began to rapidly increase from the starting condition of $\Gamma_u = 1$ of Planck spacetime. This is similar to gravity being "turned on" in the thought experiment, except the changes brought about by an increasing Γ_u were vastly larger than occurred in the thought experiment. Rather than an almost imperceptible effect on proper volume in the thought experiment, there was a tremendous increase in the proper volume of the universe as Γ_u rapidly increased. The rate of time in the universe slowed and the coordinate speed of light slowed. All of this produced the immature gravity condition. This immature gravity lacks gravitational acceleration on the large scale of homogeneity as previously described in the dust cloud example.

Comparison to the Big Bang Model: We are now beginning to resolve the difference between two models of the universe. The Big Bang model does not attempt to explain the process which results in cosmic expansion. Matter is not expanding into a preexisting void. Instead, the Big Bang model has a vast expansion in the volume of the universe but no explanation is given as to how new volume is created. The proposed "spacetime transformation model" attributes the expansion in proper volume to a change in the properties of spacetime that can be quantified as a continuous increase in Γ_u. Most important, there is a uniform increase in Γ_u everywhere which implies that there is no large scale gravitational gradient attempting to collapse the universe. This contrasts with the Big Bang model of the universe which has gravity attempting to slow down the expansion of the early universe. The following quote by P. J. E. Peebles in the book "Principles of Physical Cosmology" describes the current reasoning.

> "Newton's iron sphere theorem says that the Newtonian gravitational acceleration inside a hollow spherical mass vanishes. The relativistic generalization is that spacetime is flat in a hole centered inside a spherically symmetric distribution of matter.
>
> Now we are in a position to find the relation between the mass density, ρ, and the local rate of expansion or contraction of the material. We are considering a spatially homogeneous and isotropic mass distribution. Suppose the matter within the space within a sphere of radius *r* is removed and set to one side. Then spacetime is flat within the sphere. Now replace the matter. If *r* is small enough, we have placed a

> small amount of material into flat spacetime. Therefore, we can use Newtonian mechanics to describe the gravitational acceleration of the material."

This goes on to show that the spherical volume with homogeneous density has gravitational acceleration that attempts to contract the distributed mass. When this reasoning is applied to the entire universe it naturally results in gravity opposing the expansion of the universe. Even if the universe is undergoing accelerated expansion because of dark energy, the Big Bang model has gravity attempting to contract the universe. This sounds reasonable and it has been accepted by generations of physicists. However, it is proposed to be wrong.

If we assume that the universe has immature gravity and an increasing Γ_u, then the fallacy in the above reasoning is that removing a spherical volume of homogeneous density material from the universe would not leave a void with flat spacetime. Instead, the remaining void would have negative curvature which has gravitational acceleration away from the center of the void. Figure 13-3 showed that point "X" on the edge of the void has gravitational acceleration away from point "O". Point "X" in figure 13-3 is not unique. All other points within the void also have gravitational acceleration away from the center. This negative curvature effect can be understood since each point in the void can be thought of as existing in a spherical particle horizon centered on them. Therefore these other points within the void are similar to point "X" and also have a gravitational acceleration vector pointing away from the central point "O". These vectors exactly offset the gravitational acceleration towards point "O" caused by the test volume. Replacing the test volume would result in offsetting vectors that eliminate any gravitational acceleration. The immature gravity described here has no tendency towards gravitational collapse of the universe on the current scale of homogeneity (~ 300 million light years).

Low Density Regions of the Universe: On the scale smaller than 300 million light years the universe is currently not homogeneous. There are volumes containing galactic clusters which have above average density and volumes of space between the galactic clusters with below average density. These volumes with below average density should exhibit negative curvature analogous to the void previously discussed. A low density region in the universe would have a similarity to the concept of an electronic "hole" in a semiconductor (electrons and holes). A volume of a semiconductor that is missing an electron is the equivalent of a positive electrical charge. Similarly, a low density region in the universe (missing mass compared to the average) exhibits the repulsive properties as if the missing mass had anti-gravity properties (had an inverse rate of time gradient). This effect only happens if the universe has the immature gravity characteristic.

If low density regions of the universe exhibit something like anti-gravity, this would substantially speed the rate of formation of stars and galaxies in the early universe. Any matter within the low density regions of the early universe would tend to be expelled. Furthermore, the anti-gravity acceleration would extend into the edges of surrounding higher density regions. This would tend to drive these high density regions to even greater density. The average density of the early universe was much greater than today. Therefore the repulsive gravitational acceleration of low density regions of the early universe would be much greater than today. Modeling galaxy formation in the early universe should take this proposed effect into consideration.

Scaling Factor Based on Planck Spacetime a_u: The comoving coordinate system uses "a_o" to represent the present scaling factor of the coordinate system and the scaling is usually based on the convention of considering the current scale of the universe as $a_o = 1$. This is convenient since a model of the universe that starts with a singularity does not have any absolute scaling factor from the start of the Big Bang. However, the concept that the universe started as Planck spacetime means that the spacetime transformation model does have a definable initial size at the start of the Big Bang. It is natural that we would choose this absolute starting condition as the basis of our scaling factor. Therefore we will use the symbol "a_u" to represent the scaling factor based on the absolute scaling factor of Planck spacetime.

Therefore the spacetime transformation model sets $a_u \equiv 1$ for Planck spacetime when the universe was 1 unit of Planck time old and $\Gamma_u = 1$. According to this proposal, at the start of the Big Bang Planck spacetime had energy density of about $U_{ps} \approx 5.53 \times 10^{112}$ J/m^3 and 100% of this energy was "observable". Another way of saying this is that all the energy in Planck spacetime had quantized angular momentum. Today almost all the energy density in the universe is in the form of vacuum energy which lacks any quantized angular momentum. Therefore only roughly 1 part in 10^{122} today has quantized angular momentum and is "observable" to us and out instruments. We only interact with the vast energy density in vacuum energy through quantum mechanical effects. These numbers then become the basis for gauging the future scale of the universe.

Cosmic Expansion from Γ_u: What happens to the comoving coordinate system when there is an increase in the background gravitational gamma of the universe Γ_u? In chapter 2 we did a thought experiment involving two concentric shells. The changes that occur when mass is introduced inside the inner shell are: 1) the rate of proper time $d\tau_u$ slowed compared to coordinate time dt and 2) the proper volume between the two shells increased. We live in a universe which is proposed to have started with a background gravitational gamma $\Gamma_u = 1$ and this value then started to increase at the beginning of time (at the Big Bang). We also know that the proper volume of the universe rapidly increased initially and the proper volume of the universe continues to increase today (the so-called cosmic expansion).

Assuming that the universe is only spacetime, there appears to be only one way that the universe can rearrange itself to increase its proper volume. I am proposing that the reason for the observed cosmic expansion is that the background gravitational gamma Γ_u of the universe is continuously increasing towards $\Gamma_u = \infty$. This is a transformation in the characteristics of spacetime. When the background gravitational gamma of the universe Γ_u increases, proper volume increases, the rate of time decreases and the coordinate speed of light decreases proportional to $1/\Gamma_u^2$. It will be shown later that the model being developed results in new mass/energy continuously coming into view at our particle horizon. Furthermore, mass/energy currently within our particle horizon is decreasing its redshift which increases its gravitational influence. The proposal is that the rate of time continues to get slower, but we are unaware of this change because we cannot directly compare our rate of time to either the rate of time yesterday or the rate of time in a hypothetical empty universe that is not undergoing any change. This obviously is a different model than the Λ-CDM model currently considered to be the cosmological standard.

The proposal is that the expansion of the proper volume of the universe is caused by the background gravitational gamma of the universe Γ_u increasing.

We can see if this proposal is compatible with the Robertson-Walker metric (hereafter R-W metric). The highly successful R-W metric has been called the standard model of modern cosmology. It assumes an isotropic and homogeneous universe and a spherical coordinate system that expands with the "Hubble flow" so that the coordinate system remains in the CMB rest frame everywhere. The standard way of writing the R-W metric is:

$$dS^2 = c^2dt^2 - a^2(t)\left[\frac{dr^2}{1-kr^2} + r^2(d\theta^2 + \sin^2\theta d\phi^2)\right]$$

where $a(t)$ is the scale factor of the universe and r is physical distance. The convention is to use the current scale factor of the universe as $a_o = 1$. Therefore $a(t)$ is usually scaled into the future or past from the current scaling factor and "r" is set equal to the current distance between two points which can be considered a unit of length. However, it is also possible to choose some other standard for "a" and "r" if there is a compelling reason. In our case, we have a very compelling reason to choose a different standard for "a" and "r" because unlike the Λ-CDM model, we have an exact scale for the universe at the beginning of the beginning of time (at the start of the Big Bang). Therefore this scale factor which changes with time but was $a_u = 1$ when the universe was Planck spacetime will be designated $a_u(t)$. Also the physical length between two points will use as its standard the length when the universe was Planck spacetime ($\Gamma_u = 1$). This length standard (coordinate length) will be designated $\mathbb{R}$. Therefore, rewriting the R-W metric with these changes we have:

$$dS^2 = c^2dt^2 - a_u^2(t)\left(\frac{d\mathbb{R}^2}{1-k\mathbb{R}^2} + \mathbb{R}^2d\Omega^2\right) \qquad \text{R-W metric where } d\Omega^2 = (d\theta^2 + \sin^2\theta d\phi^2)$$

The spatial curvature term is k and in the general case "k" can take values of +1, 0 or – 1. However, analysis of the CMB using experimental data from WMAP has established that spacetime on the large scale is flat to better than 0.4% experimental accuracy. Therefore, we are going to assume a flat universe and set $k = 0$. We can determine the spatial metric for a flat universe by setting $dt = 0$ and follow a radial ray by setting $\Omega = 0$.

$$dS^2 = c^2dt^2 - a_u^2(t)\left(\frac{d\mathbb{R}^2}{1-k\mathbb{R}^2} + \mathbb{R}^2 d\Omega^2\right) \qquad \text{set } k = 0,\ dt = 0,\ \Omega = 0 \text{ and } dS = cd\tau = dL$$

$$dL^2 = a_u^2(t)d\mathbb{R}^2$$

$$a_u(t) = \frac{dL}{d\mathbb{R}}$$

The proposed physical interpretation of this is that the reason that the scale factor increases is because proper length contracts relative to coordinate length $\mathbb{R}$ when the universe had $\Gamma_u = 1$ or compared to a unit of length in a hypothetical empty universe. If a unit of proper length L is smaller than a unit of coordinate length $\mathbb{R}$, then progressing in the radial direction the rate of change in proper length dL will be greater than the rate of change in $d\mathbb{R}$. This ratio is equal to the scale factor $a_u(t)$. Since spacetime is homogeneous and isotropic on the large scale, this applies to all spatial directions since the choice of a "radial" direction is arbitrary. The relationship to the gravitational background of the universe Γ_u is proposed to be:

Seventh Starting Assumption: $\Gamma_u(t) = a_u(t) = \dfrac{dL}{d\mathbb{R}}$

It is not possible to conclusively prove this equation. Therefore, this equation is an assumption. However, it is possible to support its validity by showing that it is compatible with observations and gives a compelling model of the universe. The proper volume of the universe is indeed expanding. This equation is a key step in explaining why the universe is undergoing what appears to be a cosmic expansion. The Big Bang model does not go far enough to explain the underlying physics behind the proper volume expansion of the universe.

This equation allows us to estimate the value of Γ_u of the universe today because we know the initial scale of Planck spacetime and we can estimate the expansion that has occurred since the universe had the energy density of Planck spacetime. We will proceed by assuming $\Gamma_u = a_u$ to obtain other insights. If the answers obtained by the use of this equation are reasonable, this can also serve as a check on the equation.

The appeal of the concept that the universe is undergoing an increase in Γ_u is that: 1) it explains the apparent cosmic expansion of the universe 2) it gives the correct redshift to light from distant galaxies (proven later), 3) it gives a universe with a uniform rate of time on the comoving grid and 4) it eliminates the mystery of expanding space supposedly carrying galaxies away from us at faster than the speed of light 5) it is one of several steps that eliminate the need for dark energy 6) it solves the mystery of how the energy density of vacuum fluctuations (zero point energy) can remain constant when the proper volume of the universe expands.

Coordinate Rate of Time *dt*: As explained previously, the definition of the coordinate rate of time (designated *dt*) used by the spacetime transformation model is the rate of time when $\Gamma_u = 1$. This only occurred in our universe during the first Planck unit of time in the age of the universe. Therefore, the coordinate clock can be imagined as a clock that continues to run at the rate of time that was present at the beginning of time. This is also the rate of time that would occur in a hypothetical empty universe where always $\Gamma_u = 1$. After the first unit of Planck time, the background Γ_u of the universe began to increase ($\Gamma_u > 1$) and the rate of proper time in the universe $d\tau_u$ decreased relative to the coordinate rate of time. The gravitational gamma of the universe can also be defined by the following temporal relationship:

$$\Gamma_u = dt/d\tau_u$$

Coordinate and Hybrid Speed of Light: The symbol "*dt*" in the R-W metric represents the rate of time in the comoving coordinate system. This is actually the proper rate of time in the CMB rest frame of the universe. We need to substitute a different symbol because we want to use "*dt*" as the coordinate rate of time when $\Gamma_u = 1$. The rate of time used in the R-W metric is actually the proper rate of time in the universe (the rate of time on the cosmic clock). Therefore in the R-W metric we will make the following substitution $dt \rightarrow d\tau_u$. Also making the substitution of a_u and $\mathbb{R}$ previously discussed, we have:

$$dS^2 = c^2 d\tau_u^2 - a_u^2(t)\left(\frac{d\mathbb{R}^2}{1-k\mathbb{R}^2}\right) + \mathbb{R}^2 d\Omega^2 \qquad \text{modified R-W metric}$$

Combining these substitutions with substitutions previously explained we have:
Set: $dS = 0,\ d\Omega = 0,\ k = 0,\ a_u(t) = \Gamma_u$

$$c^2 d\tau_u^2 = a_u^2(t) d\mathbb{R}^2$$

$$c = a_u(t)\left(\frac{d\mathbb{R}}{d\tau_u}\right) \qquad \text{set } a_u(t) = \Gamma_u(t) \qquad \text{and } \frac{d\mathbb{R}}{d\tau_u} \equiv \boldsymbol{C}$$

$$\boldsymbol{C} = \frac{c}{\Gamma_u(t)} = \frac{d\mathbb{R}}{d\tau_u} = \text{hybrid speed of light (coordinate length and proper rate of time)}$$

Next we will determine the coordinate speed of light ($\mathbb{C} = d\mathbb{R}/dt$) which references the coordinate rate of time dt and the rate of change of coordinate length $d\mathbb{R}$ both in a hypothetical empty universe where $\Gamma_u = 1$. The definition of dt used for the remainder of this book is the rate of time in a hypothetical $\Gamma_u = 1$ universe. Therefore: $dt \equiv \Gamma_u(t) d\tau_u$.

$c = \Gamma_u(t)\left(\frac{d\mathbb{R}}{d\tau_u}\right)$ set $d\tau_u = \frac{dt}{\Gamma_u(t)}$

$c = \Gamma_u^2(t)\left(\frac{d\mathbb{R}}{dt}\right)$ set $\mathbb{C} = \frac{d\mathbb{R}}{dt}$

$\mathbb{C} = \frac{c}{\Gamma_u^2(t)} = \frac{d\mathbb{R}}{dt}$ = coordinate speed of light

There are times when it is necessary to use the coordinate speed of light $\mathbb{C}$ but usually the hybrid speed of light $\boldsymbol{C}$ is adequate and simpler. When possible, it is more convenient and intuitive to use the proper (comoving) rate of time. If we are determining the time required for light to travel a distance between two stationary points, we usually want the answer expressed in units of proper time that would be recorded on the cosmic clock. The difference between the hybrid speed of light $\boldsymbol{C} = d\mathbb{R}/d\tau_u$ and the proper speed of light $c = dL/d\tau_u$ is the difference between a unit of coordinate length $\mathbb{R}$ and a unit of proper length L. The reason that it takes more time for light to travel between two distant galaxies today than it did a billion years ago is that the hybrid speed of light is less today than it was a billion years ago. The distance between these two galaxies is constant when measured in units of coordinate length $\mathbb{R}$. A slowing hybrid speed of light implies that a unit of proper length, (such as 1 meter today) is contracting relative to a unit of coordinate length (such as 1 meter when $\Gamma_u = 1$).

Reconciliation With Proper Length Being Constant: Clearly the physical interpretation that is emerging is that a unit of proper length contracts when Γ_u increases. In chapter 3 it was proposed that it was an acceptable basis of a coordinate system to consider a unit of proper length, such as a meter, to be the same everywhere in the universe. A meter in a location with a large gravitational Γ was considered to be the same as a meter in a location far from any source of gravity which we were previously calling "zero gravity". How is it possible to reconcile the view that proper length is contracting as Γ_u increases with the view in chapter 3 that proper length is constant everywhere in the current universe?

The answer is that the "normalized" coordinate system of chapter 3 used the equation $L_o = L_g$. This does not imply that L_o and L_g are constant over time. It merely says that this coordinate system assumes that in a stationary frame of reference, a unit of length in a zero gravity location (L_o) is the same as a unit of length in a location with gravity (L_g) at a given instant in time (midpoint observer perspective). Both of these lengths can be simultaneously contracting as the universe ages and yet maintain $L_o = L_g$. More will be said about this in chapter 14.

Planck Sphere: We will now define terms necessary to quantify and analyze the evolution of the universe. Planck spacetime has energy density equivalent to a sphere that is Planck length in radius containing the maximum zero point energy permitted by the properties of spacetime. This maximum energy is equal to ½ Planck energy (½ $E_p \approx 9.78 \times 10^8$ J). Most important, Planck spacetime has $\Gamma_u = 1$ and all the energy possesses quantized angular momentum. The implications of these conditions will be explained later.

We will call the basic quantized unit of Planck spacetime a "Planck sphere". Besides having a radius of Planck length it also has quantized angular momentum of ħ (perhaps ½ $\hbar$). The choice between these two will have to be worked out by others, but $\hbar$ is more reasonable and we will use $\hbar$ in the following discussion. The concept of a Planck sphere is introduced primarily because this is a convenient reference to help us visualize the apparent expansion of the universe in units of proper length. We can describe what happens to the radius, energy and angular momentum that are initially in the Planck sphere. In this way the evolution of the Planck sphere becomes an easy reference for what happens to all the spacetime in the universe.

Angular Momentum in Planck Spacetime: Besides having energy density, Planck spacetime also must have a distributed density of quantized angular momentum. Our current universe possesses quantized angular momentum primarily in the form of CMB photons. Currently the CMB has the photon density of a 2.725° K black body cavity which is about 4 x 10^8 photons/m^3. The angular momentum ($\hbar$) possessed by this vast number of photons exceeds by a factor of about 10^8 the internal angular momentum possessed by baryonic matter in the universe (ignoring dark matter). If we simply imagine reversing time, all the CMB photons would be compressed and blue shifted until each photon was reduced to a sphere that is Planck length in radius. This idea can be checked with a plausibility calculation that will be made later.

Starting the Universe From Planck Spacetime: The remainder of this chapter will look at the evolution of the universe. This combines the concepts of an increasing Γ_u and Planck spacetime with the Big Bang model of expanding spacetime. This combination allows us to introduce new ideas in the familiar context of the Big Bang model. In the next chapter we will drop the Big Bang model and switch completely to the proposed spacetime transformation model that is more compatible with the premise that the universe is (and always was) only spacetime.

We are setting the stage for the start of the Big Bang. In this thought experiment we are going to witness the Big Bang from the vantage point of an infinitely small point that is at the center of a Planck sphere at the start of the Big Bang. From this vantage point we are going to pay particular attention to what happens to the approximately one billion Joules (½ E_p) that is the energy of the Planck sphere that surrounds our infinitely small vantage point. All of this energy is initially within a distance of Planck length of our location.

We will imagine that we can watch the evolution the universe (watch the Big Bang) from our infinitely small vantage point within Planck spacetime. We are also going to equip ourselves with two clocks that will start running the moment that time starts to progress forward at the start of the Big Bang. Both of these clocks are digital clocks that run in quantized increments of Planck time (~ 5.4 x 10^{-44} second steps). One of these clocks will be called the "cosmic clock" that measures the proper age of the universe in the comoving frame of reference. Time on the cosmic clock, expressed in dimensionless Planck units of time, will be designated with the symbol $\underline{\boldsymbol{\tau}}_u$ (bold and underlined designates Planck units) and defined as:

$\underline{\boldsymbol{\tau}}_u \equiv \tau_u/t_p$.

The other clock will be called the "Γ=1 clock". This is a hypothetical clock that runs at the rate of time of an empty universe where the background gravitational Γ_u is always equal to 1. Time on the Γ=1 clock also is in Planck units of time and designated as $\underline{\boldsymbol{t}}_u$. Since the universe started with $\Gamma_u = 1$, the Γ=1 clock can also be thought of as a clock that continued running at the rate of time that was present at the beginning of the Big Bang. This clock is keeping coordinate time which is the "dt" term in the equation: $\Gamma_u = dt/d\tau_u$.

The Big Bang Starts: Now for the big event: Time starts and the Big Bang has begun. Actually, the observable, proper energy density defining Planck spacetime only exists in this form during the first unit of Planck time. After this brief time the observable energy density (energy with spin) rapidly drops to less than $U_{ps} = 5.53 \times 10^{112}$ J/m^3 and Γ_u rapidly increases ($\Gamma_u > 1$). However, the total energy density of the universe remains constant when we add together the vacuum energy density (no spin) plus the observable energy density (with spin) as explained later. It is not possible to talk about what happens "before" time starts to progress (when $\underline{\boldsymbol{t}}_u = 0$) because this implies that the rate of time has stopped and there is no motion of waves in spacetime. We will adopt the position that there was no time "before" $\underline{\boldsymbol{t}}_u = 1$. In order for spacetime to be energetic, there must be moving dipole waves in spacetime (there must be dynamic spacetime). There is no energy in static spacetime. If the spin in each Planck sphere is $\hbar$, then this is the equivalent of one photon per sphere. Initially the energy of this single photon per Planck sphere would be equal to the maximum zero point energy which is ½ E_p. Another way of saying this is that all the energy of Planck spacetime had quantized angular momentum and was "observable" energy. Today only about 1 part in 10^{122} of the total energy in the universe has quantized angular momentum and is "observable".

We are going to assume that time starts simultaneously everywhere within the Planck spacetime. This obviously requires either faster than speed of light communication or some other way of synchronizing the start of time. The only justification for this assumption is that observations today indicate a simultaneous initiation of the Big Bang. Perhaps this can be rationalized by assuming that in this highest possible energy density, the entire universe was like a single particle that exhibited the instantaneous communication of entanglement or unity. We will not dwell on this point. This assumption seems more understandable than starting with a singularity, but ultimately the simultaneous initiation of the Big Bang (simultaneous starting of time) is just a starting assumption.

At the instant that the Big Bang starts, our imagined vantage point is completely isolated. There has been no time for any communication with any of the surrounding energy in Planck spacetime and there has been no nonlinear distortion of the waves in spacetime that constitute Planck spacetime. This means that at the start of the Big Bang there is no pre existing gravitational effects – no preexisting gravitational acceleration and for the first unit of Planck time, $\Gamma_u = 1$ everywhere in the universe. Therefore, for the first unit of Planck time, the cosmic clock and the Γ=1 clock both run at the same rate of time $(d\tau_u = dt)$. This starting condition is similar to the dust cloud thought experiment where we started with gravity "turned off".

Increasing Value of Γ_u: The first tick of Planck time was easy because it happens with $\Gamma_u = 1$. Our "particle horizon" was equal to Planck length which is the boundary of the Planck sphere. The question is: What happens with subsequent ticks as our particle horizon expands beyond the boundary of our Planck sphere? Speed of light contact is being made with adjacent waves in spacetime just beyond the boundary of our Planck sphere. The nonlinearity of spacetime begins to affect these waves causing an increase in the background gravitational gamma from $\Gamma_u = 1$ to $\Gamma_u > 1$. The rate of time slows and proper volume increases, but there is no time gradient. All points are experiencing the same rate of time so there is no tendency for gravitational attraction or gravitational collapse. This is the start of the immature gravity condition that continues today. A uniformly increasing Γ_u eliminates the time gradient necessary for gravitational attraction.

For the first unit of Planck time the cosmic clock and the $\Gamma = 1$ clock were synchronized. However, all subsequent ticks exhibit the fact that the cosmic clock has a rate of time that is slowing relative to the Γ=1 clock. Also the proper distance to the boundary of the Planck sphere increases. Both of these effects are the result of Γ_u increasing which in turn is the result of the nonlinear effects of spacetime accumulating. The waves in spacetime responsible for the energy density of Planck spacetime have begin to distort. Unlike the gravity produced by an isolated mass, inside the early universe the stressed spacetime is a homogeneous distribution of energy that extends beyond our particle horizon. This wave distortion would produce an increase in the background gravitational gamma Γ_u similar to the increase in the background Γ in the dust cloud thought experiment. However, because the universe started with the maximum possible quantized energy density, the effects on volume and the rate of time are vastly larger than in the dust cloud thought experiment.

Spacetime Evolves into Different Types of Energy: The distortion free oscillating spacetime (Planck spacetime) that was present during the first tick of the cosmic clock begins to exhibit distortion for all subsequent ticks. The nonlinearity of spacetime causes the waves in spacetime to distort. The distorted waves can be through of as being split into three component parts. These three components are:

1) The distortion free component of the original waves in spacetime that retain the original quantized angular momentum (spin). This is proposed to become the source of everything in the universe that we can sense today (all fermions and bosons).

2) The non-oscillating component (the $H_\beta{}^2$ component of chapter 6) that results when the waves in spacetime are distorted by the nonlinearity of spacetime. This is responsible for gravitational effects and also responsible for the background Γ_u of the universe.
3) The high frequency oscillating component of gravity (the $H_\beta cos2\omega t$ component described in chapter 6) proposed to be responsible for vacuum energy. This component lacks angular momentum and becomes the vacuum fluctuations component of the universe today.

Therefore starting with Planck spacetime means that any nonlinear distortion caused by an interaction of waves in spacetime (gravitational contact with surrounding energy) must increase Γ_u. However, as Γ_u increases this also increases proper distance between stationary points and decreases the rate of time. New energy is always adding its gravitational influence as the particle horizon expands and new energy comes into view. As Γ_u increases, the proper distance to the particle horizon increases even faster than the speed of light because our unit of length is also shrinking relative to coordinate length $\mathbb{R}$. The value of Γ_u increases towards infinity.

Avoiding Gravitational Collapse: What prevents Planck spacetime from collapsing into a singularity? In fact, when $\underline{\tau}_u = 1$ each Planck sphere appears to contain the exact amount of energy required to become a black hole with a Schwarzschild radius equal to Planck length. Even today the proper energy density of spacetime is approximately the same as the energy density of Planck spacetime. According to general relativity, energy in any form produces gravity. Therefore, general relativity considers the energy density of spacetime required by quantum mechanics to be a ridiculously large number ($\sim 10^{120}$ times larger than the critical energy density of the universe). What prevents the energy density of spacetime from collapsing into a black hole? A partial answer will be given here and additional details will be given in the next chapter.

Think of the energy density of spacetime as being the necessary ingredient to give spacetime properties such as a speed of light, impedance, a gravitational constant, elasticity, etc. Therefore it is an oversimplification to say that energy in any form creates gravity. The more correct statement would be that any form of energy that possesses quantized angular momentum creates gravity. In other words, fermions and bosons create gravity. The dipole waves in spacetime that form vacuum energy lack angular momentum and are part of the fabric of spacetime. They have superfluid properties and are as homogeneous as quantum mechanics allows. They are also the necessary ingredient required to support the existence of fermions and bosons.

When rotars with their quantized angular momentum are introduced into an otherwise homogeneous volume of spacetime, this is adding an **additional energy density** to the previously homogeneous energy density of spacetime. For example, if there was a rotar with Planck energy, then this rotar would have a quantum radius equal to Planck length. The energy density of such a rotar would be equal to the energy density of an equivalent volume of spacetime. Therefore, introducing such a rotar into a previously homogeneous volume of spacetime would **double** the energy density of that volume of spacetime. This doubling reaches the theoretical limit of the properties of spacetime and results in the creation of a black hole.

There are no fundamental particles (rotars) with Planck mass/energy. The conditions which create a stellar size black hole or a super massive black hole do not match the total energy density of spacetime (~10^{113} J/m^3). However, they do match the interactive energy density U_i previously discussed in chapter 4. Recall from chapter 4 the following:

> The interactive energy density $U_i = F_p/ƛ^2$ is a very large energy density. How does this energy density compare to the energy density of a black hole (symbol U_{bh})? We will designate the black hole's energy as E_{bh} and its classical Schwarzschild radius as R_s. Ignoring numerical factors near 1 we have:
>
> $$\mathrm{U_{bh}} = \frac{E_{bh}}{R_s^3} = \left(\frac{R_s c^4}{G}\right)\left(\frac{1}{R_s^3}\right) = \frac{F_p}{R_s^2}$$
>
> Therefore, since $U_i = F_p/ƛ^2$ and $U_{bh} = F_p/R_s^2$ it can be seen that if $ƛ = R_s$ then $U_i = U_{bh}$.

Adding additional energy to a specific volume by introducing matter increases the total energy density and produces the gravitational effects described by general relativity. The largest force that the vacuum energy/pressure can exert is Planck force ($F_\mathrm{p} = c^4/G$). With the rotar model it was stated that the energy density of a rotar implied a specific pressure. This pressure needed to be contained by an offsetting pressure exerted by vacuum energy/pressure. Likewise, the matter of a larger body such as a star has a collective energy density that must be stabilized by offsetting pressure from vacuum energy/pressure. The pressure on a star can be considered as two opposing forces exerted on opposite hemispheres of the star. The maximum force that spacetime can exert is Planck force. Therefore the conditions which form a black hole occur when spacetime is asked to exert this maximum force. The energy density of a black hole (ignoring numerical factors near 1) is $U_\mathrm{bh} = F_\mathrm{p}/R_\mathrm{s}^2$. The point is that the energy density of spacetime does not form a black hole. Instead, a black hole forms when additional energy density (matter) in introduced to a volume and equals the interactive energy density where $ƛ = R_s$ in the equation $U_i = F_p/ƛ^2$.

When the universe started at the beginning of the Big Bang ($\underline{\tau}_\mathrm{u} = 1$), 100% of the energy of Planck spacetime possessed quantized angular momentum. There was no vacuum energy during the first unit of Planck time. Therefore, the total energy density of a Planck sphere did not form a black hole and the particle horizon was equal to Planck length. The possibility of forming black holes only occurred later when some of the energy of Planck spacetime was converted to vacuum energy. Then it became possible to overload a particular volume of spacetime with the combination of vacuum energy and energy with quantized angular momentum (multiple rotars and/or photons). In chapter 14 we will see how it is possible for the proper energy density of spacetime to remain constant while the proper volume of the universe expands.

Three Epochs in the Evolution of the Universe: The rate of expansion of the universe (rate of change of Γ_u) is currently believed to have gone through 3 different phases. The following calculations use the current estimates for the rates of expansion of the universe and the current estimates of age of the universe when transitions occur. As improved estimates become available, they should be substituted for the following preliminary estimates.

The first phase is the radiation dominated epoch and is currently believed to have started with the Big Bang and ended roughly 70,000 years after the Big Bang. During this epoch, the scaling factor of the universe grew as: $a_u(t) = \underline{\tau}_u^{1/2}$. Next came the matter dominated epoch from roughly 70,000 years after the Big Bang to about 5 billion years after the Big Bang. The matter dominated epoch is believed to have a scaling factor that grew with a slope characteristic of $\underline{\tau}_u^{2/3}$. However it is not accurate to say that $a_u(t) = \underline{\tau}_u^{2/3}$ because during the radiation dominated epoch the slope was different. Therefore, we will say that during the matter dominated phase the change in scaling factor is $\Delta a_u(t) = \Delta\underline{\tau}_u^{2/3}$. From about 5 billion years until the present we are in what is referred to as the "dark energy" dominated epoch. During this phase a first approximation of the change scaling factor can be described as: $\Delta a_u(t) = \Delta\underline{\tau}_u$. However, the change in scaling factor appears to be more complex than this because the change in the scale factor is probably accelerating. The Λ-CDM model of cosmology has parameters that can be adjusted to permit it to match observations. Fortunately, the key points of the proposed spacetime transformation model can be stated without requiring a precise equation for the scale factor in the "dark energy" dominated epoch.

Radiation Dominated Epoch: The standard Big Bang theory (without inflation) has the scale factor of the universe increase proportional to the square root of time during the radiation dominated epoch $a_u(t) = \underline{\tau}_u^{1/2}$. Even the model of the universe that includes inflation starts off with the scale factor increasing proportional to $\underline{\tau}_u^{1/2}$ between the start of the Big Bang and about 10^{-37} second after the start. The inflation model then has a brief period where a vast exponential expansion takes place. This is then followed by a return to expansion proportional to $\Delta\underline{\tau}_u^{1/2}$.

The spacetime wave model proposed here does not need the hypothetical inflationary exponential expansion to make the universe homogeneous, isotropic and spatially flat. All of this automatically follows from starting the universe at the highest possible energy density that spacetime can support - Planck spacetime. This energy density is as homogeneous as quantum mechanics allows. These quantum mechanical fluctuations are traceable to the Planck length/time limitation of wave amplitude in the model of the universe based on waves in spacetime. These quantum fluctuations provide the small amount of inhomogeneity required to seed the eventual gravitational formation of stars and galaxies. The symbols and equations that we will be using to characterize the radiation dominated epoch are:

$a_u(t) = \Gamma_u = \underline{\tau}_u^{1/2} = \sqrt{\tau_u/t_p}$ radiation dominated epoch relationships

The Universe at $\underline{\tau}_u = 9$: We will illustrate some important concepts about the early stages of the expansion of the universe with an example. Previously an imaginary vantage point at the center of a Planck sphere was described. Suppose that we return to that infinitely small vantage point and look at the changes that occur 9 units of Planck time ($\underline{\tau}_u = 9$) after the start of the Big Bang. From $\underline{\tau}_u^{1/2} = \Gamma_u$ we obtain that at $\underline{\tau}_u = 9$ the background gravitational gamma of the universe is: $\Gamma_u = 3$. This has a profound effect on spacetime. The scale factor of the universe relative to Planck spacetime (a_u) has tripled. Therefore, the Planck sphere that started with a radius of Planck length l_p now has a proper radius 3 times as large ($r = 3\, l_p$). However, the coordinate radius always assumes $\Gamma_u = 1$, therefore the coordinate radius of the Planck sphere (measured in units of $\mathbb{R}$) remains constant at 1 unit of Planck length ($\mathbb{R} = 1$)

The Hubble sphere with radius r_h around the origin point, has a proper radius of $r_h = c\tau_u$ so when $\underline{\tau}_u = 9$ then $r_h = 9\ l_p$. The Hubble sphere defines the distance where objects seem to be receding at the proper speed of light. The proper distance to the particle horizon (designated r_{ph}) at an instant in time is larger than the Hubble sphere at that same instant in time. This is because the instantaneous proper distance to the particle horizon includes distance that has expanded after a speed of light signal has passed any point. During the radiation dominated epoch it can be shown that the proper distance to the particle horizon is always twice the radius of the Hubble sphere. At age of the universe τ_u, the radius of the particle horizon is $r_{ph} = 2c\tau_u = 18\, l_p$ when $\underline{\tau}_u = 9$ or $\tau_u = 4.85 \times 10^{-43}$ s. Today the value of Γ_u is much larger than 3 (calculated later). Therefore the proper dimensions quoted when $\underline{\tau}_u = 9$ and $\Gamma_u = 3$ would be different today because Γ_u is much larger. However, the coordinate dimensions (measured in units of $\mathbb{R}$) always are constant because they do not scale with Γ_u.

Any signal obtained from the particle horizon has infinite redshift but a signal emitted from inside the particle horizon has less of a redshift. The gravity of an apparently receding mass is less than the gravity of a stationary mass at the same distance. Therefore, the redshift at various distances also affects gravity. It is the combination of the gravity of all the energy inside the particle horizon that together is increasing the background gamma at our observation point. Since all other observation points are experiencing a similar gravitational effect, the background gravitational gamma of the universe is increasing homogeneously because Planck spacetime started off at the maximum homogeneity permitted by quantum mechanics.

We will now return to our example of the universe when it was 9 units of Planck time old ($\underline{\tau}_u = 9$). At this instant we had: $\Gamma_u = \underline{\tau}_u^{1/2} = dt/d\tau_u = 3$. The rate of proper time shown on the cosmic clock has slowed to a third the rate of time shown on the Γ=1 clock. Also the hybrid speed of light $\boldsymbol{C} = d\mathbb{R}/d\tau_u$ has slowed to a third the proper speed of light expressed by the universal constant $c = dL/d\tau_u$ because of the difference between $d\mathbb{R}$ and dL. Therefore:

$$\boldsymbol{C} = \frac{c}{\Gamma_u} = c/\underline{\tau}_u^{1/2} \quad \text{(assumes radiation dominated epoch)}$$

The Planck sphere initially contained about 10^9 Joules during the first unit of Planck time when the universe was Planck spacetime. All this energy initially possessed $\hbar$ of quantized angular momentum. Therefore these initial waves were photons in maximum confinement. However, energetic photons can be converted to particles. For example, it has been experimentally proven that two 511,000 eV photons can be converted to an electron/positron pair.

When $\underline{\tau}_u = 9$ and $\Gamma_u = 3$ the photon-like waves have been redshifted by a factor of 3. Therefore, the proper volume of the Planck sphere has increased by a factor of 27 and the "observable energy" (possessing quantized angular momentum) in the Planck sphere has decreased because of redshift by a factor of 3 to about 0.33 billion Joules. Where did the difference in energy go?

Lost Energy Becomes Vacuum Energy: When physics students hear about the cosmic redshift decreasing the energy of photons, they often ask where the energy went. Answers often involve a discussion of stretched wavelengths, and eventually imply that conservation of energy does not apply to the cosmic expansion of the universe. The proposed spacetime transformation model gives a different answer. When the proper volume of the universe expands, a photon loses energy but retains 100% of its proper angular momentum. Therefore the lost energy possesses no angular momentum.

It is proposed that all the observable energy lost by photons is being converted to vacuum energy (zero point energy) that is in a superfluid state that cannot possess angular momentum. In fact, it is not only photons that are losing energy to cosmic expansion. Neutrinos and other relativistic particles (moving relative to the local CMB rest frame) are also losing substantial amounts of observable kinetic energy. This lost energy is also being converted to vacuum energy. In the next chapter we will attempt to calculate the ratio of vacuum energy density to observable energy density in the universe today.

Radiation-Matter Equality Transition: The radiation dominated epoch ended when the energy density in radiation fell to eventually equal the energy density of matter in the universe. The proper energy of matter (such as an electron) does not decrease when Γ_u increases so eventually radiation energy density falls to equal the average energy density of matter. This transition is called the radiation/matter equality and occurred about 70,000 years after the Big

Bang. Before the WMAP probe accurately measured the CMB, this transition was thought to have occurred earlier, perhaps 10,000 years after the Big Bang. However, analysis of the WMAP data has determined that the energy content of the universe at 380,000 years after the Big Bang was 15% radiation, 10% neutrinos, 12% baryonic matter and 63% dark matter. Since both radiation and neutrino energy decrease in energy at virtually the same rate (assuming no new sources), the breakdown at 380,000 years can be generalized as 25% radiation-like energy and 75% energy in matter. These numbers imply the radiation/matter equality occurred about 70,000 years after the Big Bang ($\underline{\tau}_u \approx 4.09 \times 10^{55}$ Planck units of time). It is possible to calculate the value of the background gravitational gamma at the radiation/matter equality transition. This background gamma is important for later calculations and will be designated as: Γ_{eq}.

$\Gamma_u = \underline{\tau}_u^{1/2}$ set $\underline{\tau}_u \approx 4.09 \times 10^{55}$ ($\approx$ 70,000 years)

$\Gamma_{eq} \approx 6.4 \times 10^{27}$ $\Gamma_{eq} = \Gamma_u$ at the radiation/matter equality transition

Therefore, about 70,000 years after the Big Bang the absolute scale factor of the universe was: $a_u = \Gamma_{eq} \approx 6.4 \times 10^{27}$. This means that the Planck sphere increased in radius from Planck length ($\sim 10^{-35}$ m) to about 10^{-7} m (obtained from $l_p \times 6.4 \times 10^{27} \approx 10^{-7}$ m). Furthermore, the redshift that occurred during the radiation dominated epoch decreased the proper energy of radiation by a factor equal to Γ_{eq}. This means that the “observable” energy in the Planck sphere decreased by a factor equal to Γ_{eq} from about a billion Joules to about 1.53×10^{-19} J. All the missing observable energy (i.e. energy possessing angular momentum) was converted to vacuum energy. Therefore the total energy in the Planck sphere (observable energy plus vacuum energy, both measured in units of coordinate energy) remained constant at about 9.78×10^8 Joules at the end of the radiation dominated epoch (discussed later). This can be confusing since there are two different standards for energy the same way that there are two different standards of length (proper and coordinate). The conclusion is that the energy density of the universe has not changed from the Big Bang to today if vacuum energy is included in the energy density. What has changed is that the “observable” energy density of the universe (excludes vacuum energy) has decreased by a factor of about 10^{122}.

After the radiation dominated epoch ended, the next phase was the matter dominated epoch which lasted from about 70,000 years to about 5 billion years after the Big Bang. The scale factor (and Γ_u) during this epoch scales proportional to $\Delta\underline{\tau}_u^{2/3}$. The current epoch is usually referred to as the dark energy dominated epoch and extends from about 5 billion years to the present. The scale factor and Γ_u during this epoch might be linearly increasing proportional to $\Delta\underline{\tau}_u$ or it might be increasing faster than linearly in which case it would be an exponential increase. This is the famous accelerating expansion of the universe and the exact representation of this phase will be left to the astrophysicists.

Γ_{uo} Calculation from Expansion: Our objective here is to determine the current value of the background gravitational gamma for the universe designated Γ_{uo}. We have calculated the value $\Gamma_{eq} \approx 6.4 \times 10^{27}$ for the radiation dominated epoch. The remaining part of the calculation required to determine Γ_{uo} is greatly helped by the fact that the redshift from the radiation/matter equality to the present has been experimentally measured by WMAP. The following quote is from the 5 Year WMAP report[4]; "The equality redshift z_{eq} is one of the fundamental observables that one can extract from the CMB power spectrum[5]". The term "equality redshift z_{eq}" is the value of the redshift since the radiation/matter transition (equality) to the present. This redshift has been measured by WMAP and found to be: $z_{eq} = 3253 \pm 88$. Therefore this number includes all of the redshift that occurred during both the matter dominated epoch and the dark energy dominated epoch until now. This single number includes even accelerated expansion.

Therefore since the redshift z_{eq} equals the change in scaling factor since equality, we can simply multiply this times the previously calculated value of Γ_u prior to radiation/matter equality to obtain the total value of the background gravitational Γ_u of the universe today. We make use of the contention that $\Gamma_u = a_u$ therefore the current values are $\Gamma_{uo} = a_{uo}$.

$\Gamma_{uo} = \Gamma_{eq}\, z_{eq} = 6.4 \times 10^{27} \times 3253$

$\Gamma_{uo} \approx 2.1 \times 10^{31}$ $\qquad$ Γ_{uo} calculated from cosmological expansion

This calculation of Γ_{uo} and a_{uo} simply extended the starting assumption (the universe is only spacetime). This means that we begin the universe with Planck spacetime at one unit of Planck time old ($\underline{\boldsymbol{\tau}}_u = 1$) rather than starting with a singularity at $\boldsymbol{\tau}_u = 0$. The calculated expansion incorporated the radiation dominated epoch, the matter dominated epoch and the so called "dark matter" epoch when there was accelerated expansion. The calculation did not incorporate an "inflation" phase. Inflation is an *ad hoc* assumption necessitated when the universe is presumed to start from a singularity.

To keep track of the expansion since the universe was $\underline{\boldsymbol{\tau}}_u = 1$, we will be referencing as our standard of comparison the properties of a Planck sphere when $\underline{\boldsymbol{\tau}}_u = 1$. For example, the proper radius of the Planck sphere was Planck length l_p at that time and $\Gamma_u = 1$. The calculated value of $\Gamma_{uo} \approx 2.1 \times 10^{31}$ says that the proper radius of the Planck sphere today has increased by a factor of about 2.1×10^{31} times. Therefore, the proper volume of the Planck sphere has increased by a factor of about 10^{94} times (2.1×10^{31} cubed).

Γ_{uo} Calculation from Planck Temperature: One advantage of the proposed spacetime transformation model of the universe is that it describes the starting condition of the universe

[4] Five-Year Wilkinson Microwave Anisotropy Probe ∗ Observations: Cosmological Interpretation, E. Komatsu1 et.al. The Astrophysical Journal Supplement Series, 180:330–376, 2009 February

in a way that we can make both predictions and plausibility calculations that check the model. The current characteristics of the universe have been experimentally measured. It is only the physical interpretation of these measurements that is being called into question. We can do simple calculations extrapolating from the proposed starting conditions to see if the model is reasonable. The first of these plausibility calculations determines the value of Γ_{uo} by comparing the temperature of Planck spacetime to the current temperature of the CMB. The ratio of these two temperatures should be equal to Γ_{uo}. The reasoning is that the temperature of the universe changed inversely with the scaling factor which means that the change in temperature also scaled inversely with the change in Γ_u. To express this relationship we will use the following new symbols

$\mathbb{T}_{ps}$ = temperature of Planck spacetime: $\mathbb{T}_{ps} = ½\, E_p/k_B = 7.08 \times 10^{31}$ °K
$\mathbb{T}_{uo}$ = current temperature of the universe (CMB temperature) $\mathbb{T}_{uo} = 2.725$ °K
Γ_{uo} = current value of the background gravitational gamma of the universe

$\Gamma_{uo} = \dfrac{\mathbb{T}_{ps}}{\mathbb{T}_{uo}} = 7.08 \times 10^{31}$ °K/2.725 °K $\approx 2.6 \times 10^{31}$ Γ_{uo} from ratio of temperatures

This is a fantastic result. From the ratio of temperatures we obtain $\Gamma_{uo} \approx 2.6 \times 10^{31}$ compared to $\Gamma_{uo} \approx 2.1 \times 10^{31}$ from the redshift calculation. This supports the assumption that the starting condition for the Big Bang was Planck spacetime and not a singularity or any other energy density in excess of Planck energy density.

Γ_{uo} Calculation from Energy Density: There is another way that we can calculate the value of Γ_{uo} using the energy density of Planck spacetime and comparing this to the observable energy density of the universe today. The energy density of the universe today is commonly thought to be about 8.46×10^{-10} J/m^3 (equivalent to 9.4×10^{-27} kg/m^3). However, this is a calculated number based on the concept that the universe must maintain a critical density. Only about 27.9% of this energy density or 2.36×10^{-10} J/m^3 is "observable" mass/energy consisting of fermions and bosons (including dark matter). Dark matter is considered "observable" because the gravitational effects of dark matter are clearly observable. Only the observable 2.36×10^{-10} J/m^3 is traceable to Planck spacetime. The remaining approximately 72.1% of the "critical" energy density (8.46×10^{-10} J/m^3) is currently attributed to dark energy. Almost all this dark energy has supposedly been added to the universe since the universe was about 5 billion years old. It did not originate with Planck spacetime and therefore will be excluded from this calculation. Therefore, the current energy density of the universe that excludes dark energy is about 2.36×10^{-10} J/m^3. This will be called the "currently observable energy density of the universe" and designated with the symbol U_{obs}.

There is another way of calculating the value of Γ_{uo} using only U_{ps}, U_{obs} and z_{eq}. The reasoning is that the universe started with Planck spacetime with energy density of $U_{ps} \approx 5.53 \times 10^{112}$ J/m^3 and today the observable energy density is $U_{obs} \approx 2.36 \times 10^{-10}$ J/m^3. There are two reasons for this change in energy density. First, the volume of each Planck sphere increased by a factor of Γ_{uo}^3 because the radius of the Planck sphere increased by a factor of Γ_{uo}. Secondly, the cosmic redshift reduced the energy in the Planck sphere during the radiation dominated epoch. This epoch started with $\Gamma_u = 1$ and ended roughly at the radiation/matter equality with a background gamma designated as Γ_{eq}. We do not experimentally know the value of Γ_{eq}, but we do experimentally know the redshift that has occurred since the radiation/matter equality. As previously stated, this redshift value has been measured by WMAP and found to be $z_{eq} = 3253 \pm 88$. The value of Γ_{uo} is $\Gamma_{uo} = \Gamma_{eq} z_{eq}$ therefore $\Gamma_{eq} = \Gamma_{uo}/z_{eq}$. The initial energy density of Planck spacetime was reduced both because of expansion (a factor of Γ_{uo}^3) and because of cosmic redshift (a factor of Γ_{eq}). We can now calculate the value of Γ_{uo} using this knowledge.

$U_{ps}/U_{obs} = \Gamma_{uo}^3 \text{ x } \Gamma_{eq}$ set $\Gamma_{eq} = \Gamma_{uo}/z_{eq}$
$U_{ps}/U_{obs} = \Gamma_{uo}^4/z_{eq}$
$\Gamma_{uo} = (U_{ps} z_{eq}/U_{obs})^{1/4}$
set $U_{ps} = 5.53 \text{ x } 10^{112}$ J/m^3 $U_{obs} = 2.36 \text{ x } 10^{-10}$ J/m^3 $z_{eq} = 3253$
$\Gamma_{uo} = 2.95 \text{ x } 10^{31}$ Γ_{uo} calculated from U_{ps}, U_{obs} and z_{eq}

This is another successful plausibility calculation that supports the model that the universe started as Planck spacetime because this value of Γ_{uo} generally agrees with the previous two values of Γ_{uo}.

Calculation from Energy Density of the CMB: The CMB currently has energy density equal to the energy density of 2.725 °K black body radiation: $U_{CMB} \approx 4.2 \text{ x } 10^{-14}$ J/m^3. Through the entire lifetime of the universe, the energy density in radiation has scaled proportional to $1/a^4$. Therefore if we only track the energy density of radiation we have an extremely simplified model of the universe. This assumption ignores all the fermions and other bosons which have about 5,000 times greater energy density than the energy density of photons in the CMB. Therefore, this greatly simplified assumption represents a rough upper limit estimate of Γ_{uo}. We assume that the universe started as Planck spacetime with energy density of $U_{ps} \approx 5.53 \text{ x } 10^{112}$ J/m^3 and through expansion achieved the current energy density of just the U_{CMB}. The cosmological redshift plus increased volume resulted in a $1/a^4$ scaling of energy density.

$\Gamma_{uo} \approx (U_{ps}/U_{CMB})^{1/4} \approx (5.53 \text{ x } 10^{112}/4.2 \text{ x } 10^{-14})^{1/4} \approx 3.4 \text{ x } 10^{31}$

I find it surprising that this simplified estimate that includes only radiation achieves a relatively close value for Γ_{uo}. The reason is that the greatest expansion factor occurred when the universe was radiation dominated therefore most of the energy loss in fact scaled as $1/a^4$. This Γ_{uo} value would more closely approach the previous three values if we included the relativistic energy of particles in the early universe which are similar to radiation because they also exhibit a relativistic "redshift".

Calculation from Spin: There is one last calculation that I find amazing. It is based on the assumption that quantized spin should be approximately conserved. The term "quantized spin" is best defined with an example. Two gamma ray photons, each with ħ spin, can interact to form an electron and a positron. These two fermions each have spin of *½ ħ*. The concept of quantized spin ignores spin direction and makes no distinction between ħ spin and *½ ħ* spin. To determine the total number of quantized spin units we merely add together the number of bosons and fermions (*ħ* and *½ ħ* units of spin are treated the same).

We know the density of quantized spin units in Planck spacetime and we know the density of photons and fermions in the universe today (except for dark matter). The spacetime based model of the universe does not require the exchange of virtual particles to transmit forces so no quantized spin is allotted to virtual particles. However, the assumption that there is large scale preservation of quantized spin is questionable. For example, two photons can be absorbed and reemitted as a single photon. However, with black body radiation there is large scale preservation of the total number of photons because the numerous absorptions and reemissions average out. For this calculation to be accurate we will make the questionable assumption that quantized spin has a similar averaging. If the answer is reasonable, then this will support the accuracy of this assumption.

Planck spacetime had *ħ* spin in each Planck sphere with initial volume of $(4\pi/3)l_p^3$ = 1.77 x 10^{-104} m^3 or a quantized spin density of 5.65 x 10^{103} spin units/m^3. Today matter dominates the universe but the quantized spin units contained in observable matter is small compared to the quantized spin in the CMB. Ordinary matter is 4.6% of the "critical density" of the universe. Therefore the density of ordinary matter has a density of about 4.3 x 10^{-28} kg/m^3. This is equivalent to about ¼ hydrogen atom per cubic meter. Since a hydrogen atom has 3 quarks and one electron, ¼ hydrogen atom per cubic meter is equivalent to about 1 quantized spin unit per cubic meter.

Recall that the spacetime based model has no virtual photons, gravitons or gluons. If there really are gravitons, etc. then this calculation should be wrong by many orders of magnitude. The quantized spin in the photons of the CMB dominate baryonic matter because the 2.725°K blackbody CMB photon density is 4.2 x 10^8 photons/m^3 compared to about 1 fermion/m^3 for ordinary matter. The photon density of starlight is also considered insignificant because it has been estimated[6] that the density of starlight photons is less than 1% of the photon density of the CMB. We will also temporarily ignore the spin in neutrinos and dark matter. Therefore, with these exceptions the quantized spin of the CMB dominates the universe.

[6] Paul Davies, 1982 The Accidental Universe, Cambridge University Press ISBN 0-521-24212-6

If each Planck sphere contained one unit of quantized spin in Planck spacetime and if there was preservation of quantized spin, then we would expect that the expanded Planck sphere would still on average contain one unit of quantized spin. The best estimate of the current proper radius of this Planck sphere is: $l_p\Gamma_{uo} \approx l_p$ x 2.6 x $10^{31} \approx$ 4.2 x 10^{-4} m or a volume of about 3.1 x 10^{-10} m^3. This estimate uses the value of Γ_{uo} obtained from the ratio of temperatures ($\Gamma_{uo} \approx$ 2.6 x 10^{31}). This number represents the middle of the range of values and is obtained from the simplest calculation. Therefore, assuming spin preservation we would expect that the current density of quantized spin units would be 3.2 x $10^9/m^3$. It appears as if the CMB photon density of 4.2 x 10^8 photons/m^3 is low by a factor of about 7.6. However this is actually very good agreement considering that the volume has expanded by a factor of about 10^{94} from: $\Gamma_{uo}^3 = (2.6 \text{ x } 10^{31})^3 \approx 10^{94}$.

Dark Matter Calculation: Even though we should be satisfied with an agreement that is quite accurate considering that it covers a range of 10^{94}, we still have not accounted for neutrinos and dark matter. Suppose that we assume that statistically there is virtually prefect preservation of quantized spin. This assumption gives us the opportunity to estimate the energy of a dark matter particle (rotar). Using 4.2 x 10^8 photons/m^3 and an expanded Planck sphere volume of 3.1 x 10^{-10} m^3/sphere we have:

4.2 x 10^8 photons/m^3 x 3.1 x 10^{-10} m^3/sphere = 0.13 photons/sphere

Assuming spin preservation and $\Gamma_{uo} \approx$ 2.6 x 10^{31}, there should be 1 spin unit per sphere therefore we are missing 0.87 spin units/sphere. The average density of dark matter in the universe is about 2.2 x 10^{-27} kg/m^3 or an energy density of 1.9 x 10^{-10} J/m^3. The current volume of a Planck sphere is 3.1 x 10^{-10} m^3, therefore combining these we have:

1.9 x 10^{-10} J/m^3 x 3.1 x 10^{-10} m^3/spin unit x (1/0.87) = 6.8 x 10^{-20} J/spin unit

The implied energy per dark matter fundamental particle is 6.8 x 10^{-20} J $\approx$ 0.4 eV

Perhaps this is a coincidence, but out of the many orders of magnitude involved in this calculation, the answer of about 0.4 eV is in the energy range currently attributed to neutrinos and it is far removed from the $>10^{10}$ eV energy range assumed for the hypothetical WIMP dark matter particle model. Allowing for the speculative nature of this result, this surprising result warrants a new examination of dark matter candidates.

Can Neutrinos Be Dark Matter? Neutrinos have been discounted as possible explanations of dark matter because they are considered to be "hot dark matter" propagating at velocity in excess of 0.1c. They have such low rest mass that even at a temperature of about 1° K, they would have a velocity much greater than the escape velocity of a galaxy. Also, in the early universe a high density of ultra-relativistic neutrinos would excessively homogenize the CMB distribution. However, the leading candidate for dark matter (a WIMP) also has problems. For example, the hypothetical fundamental particle of a WIMP ($\sim 10^{10}$ to 10^{12} eV) must not exhibit any electromagnetic or strong interaction. Therefore these hypothetical particles would not experience collisions with baryonic matter except through the weak interaction which is highly improbable. Most important, the WIMPs cannot lose kinetic energy by EM radiation to form a stable gravitationally bound orbit.

Think about the required properties of a WIMP particle. It must have such a high probability of being formed that in the early universe energy that was destined to become a fermion had the highest probability of forming this particle. It should be very easy to form the dark matter WIMP once particle colliders reach the energy range where they are produced. Also, currently it appears as if fermions become less stable the higher energy they have. However, the hypothetical WIMP particle would have to break this trend and form a completely stable fundamental particle at energy in the range of 10^{10} to 10^{12} eV.

Now look at the ease with which neutrinos are produced. They are the lowest energy fermion known and they are known to have long term stability. Also, the low mass/energy of neutrinos more easily forms a mass distribution around a galaxy that is characteristic of the dark matter spherical "halo" provided that they can somehow fit the definition of cold dark matter. However, a plausible method for them to lose kinetic energy and cool much below 1 °K must be suggested. The point is that we have much to learn about neutrinos.

Neutrinos have the advantage that they are known to exist and they are known to be produced in large numbers in the early universe. Using the known properties of neutrinos, the density of neutrinos has been estimated[7] at about $^3/_{11}$ of the CMB photon density per species. Therefore the 3 species of neutrinos would have a total density of about 82% of the photon density ($\sim 3.4 \times 10^8/\text{m}^3$ for 3 species). This is not quite the density required to satisfy the missing quantized spin (requires $\sim 2.8 \times 10^9/\text{m}^3$), but it is within an order of magnitude. Is there a single property of the rotar model of neutrinos that would result in neutrinos acquiring a temperature roughly in the range of 0.01 °K? Neutrinos have such a small mass that this extremely cold temperature would be required for neutrinos to not greatly exceed the escape velocity of galaxies. At this temperature range neutrinos would meet the requirements to be considered "cold dark matter" particles.

A rotar model of a neutrino with internal energy of 5×10^{-20} J (about 0.3 eV) would have a quantum radius of $R_q = \hbar c/E_i \approx 6.3 \times 10^{-7}$ m or a quantum volume of about 10^{-18} m^3. The energy density of a 0.3 eV rotar would be about 10^{24} times smaller than the energy density of an electron. The enormous difference in energy density of neutrinos compared to any other fundamental particle suggests the possibility that perhaps neutrinos also possess other characteristics not observed with other fundamental particles.

[7] J Rich; Fundamentals of Cosmology (second edition 2009); Springer, Heidelberg, New York

Neutrino flavor oscillation has been well documented experimentally. However, it is difficult to explain how neutrinos can change their rest mass if they are visualized as propagating through an empty vacuum. The usual explanation invokes the neutrinos existing simultaneously in three states that differ slightly in energy. These three states would have three slightly different de Broglie frequencies when they are moving relative to an observer. The three frequencies can then constructively and destructively interfere with each other producing what is a change in neutrino flavor (mass). However, this explanation has problems if a triplet neutrino model is visualized as being observed from a stationary frame of reference. Then the three states all have the same de Broglie frequency (zero de Broglie frequency). From a stationary frame, a change in neutrino mass/energy without any other interaction would seem to be impossible.

However, now imagine that the dark matter cloud that surrounds galaxies is made up of neutrinos at a temperature in the 0.01 °K range. This extremely cold temperature is required to give the neutrinos the correct speed which is in the range of a few hundred kilometers per second. The speed range must be generally less than the escape velocity of the galaxy yet high enough speed to achieve the diffuse mass distribution of the dark matter cloud. A small percentage of neutrinos can exceed the escape velocity because they will be replaced by neutrinos captured from the background neutrinos that are distributed between galaxies. The maximum density of dark matter in galaxies is about 3×10^{-20} kg/m^3. If this density was caused by 0.4 eV neutrinos, then the maximum neutrino density near the center of galaxies would be about 4×10^{16} neutrinos/m^3.

Now we come to the key speculative point. Does the neutrino mass oscillation generate the emission of a wave in spacetime? Such an emission would have the effect of cooling the neutrino relative to the CMB. This wave would most likely be a dipole wave in spacetime, but it could also be a transverse wave similar to a gravitational wave. The following explanation will focus on dipole waves. Recall that general relativity forbids the generation of dipole waves on a macroscopic scale because they require a violation of the conservation of momentum. However, violations of the conservation of momentum are permitted by quantum mechanics provided that the violations are undetectable according to the uncertainty principle. This means that dipole waves in spacetime can be generated provided that the displacement amplitude is less than the Planck length/time limitation. The proposal is that relativistic neutrinos can interact with either real neutrinos or perhaps virtual neutrino pairs to produce neutrino flavor (mass) oscillations. Each mass oscillation would be accompanied by the emission of a dipole wave in spacetime that removes a small amount of kinetic energy and slightly cools the propagating neutrinos. This would be a loss mechanism that allows neutrinos to cool much more than the CMB photons. The dipole waves in spacetime that form vacuum fluctuations are at a temperature of absolute zero. Therefore if such a loss mechanism exists, there is nothing preventing the neutrinos from reaching a temperature of 0.01 °K or below. This would even permit neutrinos to form into cold dark matter clouds in the early universe.

This density variation could then provide the gravitational field that serves as the first step in the formation of a galaxy.

Summary of the Γ_{uo} Calculations: We took a deviation in the discussion of dark matter. However, now we will return to the earlier discussion of the Γ_{uo} calculation. We have now calculated the value of Γ_{uo} several different ways and they all give about the same answer. The closeness of the results obtained with very different approaches supports the model being used. We will use the value $\Gamma_{uo} \approx 2.6 \times 10^{31}$ as representative of the range of values calculated here for future calculations. Using this value, today each Planck sphere has expanded to a proper radius of $l_p \times \Gamma_{uo} \approx 0.42$ mm. However, measured in coordinate units which presume $\Gamma_u = 1$, the Planck sphere still has a radius of $\mathbb{R} = 1$. It also appears to still have on average 1 unit of quantized spin. The analysis of the spin per Planck sphere will be made in the next chapter.

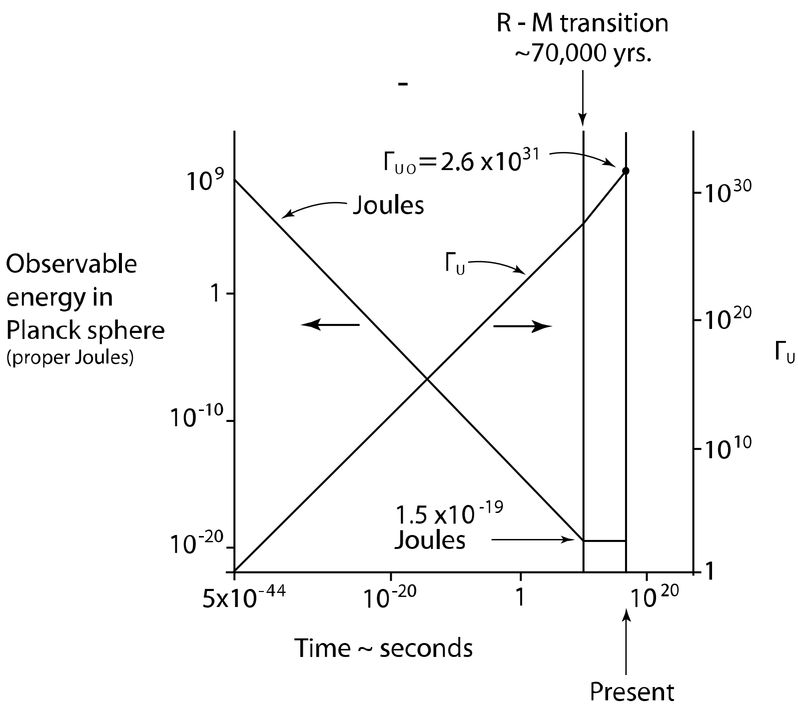

FIGURE 13-4 Left Scale: Plot of the observable energy in the Planck sphere over the age of the universe. Right Scale: Plot of the background gravitational gamma of the universe Γ_U over the age of the universe.

Graph Showing the Evolution of Γ_u and Observable Energy: Figure 13-4 shows two superimposed graphs that use the same time line but different Y axis scales. Note first that the X axis is a log scale of the age of the universe in seconds. The time scale extends from 5×10^{-44} s which is 1 unit of Planck time to 10^{20} seconds which is an age of about 3 trillion years. The present age of the universe is about 4.3 x 10^{17} seconds (~ 13.7 x 10^9 years) and is designated with an arrow and a vertical dashed line.

The graph line designated Γ_u is the value of the background gravitational gamma of the universe (Γ_u). This graph uses the right scale which is a log scale extending from $\Gamma_u = 1$ to about $\Gamma_u \approx 10^{32}$. It can be seen from this graph that $\Gamma_u = 1$ at a time of $\tau_u = 5 \times 10^{-44}$ seconds and ends with $\Gamma_u \approx 2.6 \times 10^{31}$ at the present ($\tau_u \approx 4.3 \times 10^{17}$ s). Note that there is a slight change in the slope of this line as it crosses the vertical line designated R-M transition. This is the transition between a radiation dominated universe and a matter dominated universe that occurred about 70,000 years after the beginning of the universe (the Big Bang). There should also be another slope change at the transition between the matter dominated epoch and the dark energy dominated epoch. However, this slope change is so small that it does not show up on this log-log graph.

The other graph (designated "Joules") uses the left scale and is the observable energy in the Planck sphere (also a log scale). A sphere Planck length (l_p) in radius started with about 1 billion Joules when the universe was Planck spacetime for the first unit of Planck time. Over the age of the universe as Γ_u increased, the proper radius of this sphere increased and equaled $\Gamma_u l_p$. The proper energy of this imaginary Planck sphere decreased during the radiation dominated epoch by a factor of 6.4 x 10^{27} from about 10^9 J to about 1.5 x 10^{-19} J and then the proper energy generally has remained constant since the end of the radiation dominated epoch. Therefore, note the flat line from an age of about 70,000 years to the present. However, the energy on an absolute scale where $\Gamma_u = 1$ continues to decrease as Γ_u increases. For example, the decreasing rate of time makes it appear that the Compton frequency of fundamental particles is constant. However, if we timed the Compton frequency of an electron using the $\Gamma=1$ clock, we would find that on this absolute time scale, even the Compton frequency of an electron would be slowing down each second. It is not noticeable because our cosmic clock is slowing down at the same rate.

Chapter 14

Cosmology II – Spacetime Transformation Model

Alternative Model to the Big Bang: The Big Bang theory is one of only a few theories in science that enjoys virtually universal acceptance. Before about 1929 the "Steady State theory" was favored but since then there have been numerous experimental observations that support the Big Bang theory and disprove the Steady State theory. I am going to propose an alternative to the standard Big Bang model. This might be considered by some as the equivalent of scientific heresy. However, we will faithfully follow our starting assumption (the universe is only spacetime) to its logical conclusion.

As an introduction to the cosmological implications of our starting assumption, we will use a line out of the children's story of Alice in Wonderland. In this story Alice asks the question: "Is the room getting bigger or am I getting smaller?" Scientists do not ask the equivalent question about the universe. They always assume that the universe is getting bigger while their meter sticks and clocks stay the same. The proper speed of light is constant, so this is extrapolated to the assumption that the properties of spacetime are constant.

Before Copernicus, it was assumed that the earth was the center of the universe. Now we know that we do not live in a special place in the universe, but we at least assume that both our size and our rate of time are constant. I am proposing that the final indignity to mankind is that spacetime is going through a transformation that contracts all physical objects, including the earth and our bodies. Furthermore, the rate of time is also slowing down. The universe started with $\Gamma_u = 1$ and since then Γ_u has been increasing so that currently $\Gamma_u \approx 2.6 \times 10^{31}$. This has resulted in the rate of time slowing and the proper volume increasing. In fact, it can be said that the rate of time is being exchanged for proper volume.

Planck spacetime started with the fastest possible rate of time and the smallest possible proper volume for the universe. Since the universe was Planck spacetime (the start of the Big Bang), the rate of time in the universe has decreased, the hybrid speed of light has decreased and proper length has contracted relative to coordinate length. This has resulted in the proper volume of the universe increasing and the average temperature of the universe decreasing. We do not notice the changes in the rate of time, the hybrid speed of light or proper length compared to coordinate length because everything combines in a way that keeps the laws of physics unchanged.

In chapter 3 we determined the changes in energy, force, voltage, etc. that are required to keep the laws of physics constant in different gravitational potentials where there is a difference in the rate of time. The "normalized" coordinate system of chapter 3 used the equation $L_o = L_g$.

This does not imply that L_o and L_g are constant over time. It is now proposed that both of these units of length are simultaneously contracting as the universe ages. This simultaneous contraction maintains $L_o = L_g$ in the CMB rest frame according to a midpoint observer.

Now we are attempting to understand the evolution of the universe. To do this I propose that it is most convenient to use a coordinate system based on the properties of Planck spacetime when $\Gamma_u = 1$. Even though the universe has always had flat spacetime, there has been a continuous increase in Γ_u since the Big Bang. As previously explained, the current value of Γ_u is about $\Gamma_{uo} \approx 2.6 \times 10^{31}$ and this number continues to increase. This affects many things including our rate of time, our length standard and our energy standard. The best reference we have to quantify these changes is to use a coordinate system based on the conditions that existed when $\Gamma_u = 1$. Another way of saying this is that we should reference the conditions that existed at the start of the Big Bang when we had Planck spacetime.

Relative to the spatial and temporal coordinate system that existed at the Big Bang when $\Gamma_u = 1$, there has been a decrease in the rate of time and a decrease in a standardized unit of length such as one meter. As will be explained, this combination keeps the laws of physics unchanged. This has some similarities to the gravitational effects previously discussed in chapter 3. However, with the universe the background gravitational gamma (Γ_u) is continuously increasing. One of the few indications that anything is changing in the universe is that light that was emitted a long time ago from distant sources has undergone obvious changes in wavelength and intensity.

Spacetime Transformation Model: A model of the universe based on a continuously increasing Γ_u represents an alternative to the Big Bang model. This alternative model will be called the "spacetime transformation model" until a better name can be found. What we perceive as an increase in the scale of the universe is actually due to an increase in the background Γ_u of the universe changing the spatial and temporal dimensions of spacetime. This is a change in the properties of spacetime that has an effect on everything in the universe. The radius of an atom or the quantum radius of a rotar would decrease relative to coordinate length $\mathbb{R}$. An increase of Γ_u results in the following: 1) the hybrid speed of light of the universe decreases; 2) proper length contracts relative to coordinate length; 3) the rate of proper time decreases relative to the rate of coordinate time; 4) the total energy density of the universe remains the same (total energy includes vacuum energy).

Perhaps most surprising of these is that the spacetime transformation model says that the coordinate energy density of the universe has remained constant since the beginning of the universe (since the Big Bang). The coordinate energy density utilizes coordinate length $\mathbb{R}$ and coordinate rate of time dt to quantify coordinate energy density. The observable energy density of the universe (measured in proper units of energy) has decreased by a factor of roughly 10^{120} since the beginning of time (since the Big Bang). However, including the waves in spacetime responsible for vacuum energy, it will be shown that the spacetime transformation model of the universe sees no change in the coordinate energy density of the universe. This also eliminates the famous 10^{120} discrepancy between the "critical" energy density of the universe derived from general relativity and supported by observation compared to the calculated energy density of the universe derived from quantum mechanics and quantum chromodynamics.

This spacetime transformation model might seem like an unnecessary contrarian view that is fundamentally equivalent to depicting the universe as expanding. However, it will be shown that this model is not equivalent to the Big Bang model. This proposed model gives the same redshift and the same increase in proper volume as the Big Bang model, but the spacetime transformation model offers different predictions about the future of the universe. Probably the most controversial difference is that the spacetime transformation model purports to eliminate the need for dark energy and a cosmological constant.

Observable Universe from Planck Spacetime: As previously stated in chapter 13, Planck spacetime had spherical Planck energy density. Most importantly, Planck spacetime had $\Gamma_u = 1$ and all the dipole waves in spacetime had ½ Planck energy (about 10^9 J) and $\hbar$ angular momentum. This means that 100% of the energy in Planck spacetime was "observable" (had quantized spin). The value of $\Gamma_u = 1$ also means that the rate of time was the highest possible and the proper volume of the universe was the smallest possible. $\Gamma_u = 1$ also implies that a unit of energy such as one Joule was the highest possible value when measured on the absolute energy scale which uses coordinate rate of time and coordinate length. In comparison, it will be shown that one Joule today is a vastly lower energy on the absolute energy scale because today $\Gamma_{uo} \approx 2.6 \times 10^{31}$. Also, the transformation of spacetime that has taken place since the Big Bang has resulted in a decrease in the percentage of the energy in the universe that possesses quantized angular momentum. Today, only about 1 part in 10^{122} of the energy in the universe is "observable" (possesses quantized angular momentum)

All the energy required to form our current universe (including vacuum energy) would be contained in a sphere of Planck spacetime about 15×10^{-6} meters (~ 15 microns) in radius. This radius is calculated by reducing the current distance to our particle horizon (~ 46 billion light years or 4×10^{26} m) by a factor of $\Gamma_{uo} = 2.6 \times 10^{31}$. Our current universe has $\Gamma_{uo} \approx 2.6 \times 10^{31}$ which greatly reduces both our current standard of energy and the fraction of the energy in the universe that is "observable energy"

It is presumed that the universe currently extends far beyond our current particle horizon. This means that the original volume of Planck spacetime was far bigger than the 15 micron radius spherical volume required to form everything (including vacuum energy) within our current particle horizon. This original volume of Planck spacetime might not have been infinite, but it is presumed to be effectively infinite because there is no detectable difference as far as a model of the universe is concerned. It is also presumed that there are galaxies, dark matter, etc. beyond our particle horizon that have a similar appearance and density to our observable universe.

The spacetime transformation model of the universe has a fixed (not expanding) coordinate system. For example, two distant galaxies are considered to be separated by a constant distance when measured in units of coordinate length $\mathbb{R}$. The coordinate grid used by the spacetime transformational model has similarities to the coordinate grid used by the Λ-CDM model. Both grids correspond to the CMB rest frame at all locations in the universe. However the difference is that the Λ-CDM model has a grid that expands with the proper volume of the universe and the spacetime transformation model has a grid that remains stationary. In the spacetime transformation model, the expansion in the proper volume of the universe is accommodated by the change in Γ_u over the age of the universe.

Hubble Parameter and Shrinking Meter Sticks: Today, astronomers do not realize that their meter sticks are contracting due to changes in spacetime. The term "meter stick" represents any means of length measurement. Astrophysicists calculate that the distance to distant galaxies is increasing. However, this distance is measured using contracting meter sticks (contracting units of length). The distant galaxies that are stationary on the static coordinate system appear to be receding at a velocity given by the Hubble parameter.

In astronomical terminology, the Hubble parameter is often expressed as about $\mathcal{H} \approx 70.8$ km/s/Mpc where Mpc is a unit of length used in astronomy equal to about 3.09×10^{22} meters. Converting the Hubble parameter to SI units we have $\mathcal{H} \approx 2.29 \times 10^{-18}$ m/s/m. The seconds used here are today's proper seconds. The common interpretation of the Hubble parameter is that this is the current expansion rate of the universe. The spacetime transformation model interprets the Hubble parameter differently:

$$\mathcal{H} = \frac{\frac{da_u}{d\tau_u}}{a_{uo}} = \frac{\frac{d\Gamma_u}{d\tau_u}}{\Gamma_{uo}} \quad \text{or} \quad \mathcal{H} = \frac{\dot{a_u}}{a_{uo}} = \frac{\dot{\Gamma_u}}{\Gamma_{uo}} \qquad \text{note the dots representing time derivative}$$

The dots are shorthand for time derivatives. Therefore, the Hubble parameter $\mathcal{H}$ equals the rate of change of Γ_u divided by the current background value Γ_{uo}. Also a_{uo} is the current scaling factor of the universe which is equal to Γ_{uo}.

A meter stick (1 meter long) is contracting at a velocity of about 2.29×10^{-18} meters/second when compared to a hypothetical meter stick that is not contracting (a meter stick with fixed coordinate length in units of $\mathbb{R}$). As explained in chapter 13, the Hubble sphere is a 13.7×10^9 light year (1.3×10^{26} m) radius imaginary spherical shell where galaxies and space itself are calculated to be receding away from us at about the speed of light. However, it is proposed that we are using a contracting unit of length, such as a contracting meter stick, as reference for this calculation. The proper distance between us and a galaxy at the edge of the Hubble sphere is indeed increasing by 3 x 10^8 m/s, but that is because we are measuring the distance using a contracting meter stick. Our meter stick is shrinking at the rate of 2.29 x 10^{-18} meters/second so we obtain an increase in proper distance of 3 x 10^8 m/s (obtained from 2.29 x 10^{-18} m/s/m x 1.3 x 10^{26} meters). This is not the same as saying that the galaxy is physically receding from us at the speed of light. The spacetime transformation model says that the calculated speed is erroneous because it is obtained when we measure a fixed distance using shrinking meter sticks.

The reasonable explanation is that spacetime is undergoing a transformation that changes the coordinate speed of light while keeping the laws of physics unchanged (including a constant proper speed of light). This is similar to the covariance of the laws of physics in different gravitational potentials as discussed in chapter 3. However, with the universe Γ_u increases with time but the laws of physics remain unchanged. One observable effect is that it takes longer for light to travel between galaxies as the universe ages. Since we measure no change in the proper speed of light we interpret this as indicating an expansion. However, the alternative explanation proposed here is that the change occurring in the properties of spacetime produces a dimensional contraction. In chapter 3 we saw how the rate of time can change at different elevations of a gravitational field without being detectable locally. Gravity also was shown to affect proper volume which implies a difference in the unit of length. The universe is also producing an omnidirectional gravitational effect that is continuously increasing. One result of this is what we perceive to be the cosmological increase in the volume of the universe.

It was shown in chapter 3 that gravity affects many of the units of physics in a way that keeps the laws of physics unchanged. It is proposed that something similar is happening with the entire universe except that there is an important difference. With the universe at any instant the value of Γ_u is uniformly increasing everywhere. This is the opposite of the gravity assumed in chapter 3 which was static and had a gravitational gradient. The continuous increase in Γ_u causes changes in various units of physics (energy, force, voltage. etc.) which together preserve the laws of physics. Only when we look at distant galaxies do we obtain a hint that change over time is occurring.

No Event Horizon: The Λ-CDM model considers the accelerating expansion of the universe to have an event horizon. According to the Λ-CDM model, galaxies that we observe as having a redshift greater than $Z = 1.8$ are currently beyond our event horizon. Light that is currently being emitted by these galaxies will supposedly never reach us because cosmic expansion of space is adding volume at such a fast rate that the distance increase exceeds the speed of light. Even the expansion of our Hubble sphere cannot overcome the accelerating expansion of the universe. Photons being emitted now by galaxies with $Z > 1.8$ will be swept away from us by the accelerating expansion of the universe. The only reason that we can see those galaxies today is that we are seeing the light emitted from a long time ago before they crossed our event horizon.

The spacetime transformation model of the universe makes a prediction that is different than the Λ-CDM model. The proper distance between us and the $Z > 1.8$ galaxies is indeed increasing faster than the speed of light. However, this is because of the current rate of increase in Γ_u is causing our meter sticks to shrink. The galaxies are actually stationary on the proposed coordinate grid. The prediction is that light currently being emitted from those galaxies will eventually reach us but at a slower hybrid speed of light than today. Even though the universe appears to have accelerating expansion, the spacetime transformation model says that there is no event horizon at a distance corresponding to $Z = 1.8$ or at any other distance in the foreseeable future.

We can obtain a better insight into the properties of the hybrid speed of light with a numerical example. Since $\boldsymbol{C} \equiv d\mathbb{R}/d\tau_u = c/\Gamma_u$, therefore the current value of the hybrid speed of light is:

$$\boldsymbol{C} = c/\Gamma_{uo} = {}^{c}/_{2.6 \text{ x } 10^{31}} \approx 10^{-23}\ m/\text{s}$$

This is the current hybrid speed of light where the units m/s are coordinate meters ($\mathbb{R}$) divided by proper comoving seconds (note use of italic in coordinate units). The hybrid speed of light is decelerating every second at a current rate of:

$$\boldsymbol{C}\mathcal{H} \approx 10^{-23}\ m/\text{s x } 2.3 \text{ x } 10^{-18}\ \text{s}^{-1} \approx 2.3 \text{ x } 10^{-41}\ m/\text{s}^2 \qquad \text{deceleration of } \boldsymbol{C}$$

Finally, the current rate of time ($d\tau_{uo}$) is about 2.6 x 10^{31} times slower than the coordinate rate of time (dt) which assumes $\Gamma_u = 1$.

Constant Coordinate Energy Density: The energy density of this 15 x 10^{-6} m spherical volume is equal to spherical Planck energy density: $U_{ps} \approx 5.5 \text{ x } 10^{112}$ J/m^3. At the beginning of time (the Big Bang) this energy was in the form of dipole waves in spacetime with the unique properties of Planck spacetime previously enumerated. Today the characteristics of the dipole waves in spacetime that form both vacuum energy and the observable mass/energy in our universe have changed their characteristics compared to Planck spacetime. Almost all the energy in the universe today is in the form of vacuum energy – dipole waves in spacetime that do not possess angular momentum. Only an extremely small part is in the form of observable energy that possesses angular momentum. However, it will be shown that not only the proper energy density (including vacuum energy) but also the coordinate energy density of the universe today is still the same as Planck spacetime. There have been changes relating to the distribution of quantized angular momentum, the rate of time, proper length, etc. but the total energy density has not changed even when measured using coordinate energy density that assumes $\Gamma_u = 1$. Therefore, it is possible to adopt a coordinate system based on these coordinate values that does not expand over time. This is the stationary coordinate system of the spacetime transformation model.

It might seem that the Big Bang model is ultimately equivalent to the spacetime transformation model with its stationary coordinate system. However, this is not a case of simple coordinate transformation. For example, the two models make different predictions about the existence of an event horizon as previously noted. Also, the Big Bang model cannot accommodate the fact that new volume being added to the universe must also possess the vacuum energy with energy density exceeding 10^{112} J/m^3. Where did this additional energy come from? The spacetime transformation model can accommodate this requirement as will be explained later in this chapter.

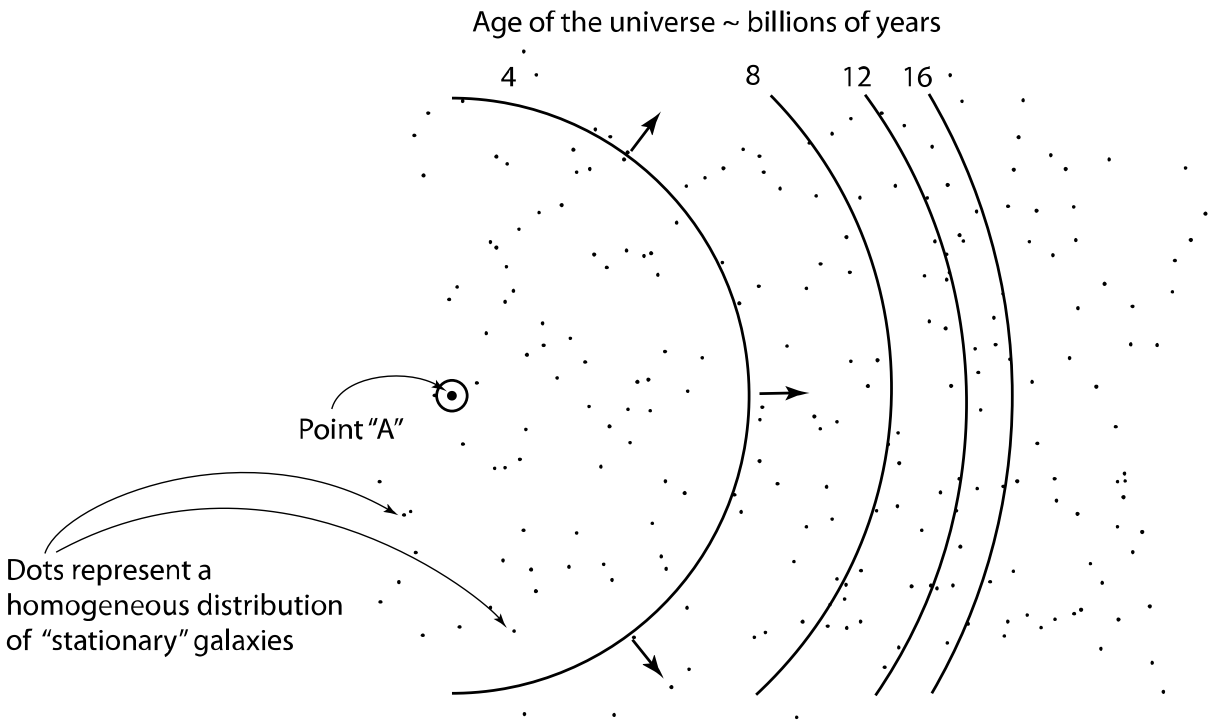

FIGURE 14-1 This Figure is drawn assuming the dimensional contraction model which uses coordinate length and assumes a homogeneous distribution of stationary mass (galaxies). The gravitational influence of energy at a point spreads at the coordinate speed of light which is decreasing with time as Γ_u increases.

Illustration of Slowing Hybrid Speed of Light: Figure 14-1 illustrates the concept of a stationary coordinate system with a slowing hybrid speed of light. This figure uses coordinate length, therefore the distance in coordinate length units between Point A and the furthest curved surface (16 billion years) is roughly 10^{-5} *m*. Point "A" can be imagined as initially a Planck sphere within Planck spacetime at the beginning of time. This sphere contained about a billion Joules, so when time began to progress the gravitational influence of this energy began to propagate away from point A at the proper speed of light c. However, the rate of propagation as measured using the hybrid speed of light decreases as Γ_u increases. After 4 billion years the gravitational influence had reached the propagating particle horizon designated 4 billion years. (The term "propagating particle horizon" is used here to designate the expanding sphere of influence of a point of mass/energy) Similarly, the propagating particle horizons for 8, 12 and 16 billion years are shown.

The purpose of this figure is to illustrate the slowing rate of propagation as indicated by the decreasing distance separating the curved surfaces as time progresses and Γ_u increases. There is no tendency for this progression to be swept backwards by cosmic expansion. The rate of progress will continue to decrease, but there is no event horizon where the progress is stopped. It is speculation whether Γ_u ever reaches such a large value that a quantum mechanical transition occurs. The spacetime transformation model of the universe predicts that for the foreseeable future, we will continue to see new, more distant galaxies appear in the sky. The galaxies that we currently see will get dimmer (less photons per second per m^2) but also paradoxically be less redshifted than today.

Redshift: The spacetime transformation model is also the best model to see why an increasing background Γ_u produces a redshift on the light that we see from a distant galaxy. The presence of a redshift in cosmology is counter intuitive when it is realized that the spacetime transformation model claims that the rate of time was faster when the light was emitted $(d\tau_{em})$ than when the light is observed ($\Gamma_{em} < \Gamma_{obs}$ and $d\tau_{obs} < d\tau_{em}$). For example, Schwarzschild assumed a single stationary mass in an empty universe. This assumption presumed a "mature gravity" condition (no time dependence). Under these conditions, light propagating from a location far from the mass (small gravitational Γ) to a location near the mass (large gravitational Γ), undergoes a "gravitational blue shift". This was previously discussed and shown that a distant observer using a single rate of time perceives no change in the energy of the photon. The locally observed apparent increase in energy is due to the slow rate of time in gravity (large Γ).

When the background Γ_u of the universe increases uniformly everywhere, this is completely different than a photon propagating from a location with a small value of Γ to a location with a larger value of Γ. It will be shown below that an increase in the background Γ_u of the universe produces a redshift which includes an increase in proper wavelength and a decrease in proper frequency and a decrease in proper energy.

Coordinate Wavelength Constant: When the background Γ_u of the universe is increasing homogeneously throughout the universe, this means that the hybrid speed of light is decreasing homogeneously as: $\boldsymbol{C} = c/\Gamma_u$. Light in flight just slows down homogeneously everywhere. This homogeneous slowing maintains the same coordinate wavelength for a light wave. The entire wave just slows down without changing its size when measured using coordinate length. If the light in flight is constant wavelength when measured in units of coordinate length, what result will we obtain when we measure the wavelength in units of proper length using a contracting meter stick? We will obtain the result that the light is increasing its wavelength relative to the contracting meter stick. In other words, we would see a redshift (an increase in wavelength).

Redshift – Wavelength Analysis: To analyze this we will assume that light is emitted in location #1 at an age of the universe t_1 and a background gravitational gamma Γ_1. The emission is at coordinate wavelength $\boldsymbol{\lambda}$ which can be converted to proper wavelength λ_1 at the time of emission. At a later time (age of the universe t_2 and background gamma Γ_2) the coordinate wavelength is still the same $\boldsymbol{\lambda}$ but the proper wavelength is λ_2 relative to the contracted meter stick. All we have to do is compare λ_1 to λ_2 which means that we need to convert $\boldsymbol{\lambda}$ which is always in units of coordinate length $\mathbb{R}$ into wavelength λ expressed in proper length at two different times. The coordinate wavelength $\boldsymbol{\lambda}$ does not change; it only slows down due to a change in the hybrid speed of light $\boldsymbol{C}$ when Γ_u increases ($\boldsymbol{C} = c/\Gamma_u$). Therefore we must convert between coordinate length and proper length at two different values of background gamma: Γ_1 and Γ_2. From chapter 13 we know that the conversion of units of coordinate length $\mathbb{R}$ to units of proper length is $L = \Gamma_u \mathbb{R}$. When we express this conversion in terms of wavelength symbols we have $\lambda = \Gamma_u \boldsymbol{\lambda}$. This says that a given wave appears to have a bigger wavelength (more units of proper length) when it is measured with the contracted meter stick used for proper length than when it is measured with the coordinate scale meter stick that is not contracted. Since $\boldsymbol{\lambda}$ is independent of the background Γ_u we have:

$\boldsymbol{\lambda}$ = wavelength of light when measured in units of coordinate length.
λ_1 and λ_2 = wavelength of light (proper wavelength) at time $\underline{t}_1$ and $\underline{t}_2$ where $\underline{t}_2 > \underline{t}_1$
Γ_1 and Γ_2 = background Γ_u of the universe at time $\underline{t}_1$ and $\underline{t}_2$ where $\underline{t}_2 > \underline{t}_1$
a_{em} = cosmological scale factor at emission (a_{em}) at time = $\underline{t}_1$
a_{obs} = cosmological scale factor at observation (a_{obs}) at time = $\underline{t}_2$

$\boldsymbol{\lambda} = \frac{\lambda_1}{\Gamma_1}$ and $\boldsymbol{\lambda} = \frac{\lambda_2}{\Gamma_2}$ conversion of $\boldsymbol{\lambda}$ to λ_1 and λ_2

$\frac{\lambda_2}{\lambda_1} = \frac{\Gamma_2}{\Gamma_1}$ since $\Gamma_2 > \Gamma_1$ therefore $\lambda_2 > \lambda_1$ (wavelengths in units of proper length)

Since Γ_u is increasing with time, therefore $\Gamma_2 > \Gamma_1$ and $\lambda_2 > \lambda_1$. This all says that λ_2 is redshifted (longer wavelength) compared to λ_1. The amount of the redshift is: $\lambda_2/\lambda_1 = \Gamma_2/\Gamma_1$ which can also be expressed in terms of the ratio cosmological scaling factors at emission ($a_{em} = a_1$) and observation ($a_{obs} = a_2$) or in terms of redshift $1 + Z$.

$$\frac{\lambda_2}{\lambda_1} = \frac{\Gamma_2}{\Gamma_1} = \frac{a_2}{a_1} = \frac{a_{obs}}{a_{em}} = 1 + Z$$

Since λ_1 is the proper wavelength at emission (time t_1) and λ_2 is the proper wavelength at observation (time t_2), therefore the relationship can be written as:

$$\frac{\lambda_{obs}}{\lambda_{em}} = \frac{a_{obs}}{a_{em}} = 1 + Z$$

This answer, obtained from the spacetime transformation model agrees with the answer obtained from the Big Bang model that assumes cosmic expansion of the universe.

Redshift – Frequency Analysis: Therefore, it has been shown that looking just at wavelength there is the correct redshift when we presume that the redshift is caused by a change in the background Γ_u rather than an expansion of the universe. It is possible to work this same problem looking at the frequency of the radiation rather than at the wavelength. In this case we would expect a lower frequency at a later time when we express frequency relative to proper time.

We will start off by working this problem using coordinate values. As before, there is no change in wavelength expressed in terms of coordinate length between the emission and observation. The new symbols are:

$\boldsymbol{C}_1$ and $\boldsymbol{C}_2$ = hybrid velocity of light at times t_1 and t_2 respectively
$\boldsymbol{\Lambda}$ = wavelength expressed in units of coordinate length – this does not change at t_1 and t_2
υ_1 and υ_2 = proper frequency of light at times t_1 and t_2 respectively
proper frequency has a redshift since $\upsilon_1 > \upsilon_2$ and $\Gamma_{u2} > \Gamma_{u1}$

Since υ_1 can be considered the frequency when the light was emitted ($\upsilon_1 = \upsilon_{em}$) and υ_2 can be considered the frequency when the light was observed ($\upsilon_2 = \upsilon_{obs}$), therefore the following is another way of stating these results:

$$\frac{\upsilon_{obs}}{\upsilon_{em}} = \frac{a_{em}}{a_{obs}} = \frac{1}{Z+1}$$

Therefore the spacetime transformation model gives the same redshift (proper wavelength and proper frequency) as the Big Bang model. However, this analysis leaves one question unanswered. If the rate of time was faster in the past than it is today, why don't we observe a blue shift on light from distant galaxies? The answer to this question is not obvious in the previous analysis because that analysis used the "hybrid speed of light $\boldsymbol{C} = d\mathbb{R}/d\tau_u$. This definition incorporates the proper rate of time in the universe ($d\tau_u$) which hides the question about the blue shift. This question can only be answered if we compare proper values to coordinate values. This comparison requires that we rework the problem using coordinate rate of time (dt), coordinate speed of light ($\mathbb{C}$) and coordinate frequency (υ_c).

To begin, we will return to the example previously stated and examine light emitted at location #1 at an age of the universe t_{u1} which had a background gravitational gamma Γ_{u1}. This light is later observed at location 2 with the age of the universe t_{u2} and background gamma Γ_{u2}. Again, the wavelength of the light measured in units of coordinate length is $\boldsymbol{\lambda}$. This coordinate wavelength does not change; the light merely slows as the coordinate speed of light decreases. The coordinate speed of light at ages of the universe t_{u1} and t_{u2} will be designated as $\mathbb{C}_1$ and $\mathbb{C}_2$ respectively.

$$\mathbb{C}_1 = \frac{c}{\Gamma_{u1}^2} \quad \text{and} \quad \mathbb{C}_2 = \frac{c}{\Gamma_{u2}^2}$$

We will now state the frequency of this light using the rate of coordinate time dt as our standard. Recall that $dt = \Gamma_u d\tau_u$. Frequency obtained using the coordinate time standard will be designated ν_c. The particular coordinate frequency produced by wavelength $\boldsymbol{\lambda}$ will be designated ν_{1c} when the background gamma is Γ_{u1} and ν_{2c} when the background gamma is Γ_{u2}. Therefore:

$$\boldsymbol{\lambda} = \frac{\mathbb{C}_1}{\nu_{1c}} = \frac{\mathbb{C}_2}{\upsilon_{2c}} \qquad \text{set } \mathbb{C}_1 = \frac{c}{\Gamma_{u1}^2} \text{ and } \mathbb{C}_2 = \frac{c}{\Gamma_{u2}^2}$$

$$\frac{c}{\upsilon_{1c}\Gamma_{u1}^2} = \frac{c}{\upsilon_{2c}\Gamma_{u2}^2}$$

$$\frac{\upsilon_{2c}}{\upsilon_{1c}} = \left(\frac{\Gamma_{u1}}{\Gamma_{u2}}\right)^2 \qquad \text{ratio of coordinate frequencies}$$

This says that using coordinate frequency results in a redshift proportional to the square of the ratio of gammas. This means that the correction due to the slowing rate of time does not produce an observable blue shift, but instead this blue shift is used to reduce a coordinate redshift that is proportional to $(\Gamma_{u1}/\Gamma_{u2})^2$ to a proper redshift proportional to just $(\Gamma_{u1}/\Gamma_{u2})$. This is shown by making the substitution $\upsilon_{1c} = \frac{\upsilon_1}{\Gamma_{u1}}$ and $\upsilon_{2c} = \frac{\upsilon_2}{\Gamma_{u2}}$ to obtain the ratio of frequencies expressed in proper frequencies υ_1 and υ_2.

$$\frac{\upsilon_2}{\upsilon_1} = \frac{\Gamma_{u1}}{\Gamma_{u2}} \qquad \text{ratio of proper frequencies}$$

Rotar's Frequency: Since photons lose proper frequency as Γ_u increases, why does the proper Compton frequency of rotars remain constant? To put this question in perspective, we should first acknowledge that on the coordinate time scale that assumes $\Gamma_u = 1$ the Compton frequency of a rotar does decrease. Therefore, all fundamental rotars are continuously slowing down on an absolute time scale. We do not notice this slowing because our cosmic clock is also slowing. Therefore we are using a continuously slowing clock to time the frequency of a continuously slowing rotar such as an electron. This is a moving standard, but each second an electron is losing about 282 Hz if we measured the Compton frequency using the rate of time that existed in the previous second ($\omega_c\mathcal{H}/2\pi \approx$ 282 Hz/s).

Therefore, on an absolute time scale, why does a photon's frequency decrease proportional to $(\Gamma_{u1}/\Gamma_{u2})^2$ while a rotar's frequency scales with just $(\Gamma_{u1}/\Gamma_{u2})$? The answer is that the propagation rate of the rotar's dipole wave decreases proportional to $(\Gamma_{u1}/\Gamma_{u2})^2$ but this is partly offset by a decrease in the rotar's circumference (measured on the absolute scale of $\mathbb{R}$). The reduced circumference distance and reduced quantum radius (both measured on the absolute scale of $\mathbb{R}$) means that a dipole wave with quantized angular momentum propagates around the shortened circumference (measured in units of $\mathbb{R}$). The decrease in a rotar's circumference results in a rotar's frequency scaling with $(\Gamma_{u1}/\Gamma_{u2})$ which matches the rate of time decrease on an absolute scale. Therefore, the rotar's Compton frequency appears to be constant while the frequency of a photon decreases when measured using proper rate of time. The standard explanation of the cosmic redshift based on expansion of the universe is proposed to be wrong. Wavelengths are not being stretched. There are no point particles. Particles with finite dimensions are also affected by the transformation of spacetime. However the effects on particles are not noticeable because there are offsetting effects on the rate of time, on the standard of energy and on other units of physics.

Estimating the Vacuum Energy Density: In the last chapter we calculated the value of Γ_{uo} several different ways. One of these ways utilized the ratio of the energy density of Planck spacetime ($U_{ps} \approx 5.53 \times 10^{112}$ J/m^3) to the "observable" energy density of the universe today ($U_{obs} \approx 2.36 \times 10^{-10}$ J/m^3 – excludes dark energy). This ratio is: $U_{ps}/U_{obs} \approx 2.34 \times 10^{122}$. Now we want to attempt to determine the current energy density of vacuum energy (designated U_{vac}) This is one of the most perplexing problems in physics because quantum mechanics and quantum chromodynamics both require that the vacuum must have a tremendously large energy density. However, any energy density substantially in excess of the "critical" density of the universe appears to be forbidden by general relativity. The number most commonly quoted from quantum mechanics is derived from the concept that the vacuum has "zero point energy" and that all frequencies are present up to Planck angular frequency. This concept yields an energy density approximately equal to spherical Planck energy density of 5.53×10^{112} J/m^3.

Quantum chromodynamics requires interactions with vacuum energy. The minimum energy density required to accomplish known processes within hadrons is about $U_{vac}/U_{obs} \geq 10^{60}$. Other more inclusive estimates from quantum chromodynamics also approach 10^{120}. If all frequencies are currently present up to Planck frequency, then this presents another problem for the Big Bang model of the universe. The problem is that throughout the history of the expanding universe, the proper energy density of vacuum energy would have to remain constant at spherical Planck energy density $U_{vac} \approx 5 \times 10^{112}$ J/m^3. The expanding volume would appear to require a mechanism to continuously add a tremendous amount of new energy to the expanding universe. For example, the Hubble parameter of $\mathcal{H} \approx 2.3 \times 10^{-18}$ m/s/m indicates that each cubic meter in the universe is expanding and increasing its volume by ~ 10^{-53} m^3/s. If the vacuum energy density required to fill this additional volume is $U_{vac} \approx 10^{112}$ J/m^3, then the additional volume generated by EACH cubic meter in the universe requires additional 10^{59} Joules/second. To put this in perspective, the $E = mc^2$ total observable energy of the Milky Way galaxy is also about 10^{59} Joules. Therefore it would appear that each cubic meter of volume in the universe must be supplied with about 10^{59} Joules of energy each second.

Therefore, the problem of supplying the universe with dark energy each second is trivial compared to the problem of supplying the universe with new vacuum energy each second. This all seems to be impossible, so most physicists presume that there must be some mechanism that cancels out almost all the implied vacuum energy density in the universe. However, this hypothetical cancelation mechanism must be careful to leave the one part in 10^{122} that constitutes our observable universe. Also the effect capable of canceling 10^{112} J/m^3 must be equally as large.

Expansion of the Universe: Now we are ready to offer an alternative explanation for the expansion of the universe. We are comparing a volume of space at two different ages of the universe. More importantly, we are also acknowledging that the background gravitational field of the universe (Γ_u) is changing with time. All of this requires that we adopt a coordinate system that references flat spacetime at a particular age of the universe. If the universe started the Big Bang as Planck spacetime with $\Gamma_u = 1$, then the background gravitational gamma of the universe has been increasing ever since. This perspective gives the answer that a meter of proper length is continuously shrinking relative to a meter of the coordinate length present at the start of the universe when $\Gamma_u = 1$. Next we will calculate the transformation of the units of physics that are occurring in the universe as Γ_u increases.

New Transformations of Units: Recall that in chapter 3 we made a table of transformations of the units of physics showing the difference between a "zero gravity" location and a location with gravity. In chapter 3 we designated the "zero gravity" location as having $\Gamma = 1$. Now it is necessary to realize that this designation incorporated a simplification. We were ignoring any change in the background gravitational gamma of the universe Γ_u. Another way of saying this is that we defined a "zero gravity location" as having $\Gamma = 1$. Now that we are talking about the evolution of the universe it is necessary to be more precise. The length transformation was previously expressed as: $L_o = L_g$. However, to put this in the bigger perspective that incorporates Γ_u and $\mathbb{R}$, we can now say:

$L_o = L_g = \mathbb{R}/\Gamma_u$

This equation says that what we were previously calling L_o and L_g were both changing relative to our absolute length standard $\mathbb{R}$ that was present at the start of the universe when $\Gamma_u = 1$. When we are dealing with the universe and time scales where the effects of a changing background Γ_u are significant, then it is no longer possible to adopt proper length as the coordinate unit of length. A different coordinate length transformation is required to characterize the relationship between the units of physics when they are compared at the same location but at substantially different ages of the universe. The value of Γ_u increases with the age of the universe.

In chapter 3 we were able to obtain all the other transformations using dimensional analysis once we had the transformations for length, time and mass. Previously these three transformations were expressed as:

$L_o = L_g$	unit of length transformation
$T_o = T_g/\Gamma$	unit of time transformation
$M_o = M_g/\Gamma$	unit of mass transformation

In these transformations the symbols L_o, T_o and M_o represented coordinate (zero gravity) units of length, time and mass respectively. Now it is necessary to adopt new coordinate units to represent a unit of coordinate length, coordinate time and coordinate mass at the start of the Big Bang when the universe was one unit of Planck time old ($\underline{\boldsymbol{\tau}}_u = 1$) and had $\Gamma_u = 1$. We have previously been using $\mathbb{R}$ to represent one unit of coordinate length in a universe where $\Gamma_u = 1$. However, now it is necessary to add a subscript "1" to this designation to conform to a pattern where all units of physics need to be specified when $\Gamma_u = 1$. For example, E_1, Q_1 and U_1 will be used to specify a unit of energy, charge and energy density respectively when $\Gamma_u = 1$. The symbols $\mathbb{M}_1$ and $\mathbb{T}_1$ will be used to specify a unit of mass and time respectively at the start of the Big Bang when $\Gamma_u = 1$.

In chapter 3 the subscript "*g*" was used to specify a location in gravity. The analogous condition when dealing with the evolution of the universe is to specify the unit of physics when it feels the effect of a background gravitational gamma that is greater than 1 ($\Gamma_u > 1$). This condition will be specified by the subscript "*u*". For example, a unit of length, time and mass when $\Gamma_u > 1$ will be designated as L_u, T_u and M_u respectively. For the evolution of the universe the time and mass transformations are similar to those in chapter 3 but with new symbols. Only the length transformation equation is not analogous to $L_o = L_g$ from chapter 3. The new length transformation equation needs to specify the fact that we are now recognizing the change in a unit of length that scales with Γ_u. Therefore we have:

$\mathbb{R}_1 = \Gamma_u L_u$ unit of length transformation
$\mathbb{T}_1 = T_u/\Gamma_u$ unit of time transformation
$\mathbb{M}_1 = M_u/\Gamma_u$ unit of mass transformation

In utilizing the mass transformation $\mathbb{M}_1 = M_u/\Gamma_u$, it is important to recall the assumption stated in chapter 3 that the same rate of time must be used to quantify both $\mathbb{M}_1$ and M_u. Mass is a measurement of inertia, which in turn involves force and acceleration. All of these imply the use of a rate of time. Mass is not synonymous with matter. In chapter 3 we often assumed that coordinate time would be used. However, in the current universe with $\Gamma_{uo} \approx 2.6 \times 10^{31}$, the rate of coordinate time on the Γ=1 clock is about 2.6×10^{31} times faster than the rate of time on the cosmic clock, so it might not be convenient to use coordinate rate of time. All that is important is that we remember that the transformation of units requires that we use the same rate of time to express both $\mathbb{M}_1$ and M_u or other units of physics at different ages of the universe with different values of Γ_u.

Because of the change in the length transformation, it is necessary to recalculate the other transformations using the dimensional analysis procedures established in chapter 3. Using the above transformations for units of length, time and mass we obtain:

Impedance of Spacetime Z_s : $Z_{s1} \rightarrow \mathbb{M}_1/\mathbb{T}_1 = \dfrac{\left(\frac{M_u}{\Gamma_u}\right)}{\left(\frac{T_u}{\Gamma_u}\right)} \rightarrow Z_{su}$

$Z_{s1} = Z_{su}$ impedance of spacetime transformation

Energy E: $E_1 \rightarrow {}_1\mathbb{R}_1{}^2/\mathbb{T}_1 = \dfrac{\left(\frac{M_u}{\Gamma_u}\right)(L_u^2\Gamma_u^2)}{\frac{T_u}{(\Gamma_u)^2}} \rightarrow \Gamma^3 E_u$

$E_1 = \Gamma_u{}^3 E_u$ units of energy transformation

Energy Density U: $U_1 \rightarrow {}_1/\mathbb{R}_1\mathbb{T}_1{}^2 = \dfrac{(M_u/\Gamma_u)}{(L_u\Gamma_u)(T_u^2/\Gamma_u^2)} \rightarrow U_u$

$U_1 = U_u$ units of energy density transformation

Coordinate Speed of Light $\mathbb{C}$: $\mathbb{C}_1 \rightarrow \mathbb{R}_1/\mathbb{T}_1 = \dfrac{L_u\Gamma_u}{T_u/\Gamma_u} \rightarrow \Gamma^2\mathbb{C}_u$

$c = \mathbb{C}_1 = \Gamma_u{}^2\mathbb{C}_u$ coordinate speed of light transformation

These are the most important transformations and some of them will be used to determine the current vacuum energy density and analyze the 10^{120} mystery. First, the impedance of spacetime should be unaffected by a change in Γ_u. The fact that the transformation gave $Z_{s1} = Z_{su}$ shows that the length, time and mass transformations are correct. This acts as a check on the transformation process. Above we assumed the mass transformation was the same as chapter 3. In truth, this was not a foregone conclusion. However, the impedance of spacetime should remain constant. Assuming the length and time transformations, there is only one possible mass transformation that achieves a constant impedance transformation.

Energy and Energy Density Transformations: Next, the units of energy transformation $E_1 = \Gamma_u^3 E_u$ will be illustrated with an example. Suppose that there was an electron in a hypothetical universe with $\Gamma = 1$. The energy of the electron in the $\Gamma_u = 1$ universe would be 8.19×10^{-14} Joules measured locally which is the same energy we would measure for the electron in our current universe. However, the measurement in the $\Gamma_u = 1$ universe used a local clock that is running 2.6×10^{31} times faster than the cosmic clock in our current universe. Furthermore, a meter in the $\Gamma_u = 1$ universe is 2.6×10^{31} times larger than a meter in our current universe. Both of these factors combine to make 1 Joule in the $\Gamma_u = 1$ universe equivalent to $\Gamma_{uo}^3 \approx 1.8 \times 10^{94}$ joules in our current universe. Therefore, even though both electrons have the same energy measured locally, different standards of energy are being used. When we correct for this difference, the electron in the $\Gamma_u = 1$ universe has $\Gamma_{uo}^3 \approx 1.8 \times 10^{94}$ more energy.

Using the rotar model, suppose that we wanted to compare the energy density of the $\Gamma_u = 1$ electron and an electron in the universe today. The transformation of units of length is $\mathbb{R}_1 = \Gamma_u L_u$. This says that a meter in the Γ=1 universe would be about 2.6×10^{31} times longer than a meter stick in our current universe because we are living in a universe with $\Gamma_u \approx 2.6 \times 10^{31}$. Therefore, the quantum radius of the electron in the Γ=1 universe would be 2.6×10^{31} times bigger and the quantum volume of that electron would be $\Gamma_{uo}^3 \approx 1.8 \times 10^{94}$ times greater than the quantum volume of an electron in our universe. The result is that both electrons would have the same energy density because the 1.8×10^{94} difference in the electron's energy is offset by the factor of 1.8×10^{94} difference in the sizes of the quantum volumes. The transformation of energy density is shown above and results in $U_1 = U_u$.

This illustrates how the proper energy density of the universe (including vacuum energy) remains constant even when the universe experiences a vast increase in Γ_u.

This is a fantastic result because it is a key component in solving the mystery of the 10^{122} difference between vacuum energy density and currently observed energy density. When the universe was Planck spacetime, it had energy density of 5.53×10^{112} J/m^3. The spacetime transformation model of the universe views the current universe as the same size and same energy density as Planck spacetime. Therefore, the transformation $U_1 = U_u$ says that the proper energy density of the universe equals the tremendously large energy density of the universe obtained when the energy density is expressed in coordinate units. It is not necessary to add energy to the universe to keep the energy density of vacuum energy constant. Instead, nature uses two different standards for a unit of proper energy (in addition to different standards of length, force, the rate of time, etc.) This difference in energy standards exactly offset the change in proper volume thereby maintaining a constant energy density. The total proper energy density of the universe (including vacuum energy) has remained constant at 5.53 x 10^{112} J/m^3 since the beginning of time (since the Big Bang). Today almost all of this energy of the universe is in the form of vacuum energy.

Additional Transformations: If we carry these transformations further, we obtain a few counter-intuitive results. For example, the transformations of charge (Q) and momentum (p) are:

$Q_1 = \Gamma_u Q_u$ unit of charge transformation
$p_1 = \Gamma_u p_u$ unit of momentum transformation

At first these transformations seem to be saying that neither charge (Q) nor momentum (p) is conserved when the universe ages and Γ_u increases. However, these are the transformations required to preserve charge, momentum and the laws of physics when measured locally (proper measurement) and assuming a CMB rest frame which has the distance between points increase with the Hubble flow. The momentum transformation ($p_1 = \Gamma_u p_u$) will be used to illustrate this point.

We will start with a thought experiment. Suppose that there is a hydrogen atom in an excited state that is at rest relative to the CMB and also at rest at the origin of a coordinate system. The hydrogen atom emits a photon in the +Y direction and the photon's momentum causes the hydrogen atom to recoil in the – Y direction carrying the opposite momentum. As shown in chapter 5, the momentum imparted to the atom by the emission of a photon results in the atom having a de Broglie wavelength that equals the wavelength of the emitted photon. If we view this from a rigid frame of reference that does not expand with the Hubble flow, then there is no loss of momentum over time. However, if we view both the recoiling atom and the propagating photon from a coordinate system that expands with the Hubble flow, then relative to this coordinate system there is a loss of momentum. Both the photon and the de Broglie waves of the atom undergo a redshift (lose momentum) relative to a coordinate system that expands with the Hubble flow. The coordinate system used by the spacetime transformation model is rigid but the effect of an increasing Γ_u produces effects similar to adopting an expanding coordinate system. Therefore the equation $p_1 = \Gamma_u p_u$ is merely expressing this difference in perceived momentum between the two coordinate systems. Similarly, the charge transformation $Q_1 = \Gamma_u Q_u$ keeps the proper laws of physics unchanged in both an expanding coordinate system and in the spacetime transformation coordinate system as Γ_u increases.

10^{120} Calculation: Now we are going to calculate the current ratio of vacuum energy density to observable energy density. A Planck sphere originally contained about a billion Joules measured using the coordinate energy standard of energy because the universe started as Planck spacetime with $\Gamma_u = 1$. The Planck sphere started with radius of Planck length and today the proper value of this radius has increased by a factor of $\Gamma_{uo} \approx 2.6 \times 10^{31}$ to 0.42 mm radius or a volume of 3.1×10^{-10} m^3. The 10^9 J of coordinate energy when $\Gamma_u = 1$ has had an apparent increase so that currently this much energy would appear to have increased by a factor of Γ_{uo}^3. The objective of the following calculation is to find the current vacuum energy density U_{vac}.

10^9 J x $\Gamma_{uo}^3 = 1.8 \times 10^{103}$ J conversion of coordinate energy to proper energy
$(4\pi/3)\, l_p^3 \Gamma_{uo}^3 = 3.18 \times 10^{-10}$ m^3 current proper volume of Planck sphere
1.8×10^{103} J $/3.18 \times 10^{-10}$ m$^3 \approx 5.5 \times 10^{112}$ J/m$^3 = U_{vac}$

Ignoring vacuum energy, the current critical energy density of the universe depends on the value of the Hubble parameter used. Using $\mathcal{H} \approx 70.8$ km/s/Mpc the critical energy density of the universe U_{crit} is about 8.5×10^{-10} J/m^3 if we include hypothetical dark energy. If we exclude dark energy which represents about 72.1% of the total energy density, then we have observable energy density U_{obs} of about 2.36×10^{-10} J/m^3.

$U_{vac}/U_{crit} \approx 5.5 \times 10^{112}$ J/m^3/8.5×10^{-10} J/m$^3 \approx 6.5 \times 10^{121}$ ratio including dark energy
$U_{vac}/U_{obs} \approx 5.5 \times 10^{112}$ J/m^3/2.4×10^{-10} J/m$^3 \approx 2.3 \times 10^{122}$ ratio excluding dark energy

Either of these numbers qualifies as the famous 10^{120} discrepancy between the theoretical energy density of the universe and the observed energy density. Here is how we achieve spherical Planck energy density using one of the 5 wave-amplitude equations ($U = H^2\omega^2 Z/c$). Using the proper rate of time on the cosmic clock, the frequency appears to be Planck angular frequency ω_p. Furthermore, strain amplitude is a dimensionless number that does not change with Γ_u. Therefore we will insert $H = 1$. Finally we must insert the constant k' to convert from cubic to spherical with the factor of ½ associated with zero point energy.

$U = H^2\omega_p^2 Z_s/c$
set $\omega = \omega_p = 1.855 \times 10^{43}$ s^{-1}; $Z = Z_s = 4.038 \times 10^{35}$ kg/s; $H = 1$ and add $k' = 3/8\pi$

$U_{ps} = k' H^2\omega_p^2 Z_s/c = (3/8\pi)\, 1^2\, (1.855 \times 10^{43})^2\, (4.04 \times 10^{35})/3 \times 10^8$
$U_{ps} = 5.53 \times 10^{112}$ J/m^3
$U_{ps} = U_{vac} + U_{obs}$

The spacetime transformation model of the universe proposes that over the age of the universe there has been no change in the total energy density of the universe. Today virtually all of the energy density of the universe is in the form of vacuum energy U_{vac} which lacks quantized angular momentum. However, at the start of the Big Bang all the energy density of Planck spacetime U_{ps} was observable energy density U_{obs} because all the energy possessed quantized angular momentum. Over time the transformation of spacetime has resulted in a dramatic decrease in the observable energy density of the universe and an equal increase in vacuum energy density of the universe. Today $U_{vac} \approx 10^{122} U_{obs}$ but the total energy density has not changed: $U_{vac} + U_{obs} = U_{ps}$.

Today we perceive the maximum frequency of the waves that form vacuum energy to be equal to Planck angular frequency. However, this is a proper frequency that has been slowed by a factor of $\Gamma_{uo} \approx 2.6 \times 10^{31}$ compared to the coordinate frequency that occurred when the universe was Planck spacetime. How is it possible for today's vacuum energy to possess virtually the same energy density as Planck spacetime if the current maximum frequency of the dipole waves is a factor of about 2.6×10^{31} times slower than the dipole waves that formed Planck spacetime? The answer to this question is analogous to the answer given previously in the section titled "Energy and Energy Density Transformations". There it was shown how the energy density of an electron remains constant even when there is a big increase in Γ_u. The energy scales proportional to $1/\Gamma_u^3$ but the volume also scales with $1/\Gamma_u^3$ so the energy density of the electron remains constant. This holds true for any dipole wave in spacetime that has a specific frequency and strain amplitude. The highest frequency dipole waves have a proper frequency equal to Planck angular frequency ω_p and a proper volume that is Planck length in radius. However, this volume is $1/\Gamma_u^3$ times smaller than it was in Planck spacetime. The wavelets that form vacuum energy are continuously forming new wavelets as previously explained. These wavelets adapt to the changing scale of length.

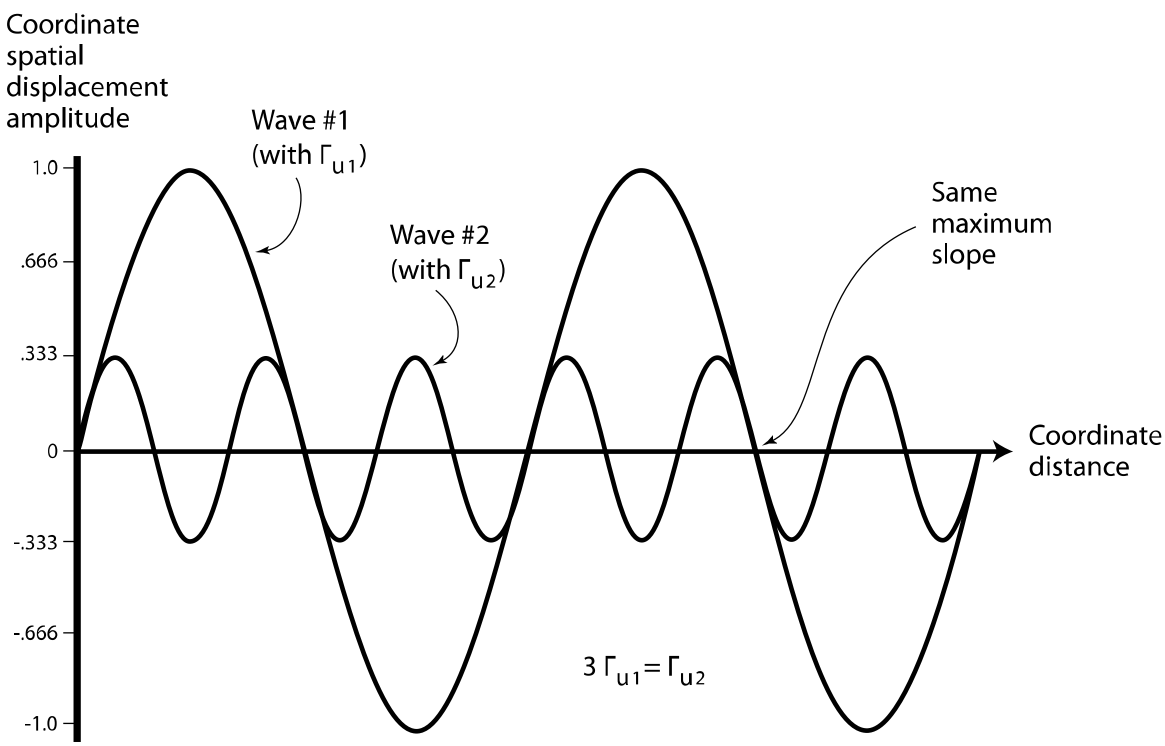

FIGURE 14-2 Two sine waves with different displacement amplitudes and different coordinate speeds of light but the same strain amplitude. The strain amplitude is ΔL/L and therefore related to the maximum slope.

Illustrations Showing the Effect of Γ_u on Waves: Next, we want to see what happens to the waves in spacetime that form vacuum energy when there is an increase of Γ_u. The mystery to be explained is how the wave structure of vacuum energy changes to result in an increase in proper volume as the universe ages. In figure 14-2 we have two sine waves designated wave #1 and wave #2. These are crude representations of the dipole waves in spacetime responsible for vacuum energy. Since the nonlinearity is particularly strong in the early part of the evolution of the universe, instead imagine these as representing vacuum energy at more recent times. In fact, wave #2 can be thought of as representing vacuum energy today with $\Gamma_{uo} \approx 2.6 \times 10^{31}$ and wave #1 representing vacuum energy when the comoving grid was $^1/_3$ its current size which is equivalent to $\Gamma_u \approx 10^{31}$. Therefore, it is important to remember that there is a factor of 3 difference between the value of Γ_u for wave #1 compared to the background gamma present for wave #2. This is written as $3\Gamma_{u1} = \Gamma_{u2}$.

Both of these waves would be exactly the same if they were drawn using proper units of length. The displacement amplitude of both waves is dynamic Planck length when the displacement of spacetime is expressed in units of proper length. However, figure 14-2 uses coordinate length for both the X and Y axis. Therefore, the spatial displacement amplitude of wave #1 is 3 times larger than the spatial displacement amplitude of wave #2 because of the factor of 3 difference between Γ_{u1} and Γ_{u2}. The displacement amplitude (Y axis) is set so that wave #1 has amplitude of 1. This makes the coordinate amplitude of wave #2 equal to 0.333. If the displacement amplitude was expressed using the absolute coordinate scale where Planck length equals 1 when $\Gamma_u = 1$, then wave #1 would have a displacement amplitude of 10^{-31}. This is because wave #1 is presumed to exist in a universe with a background value of $\Gamma_u \approx 10^{31}$. This large value of Γ_u contracts proper length compared to a unit of coordinate length $\mathbb{R}_1$.

The maximum slope of a sine wave occurs when the sine wave crosses the zero line. The arrow shows one of many points where the two waves have the "same maximum slope". This slope is a dimensionless number that is the strain amplitude of the sine wave. The point of this figure is to show that the maximum slope is the same even though the waves have a different scale. The strain produced by waves in spacetime is proportional to the maximum slope. Therefore both waves have a strain amplitude of $H = 1$. Naturally, the slope would also be the same if the waves were drawn using proper length because both waves would then be exactly the same in displacement, wavelength and maximum slope. The waves that form vacuum energy can maintain the same strain amplitude even when Γ_u is increasing. The frequency, measured locally, remains the same so the proper energy density also remains constant when Γ_u increases. The point is that the strain amplitude is always $H = 1$ for all values of Γ_u. This is a key component in maintaining the total energy density of the universe at 10^{113} J/m^3 throughout the age of the universe.

It is interesting to note what these waves would look like if they were plotted in the temporal domain rather than the spatial domain. The Y axis would be labeled “Coordinate Temporal Displacement Amplitude” and the X axis would be labeled “Coordinate Time”. The figure would physically look the same as figure 14-2 except that the labels for wave #1 and #2 would be reversed. Wave #2 (larger value of Γ_u) would have the larger temporal displacement amplitude when measured in coordinate units of time. This comparison helps to illustrate how a change in Γ_u exchanges the temporal properties of spacetime for the spatial properties of spacetime.

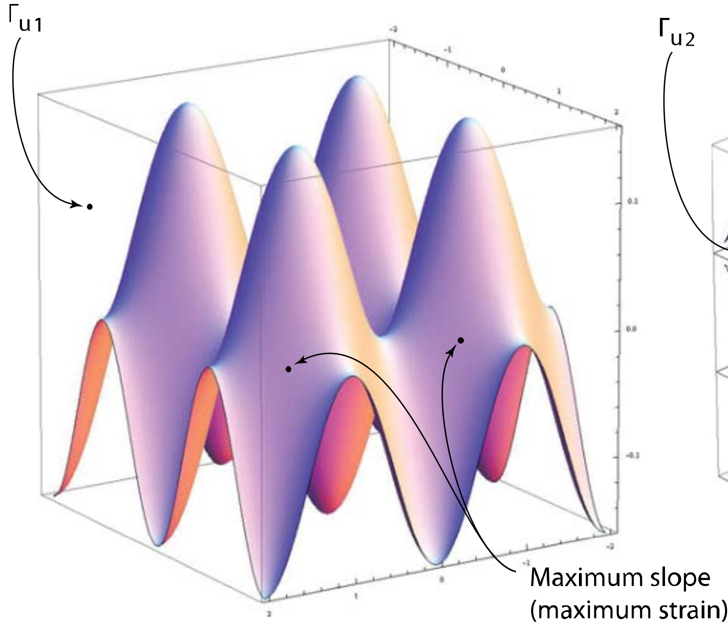

FIGURE 14-3

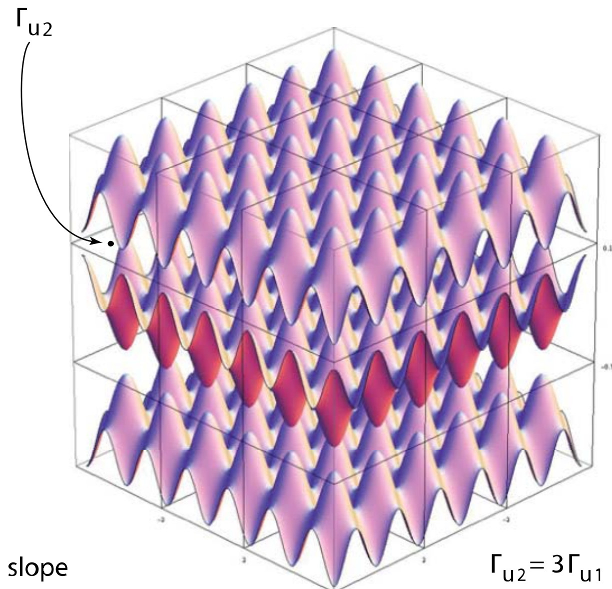

FIGURE 14-4

Figures 14-3 and 14-4 show a simplified representation of chaotic dipole waves in spacetime that form vacuum energy. These figures depict different ages of the universe when there is a factor of 3 difference in Γ_u.

Figures 14-3 shows a 3-dimensional plot of wave #1 in figure 14-2 and figure 14-4 shows a 3-dimensional plot of 3 layers of wave #2 in figure 14-2 (original definitions of Γ_u). These two figures are oversimplified. The wave structure should be more chaotic and unsymmetrical. Imagine the waves in figure 14-4 as oscillating at $^1/_3$ the frequency of the waves in figure 14-3. The grid pattern in figure 14-4 is only $^1/_3$ the coordinate length so each grid cube has only $^1/_{27}$ the coordinate volume of the grid cube in figure 14-3. However, each grid cube also only contains $^1/_{27}$ the coordinate energy as the grid cube in figure 14-3, so the energy density is the same no matter whether it is assessed using the proper standard of energy density or the coordinate standard of energy density.

Quantum mechanics has been telling us that the vacuum energy density should be constant even as the universe ages and the proper volume increases. Now it is possible to see that the spacetime based model of the universe shows that this is possible. In fact, in order for the laws of physics to remain constant, it is necessary that the vacuum energy density remains constant. If the vacuum energy density decreased as the proper volume of the universe expanded, then the high frequency virtual particle pairs would eventually be lost and this would be detectable.

Does Dark Energy Exist? Dark energy is supposedly a homogeneous form of energy that produces a force that is the opposite of gravitational attraction. Dark energy is sometimes considered a "negative pressure" and other times considered a type of anti-gravity. The term "negative pressure" will be avoided here because there are logical incompatibilities when we critically examine the relationship between pressure, energy density and gravity. Instead, dark energy will be considered a mysterious form of energy that possesses anti-gravity properties. The reason that the concept of dark energy was invented is because the Big Bang model cannot explain the observed universe without inserting a substance with anti-gravity properties that also grows in importance as the volume of the universe increases.

The concept is that dark energy density remains constant at about 6×10^{-10} J/m^3. Therefore, as the proper volume of the universe increases, the energy density of ordinary matter and dark matter decrease while the energy density of dark energy remains constant. Since there is a continuous increase in proper volume, a constant energy density means a continuous increase in the amount of dark energy in the universe. Therefore, dark energy supposedly was an insignificant fraction of the total energy of the universe at 380,000 years after the Big Bang (CMB observations). However, since then the radius of a given spherical volume of spacetime (such as a Planck sphere) has increased by a factor of about 1080. This means that the volume of such a hypothetical sphere has increased by a factor of $\sim 1.3 \times 10^9$ and the dark energy content of this sphere has also increased by this factor. Starting at an age of about 5×10^9 years, dark energy supposedly began to dominate the universe and now dark energy is believed to represent about 72% of the total energy content of the universe.

Everything about hypothetical dark energy conflicts with the concepts presented in this book. The starting assumption is that the universe is only spacetime and a corollary of this is that there is only one fundamental force $F_r = P/c$. This is the force exerted by energy traveling at the speed of light and it is always repulsive. Positive energy traveling at the speed of light (such as light or waves in spacetime) produces this repulsive force. It has been shown how vacuum energy (high frequency waves in spacetime) can produce what appears to be either an attractive force or a repulsive force on rotars using only the relativistic force that is always repulsive. Gravity and curved spacetime was also shown to result from spacetime being a nonlinear medium for waves in spacetime.

The spacetime based explanation of the universe has shown that energy density U and pressure $\mathbb{P}$ is: $U = \mathbb{P} = H^2\omega^2 Z_s/c$ (ignores dimensionless constants). Therefore, how is it possible to create negative pressure $\mathbb{P}$ or negative energy density U? Even if there was such a thing as negative amplitude H or negative frequency ω, both of these are squared so we always obtain a positive value when squared. Also there is only one definition of the impedance of spacetime $Z_s = c^3/G$ and only one universal constant c. Therefore, these must be the same positive values as in other calculations that are interpreted as giving a positive value of energy density and pressure. There appears to be no way to obtain negative pressure or negative energy density from $U = \mathbb{P} = H^2\omega^2 Z_s/c$. Waves can cancel in one location, but the positive energy is not destroyed – it merely appears in another location where there is constructive interference.

There is no single explanation for dark energy, but the simplest explanation given for the existence of dark energy that scales with volume is that dark energy is "the cost of having space". Each time cosmic expansion somehow creates an additional cubic meter of spacetime; this volume is supposedly left with an energy deficit of about 6 x 10^{-10} J of "negative energy". There simply is no spacetime wave model of negative energy or negative pressure. Furthermore each new cubic meter of spacetime must contain about 10^{113} J of positive zero point energy. The spacetime transformation model shows how this is accomplished. The Λ-CDM model assumes that this requirement is somehow canceled.

In fact, the Λ-CDM model does not respect the conditions that must be met to create a cubic meter of "new" space. This new space must have the impedance of spacetime $Z_s = c^3/G$ and the interactive bulk modulus of spacetime $K_s = F_p/\mathcal{A}^2$. The new space must be filled with zero point energy at energy density of 10^{113} J/m^3. The new space must have elasticity and properties that permit a gravitational wave to propagate at the speed of light. The list goes on. As before, the problem is in the physical interpretation of observations and equations. If the proper distance between galaxies increases, this can be interpreted different ways. The model proposed here is actually the simplest because it does not demand any new physics or new energy to be added to the universe.

There is no direct experimental evidence that dark energy exists. Dark energy is a theoretical concept that appears to be necessary to explain the apparent acceleration of the expansion of the universe and also to explain that the energy density of the universe has fallen below the "critical density". Baryonic matter, dark matter and radiation only achieve about 28% of the energy density calculated to be necessary to achieve flat spacetime. However, this calculation depends on the accuracy of the model of the universe being used. The concept of "critical density" of the universe assumes that the universe possesses a gravitational gradient. This does not exist in the condition previously described as "immature gravity". It does not make any difference whether the immature gravity occurs in the low gravitational Γ of the dust cloud thought experiment or the high gravitational Γ_u of the universe. The important point is that immature gravity produces an increasing gravitational Γ_u and a uniform instantaneous rate of time in the CMB rest frame. If there is no large scale rate of time gradient from the midpoint observer perspective, then there is no large scale gravitational acceleration and nothing that demands an explanation that incorporates anti-gravity.

The concept of critical density of the universe assumes that there is a gravitational acceleration that is attempting to collapse the universe. If the universe is pictured as the homogeneous and static distribution of galaxies with proper volume increase because of the spacetime transformation of the rate of time and of proper length, then the universe is not struggling to expand against gravity. There is no such thing as a critical density. The dust cloud thought experiment did not meet the conditions of "critical density" and yet there was no gravitational acceleration in the first few milliseconds after gravity was "turned on".

As long as the universe has no detectable boundary (no edge), the mature gravity condition cannot be established. It takes a density change at a boundary to establish a rate of time gradient and gravitational acceleration. The proposed model of the universe started with Planck spacetime that had a uniform rate of time. At speed of light communication, we still have no detectable boundary. The rate of time has slowed down but there still is no large scale rate of time gradient. Gravitational acceleration and curved spacetime both require a rate of time gradient. Therefore, the universe has never possessed large scale curved spacetime or gravitational acceleration. New mass/energy will continue to appear on the particle horizon of the observable universe. The background Γ_u of the universe will continue to increase towards infinity and there will be no rate of time gradient on the scale of universal homogeneity unless one day we become aware of a large scale density discrepancy that is the equivalent of a boundary condition that gives an "edge" to the universe.

Dark Energy Not Needed: What is being proposed is that the spacetime transformation model does not require the invention of dark energy to provide the missing critical density and does not need any mysterious force with anti-gravity properties that is causing the apparent expansion of the universe to accelerate. When viewed from a hypothetical coordinate rate of time and coordinate unit of length, there is no expansion of the universe. No work is being done against gravity. The immature gravity condition previously discussed eliminates the tendency for the universe to have a gravitational contraction. The coordinate volume of the universe has never changed and the coordinate energy density (including vacuum energy) has remained constant at the large scale of 300,000 light years. At a smaller scale matter has formed stars and galaxies which distort the homogeneous energy density of vacuum energy. We call this distortion "curved spacetime". Our perception of the volume of the universe indicates continuous expansion. However, this is the result of a continuous increase in the background Γ_u of the universe. What we perceive as acceleration of the expansion is due instead to an acceleration in the rate of change of $d\Gamma_u/d\tau_u$.

All the factors that determine $d\Gamma_u/d\tau_u$ (the rate of change of Γ_u in proper time) are not known. This would be a function the age of the universe, but it probably also includes other factors relating to the composition and the observable energy density of the universe. For example, when the universe was radiation dominated, a substantial amount of the observable energy was being converted to vacuum energy. This process resulted in $d\Gamma_u/d\tau_u$ being proportional to $\tau^{1/2}$. During the matter dominated epoch the electromagnetic radiation was a small percentage of the observable energy of the universe and $d\Gamma_u/d\tau_u$ was proportional to $\tau_u^{2/3}$. Today we have an increase in proper volume that is acceleration. If this is viewed as an acceleration in the rate of change of $d\Gamma_u/d\tau_u$, then mystery becomes easier to perceive and perhaps easier to solve.

Why Does Vacuum Energy Not Produce Gravitational Acceleration? An important axiom of general relativity is that energy in any form produces gravity. However, it is proposed that this is an over-simplified statement. It is proposed that vacuum energy lacks quantized angular momentum and is a completely different form of energy that does not fit this axiom. Even though the energy density of vacuum energy is vastly larger than the energy density of ordinary mass/energy, vacuum energy is a superfluid of dipole waves in spacetime that is as homogeneous and isotropic as quantum mechanics allows. Wavelets are continuously forming and redistributing the fluctuations that are subject to the Planck length/time limitation. These fluctuations do not form concentrations of energy like the fundamental particles (rotars) because there is no quantized angular momentum. This form of energy does not form rate of time gradients, nor does it respond to gravitational acceleration produced by concentrations of matter. Only the introduction of energy possessing quantized angular momentum locally exceeds the homogeneous norm of vacuum energy and results in a distortion we call curved spacetime.

The mechanism by which rotars feel a gravitational force involves the time difference across the rotar influencing the pressure difference exerted on a rotar by the vacuum energy. This structure requires quantized angular momentum. In contrast, vacuum energy dipole waves are not a cohesive unit. They have no quantum radius over which they act like a quantized unit. Even if they are present in a rate of time gradient, this gradient does not produce a pressure difference. All of this says that the energy density of vacuum energy does not count towards the "critical density" of the universe. Vacuum energy is a fundamental property of spacetime and is necessary to give spacetime its other properties.

Previously it was shown that large scale flat spacetime occurs in the universe as long as there is no detectable boundary to the universe (immature gravity). It is possible for the universe to have less than the critical energy density of ordinary matter/energy and still produce flat spacetime because the universe is still in the "immature gravity" condition. When vacuum energy is in the presence of a local gravitational field, that gravitational field will undergo a transformation as the universe ages. The rate of time in the gravitational field is slowed proportionately so that there is no detectable change relative to other parts of the universe.

Offsetting the Rate of Change of Γ_u: Returning to the increase in Γ_u, how fast would an object need to be raised in the earth's gravitational field in order for the decrease in the earth's Γ to offset the increase in Γ_u of the universe? In other words, what rate of increase in elevation achieves $(d\Gamma/dt)/\Gamma = \mathcal{H} \approx 2.29 \times 10^{-18}\ s^{-1}$ in the earth's gravitational acceleration of 9.8 m/s²?

$$g = c^2\left(\frac{d\beta}{dL_R}\right) \approx c^2\left(\frac{d\Gamma}{\Gamma dL_R}\right) \qquad \text{set } \frac{d\beta}{dL_R} \approx \frac{d\Gamma}{\Gamma dL_R} \text{ weak gravity approximation}$$

$$\frac{d\Gamma}{\Gamma d\tau_u} = \left(\frac{g}{c^2}\right)\left(\frac{dL_R}{d\tau_u}\right) \qquad \text{set } \frac{d\Gamma}{\Gamma d\tau_u} = \mathcal{H} \quad \text{and } g = 9.8\ \text{m/s}^2$$

$$\left(\frac{dL_R}{d\tau_u}\right) \approx \mathcal{H}\frac{c^2}{g} \approx .021\ \text{m/s} \qquad \left(\frac{dL_R}{d\tau_u}\right) = \text{vertical velocity}$$

Therefore an elevation velocity of about 2.1 cm/s or about 75 meters per hour in the earth's gravity offsets the temporal effects of an increase in the Γ_u of the universe. Obviously this is only a temporary reprieve made possible because an object in the earth's gravity starts off at a lower energy state (larger total Γ) than the same object if it was isolated on the comoving coordinate system. Still, this example gives a physical feel for the rate of change that is currently taking place in the universe.

All physical objects are losing energy each second when measured with an absolute energy scale that does not decrease as Γ_u increases. For example, the sun is currently radiating about 4×10^{26} watts of electromagnetic radiation but the sun is losing about 1000 times this energy per second as the energy in the sun's rotar's is being converted to vacuum energy. This is an undetectable effect using the proper energy standard which does not acknowledge the effect of an increasing Γ_u on everything in the universe.

There is another interesting way of looking at the changing rate of time as the universe ages. An electron has two different rates of time in its two lobes as explained in chapter 5. These rates of time differ by $H_\beta = 4.18 \times 10^{-23}$. How many seconds does it take for Γ_u to change by a factor of 4.18×10^{-23}? In other words, what difference in the age of the universe produces a rate of time difference equal to the rate of time difference in an electron?

$H_\beta/\mathcal{H} = 4.18 \times 10^{-23}/2.29 \times 10^{-18}\ s^{-1} = 1.8 \times 10^{-5}$ second

Time's Arrow: The equations of physics seem to be reversible in time. Except for entropy, it appears as if it should be possible to go backwards in time. However, if the background Γ_u of the universe is increasing continuously and all matter is converting energy into vacuum energy, then it is not possible to go backwards in time. Yesterday all the rotars and photons in the universe had more energy than they possess today (measured on the scale of coordinate energy). Also, the lower background Γ_u of yesterday also affects many other things such as the units of force, velocity, voltage, etc. Even though the laws of physics are the same today and yesterday, all the components that makeup the universe are different. The universe is undergoing a transformation and this makes Time's arrow only point one direction – to the future.

Black Holes: *The following discussion of black holes is more speculative than the rest of this book. Therefore the following should be considered just a few preliminary thoughts about black holes.*
Do black holes have a different structure in a spacetime based universe than they would have if the universe is populated by point particles? So far the general relativity analysis of black holes has indirectly assumed the standard model of particles. With the point particle assumption, a black hole has an accretion disk, an event horizon, a volume inside the event horizon and finally a singularity at the center. This singularity supposedly has infinite energy density (the same as point particles). The volume inside the event horizon supposedly has modulation of the properties of spacetime that would require in excess of 100% depth of modulation of spacetime. Clearly these conditions cannot be achieved by the spacetime based model of the universe proposed here. The event horizon of a black hole supposedly has a rate of time that is stopped and a coordinate speed of light equal to zero. It is questionable whether a complete stoppage of the rate of time and stopping the propagation of light can be achieved by the wave-based model of hadrons and bosons proposed here.

If your model of a fundamental particle is a point particle with no physical size and no structure, then such a particle would be able to survive the plunge past the event horizon of a black hole. However, if we assume the rotar model of matter, then a preliminary analysis seems to indicate a different answer. As previously explained, a rotar is just a slight distortion of spacetime that has a specific frequency, quantum radius, and displacement amplitude. It seems as if a spacetime based explanation of the universe cannot form a true black hole event horizon. This is because such an event horizon would eliminate the waves in spacetime required for its formation. If a mass collapsed to a degree that the rate of time is slowed down by an enormous amount such as 10^{20} or more (compared to the comoving rate of time), then externally this would be indistinguishable from a conventional black hole. In this scenario, after a black hole forms, all additional mass/energy that falls towards the black hole adds to the orbiting accretion disk and never reaches an event horizon. The spacetime wave properties of rotars and photons would have to be taken into consideration in order to properly characterize the accretion disk that never quite reaches an event horizon. If hadrons and bosons never quite reach a true event horizon, then this would explain how it is possible for information about the black hole's charge, magnetic field, mass and rotational direction can be communicated to the rest of the universe outside of the black hole.

Like any gravitational capture, mass must shed some energy in order to be captured by a pseudo black hole. This sheading of energy is done by the emission of radiation and by the energy emitted by the polar jets associated with black holes. The energy that is captured can change its form but its gravitational effect remains constant. Recall the example previously given of a planet in a highly elliptical orbit around a star. The total gravitational effect of the combination of the star and the planet is constant even though the energy in the planet changes form. Similarly, a photon falling into a pseudo black hole would appear to be blue shifted if the photon could be observed locally in a region with a high gravitational gamma Γ. A rotar would gain kinetic energy to offset the loss of internal energy associated with a high Γ. In neither case does the energy pass an event horizon where contact with the outside universe would be lost.

The model of spacetime currently accepted is that the effects of curved spacetime can somehow transcend an event horizon. We can obviously accurately measure the mass, spin and charge of a black hole. These are examples of communication that appears to be coming from inside an event horizon. The spacetime based model of gravity requires waves in spacetime to produce a nonlinear interaction in spacetime. When the energy density of matter and radiation approaches the energy density that would require 100% modulation of spacetime then we are approaching the conditions of a black hole. However, the spacetime based model never actually reaches 100% modulation of spacetime. Time never quite stops compared to coordinate time and length never quite contracts to zero compared to coordinate length. The singularity associated with the conventional black hole requires energy density in excess of Planck energy density. This is usually "explained" by saying that "the laws of physics break down". The spacetime based model of the universe never requires that the laws of physics break down.

I visualize the volume near the center of a wave based black hole to be primarily photons that have been highly blue shifted relative to the local rate of time. Matter falling into the accretion disk will undergo highly energetic collisions. While new particles would be formed, repeated collisions and decompositions would eventually result in a high percentage of the energy being photons. Therefore, photon density would increase with depth. There would be no event horizon, but energy in the accretion disk would cause the gravitational gamma Γ to approach infinity. For example, suppose that this energy density achieves a rate of time that is 10^{20} times slower than the surrounding volume of the universe. This would look like a black hole, but information about charge, mass and rotational direction could still be communicated to the surrounding space.

The Spacetime Transformation Model Versus The Inflationary Model: In chapter 13 we performed several calculations to find the value of Γ_{uo}. However, the same data can be rearranged to support the contention that the proposed spacetime transformation model of the universe is correct and that there was not an inflationary phase. Here is the reasoning. When we calculate the change in scale factor starting from one unit of Planck time (~5 x 10^{-44} s) and ending with 13.7 billion years, we obtained scaling factors of 2.1, 2.6, 2.95 and an upper limit of 3.4 (all x 10^{31}). These numbers are approximately the same yet they were obtained from diverse sources such as the currently observable energy density of the universe, the observed CMB temperature and the CMB photon energy density.

Now we will reverse the thought process and extrapolate back in time to when the universe was 5 x 10^{-44} seconds old (1 unit of Planck time). Starting with the currently observable energy density, CMB temperature and CMB photon energy density of today's universe we always arrive at the properties of Planck spacetime using an average value of $\Gamma_{uo} \approx 2.6 \times 10^{31}$. This extrapolation makes the assumption that there was no inflationary phase in the expansion of the proper volume of the universe.

However, suppose that we include inflation in this backwards extrapolation. Between about 10^{-35} seconds and 10^{-32} seconds we have to deviate from the radiation dominated condition that scales with $\Gamma_u^{1/2}$ and insert the inflationary exponential scaling factor. This inflation factor is unknown, but it is usually considered to be in excess of 10^{25}. At an age of 5 x 10^{-44} second, including inflation implies that the energy per photon exceeds Planck energy by a factor of at least 10^{25}. Similarly the implied temperature exceeds Planck temperature by more than 10^{25} and the implied energy density exceeds Planck energy density also by a similar factor. These are impossibilities according to the known laws of physics. Therefore physicists casually disregard this by saying that the laws of physics must "breakdown" under these conditions. Even the idea that the inflationary expansion greatly exceeded the speed of light requires a breakdown of the laws of physics.

There is no experimental proof that it is possible for the laws of physics to "breakdown". This is merely a term used when a particular theory gives an impossible answer according to the known laws of physics. Instead, when a theory requires a breakdown in the laws of physics, this should be a strong indication that the theory is wrong. The beauty of assuming that the universe is only spacetime is that there should be no cases where the theory needs to revert to saying that the laws of physics must breakdown in order to explain a particular implied result.

Cosmic inflation is an *ad hoc* solution required by a model of the universe that has point particles and forces carried by the exchange of virtual particles. If the universe is only spacetime, then it was only spacetime (the composite quantum mechanical and relativistic spacetime model) even at the beginning of the Big Bang. Extrapolating backwards from today results in the "Planck spacetime" homogeneous state. This is the highest observable energy density spacetime can support. The laws of physics never break down. For example, there are no singularities in this spacetime based model of the universe. All the steps are conceptually understandable and accessible to physicists today. Planck spacetime is as homogeneous as quantum mechanics allows, so there is no need for inflation to expand spacetime to achieve local homogeneity.

Unity and Entanglement Revisited: It was previously proposed that quantized waves in spacetime such as rotars and photons can have internal communication faster than the speed of light. This property also extends to communication between two entangled photons or rotars. No information can be imposed on this internal communication so there is no violation of the prohibition against faster than light communication. Still there is a question about how spacetime accomplishes the faster than speed of light internal communication. One possibility is that this internal communication might be taking place at the speed of light characteristic of Planck spacetime. This speed would be about 2.6 x 10^{31} times faster than the proper speed of light. At this speed, internal communication within a photon distributed over one light year would only take about 10^{-24} second and a CMB photon generated 380,000 years after the Big Bang would collapse within about 10^{-14} seconds. The microwave photons that make up the CMB have a peak frequency of about 1.6 x 10^{11} Hz. Therefore a collapse with a time delay of about 10^{-14} s would meet the conditions of being virtually instantaneous. Perhaps the internal communication is actually instantaneous, but communication at 2.6 x 10^{31} times faster than c is indistinguishable from being instantaneous.

Are All Frames of Reference Really Equivalent? A basic assumption of relativity is that all frames of reference are equivalent. The CMB rest frame is clearly the preferred frame for cosmological purposes, but the laws of physics are presumed to work equally well in all frames of reference. Experimental observations have not detected any preference for frames of reference, but does this mean that ultra-relativistic frames relative to the CMB rest frame are equivalent? Recall that in chapters 4 and 11 the subject of the spectral energy density of zero point energy (quantized harmonic oscillators) was discussed. It was stated:

> "This spectrum with its ω^3 dependence of spectral energy density is unique in as much as motion through this spectral distribution does not produce a detectable Doppler shift. It is a Lorentz invariant random field. Any particular spectral component undergoes a Doppler shift, but other components compensate so that all components taken together do not exhibit a Doppler shift."

There is one problem with this concept. Vacuum fluctuations have a cutoff frequency equal to Planck frequency ω_p. If this cutoff frequency is symmetrical when viewed from the CMB rest frame, then there must be an ultra-relativistic frame of reference (relative to the CMB) where the asymmetry becomes obvious. An example will help to define this question. We can currently accelerate an electron to energy of 50 GeV. This is a relativistic Lorentz factor of $\gamma \approx 10^5$ relative to the CMB rest frame. However, a frame of reference with $\gamma = 10^5$ does not come close to testing the questions related to the limits of extreme ultra relativistic frames of reference. Imagine an electron with an ultra-relativistic speed with $\gamma \approx 2.4 \times 10^{22}$ as seen from the CMB rest frame. This is the Lorentz factor where the electron's de Broglie wavelength λ_d would be shorter than Planck length ($\lambda_d \approx \lambda_c/\gamma$ approximation valid when $\gamma >> 1$). This is very close to the speed of light but it does not equal the speed of light. Therefore, it is hypothetically a permitted frame of reference for an electron.

However, in the CMB rest frame the electron would have a de Broglie wavelength less than Planck length and de Broglie frequency exceeding Planck frequency. According to the premise of this book, spacetime is not capable of producing this wavelength and frequency. Also, in the electron's frame of reference there would be an extreme redshift in one direction of the dipole waves in spacetime required to stabilize the energy density (pressure) of the electron. This redshift would prevent the vacuum energy from exerting the pressure required to stabilize an electron in this frame of reference. If the universe is only spacetime, then this frame of reference is not permitted for an electron. Instability would appear as an electron approached the Planck length/frequency limit as seen from the CMB rest frame. The electron would exhibit properties in this ultra-relativistic frame of reference that the electron does not possess in the CMB rest frame. Other particles would exhibit unusual properties and instabilities at different ultra-relativistic frames relative to the CMB rest frame. This is just one example where the finite frequency spectrum of vacuum energy affects the properties of fundamental particles in ultra-relativistic frames (relative to the CMB). Also, if all frames of reference are not equivalent, then this undermines one of the starting assumptions of string theory.

The Fate of the Universe: The currently accepted model of the universe has mysterious dark energy becoming more dominant and accelerating the expansion of the universe until we lose sight of distant galaxies. In the most extreme extension of this process, a Big Rip eventually occurs when the expansion becomes so extreme that gravitationally bound objects such as galaxies and stars are dispersed by the expansion of space. Finally even atoms are ripped apart and the universe dies as subatomic particles are eventually converted to photons.

The model proposed here has not been developed sufficiently to have a clear prediction about the eventual fate of the universe. However, as previously explained, the near term (a few billion years) has distant galaxies getting dimmer but also the currently observed redshift of any particular distant galaxy will decrease. This counter intuitive prediction is actually a continuation of the process that has occurred throughout the history of the universe.

Over the longer term the spacetime transformation model of the universe offers an intriguing possibility. The total energy density of the universe (observable energy + vacuum energy) remains the same over the lifetime of the universe. Presently observable energy (including dark matter) represents only about 1 part in 10^{122} of the total energy in the universe. As previously explained, we only can observe and interact with waves in spacetime that possess quantized angular momentum (fermions and bosons). Furthermore, the fraction of the total energy that possesses angular momentum (10^{-122}) is dropping daily and the rate of change of $d\Gamma_u/d\tau_u$ appears to be accelerating.

If fundamental particles eventually decay into photons in the far distant future of the universe, then an intriguing possibility exists. When the quantized angular momentum of the photons becomes homogeneously distributed throughout the universe, then this condition of spacetime begins to look like Planck spacetime. The energy density is the same and the average distribution of the quantized angular momentum is the same. The major difference is that Planck spacetime has $\Gamma_u = 1$ and this final state of the universe has Γ_u approaching infinity.

Perhaps the energy in these photons becomes such a small fraction of the vacuum energy density of the universe that quantum mechanics allows the background gamma of the universe to round off to $\Gamma_u = \infty$. The rate of time would stop and the hybrid speed of light would stop. This is a discontinuity that would allow a rebirth of the universe. All that has to happen is that the background gamma of the universe has to change from $\Gamma_u = \infty$ to $\Gamma_u = 1$. No collapse is required because the universe is already at the required energy density. Also, the required quantized spin units would be preserved and evenly distributed. All that has to change is the rate of time and the spatial characteristics must revert back to the $\Gamma_u = 1$ condition. This would produce Planck spacetime and the universe would start a new cycle with a new "Big Bang".

Personal Note: While working on the ideas contained in this book, there were times that I questioned whether I should be undertaking this large project. Was there really a conceptually understandable solution to a particular problem? Why should I be the one attempting to find this solution? At those times I thought about and received encouragement from the following quote by John Archibald Wheeler. Predicting a new revolution in physics, he said:

"And when it comes, will we not say to each other, Oh, how beautiful and simple it all is! How could we ever have missed it so long?"

–John Archibald Wheeler

PS – This book was made available online free of charge in the hopes that readers would give feedback. Please send your comments to: *john@onlyspacetime.com*

Chapter 15

Equations and Definitions

Properties of a Single Rotar

$H_\beta = \frac{L_p}{R_q} = T_p\omega_c = \sqrt{\frac{Gm^2}{\hbar c}} = \frac{m}{m_p} = \frac{E_i}{E_p} = \frac{\omega_c}{\omega_p} = \sqrt{\beta_q} = \sqrt{\frac{P_c}{P_p}}$ H_β = rotar strain amplitude

$R_q = \frac{\hbar}{mc} = \frac{c}{\omega_c} = \frac{\hbar c}{E_i} = \frac{L_p^2}{R_s} = \frac{L_p}{H_\beta}$ R_q = quantum radius

$\omega_c = \frac{mc^2}{\hbar} = \frac{c}{R_q} = \frac{c}{\lambda\!\!\!^{-}_c} = H_\beta\omega_p$ ω_c = Compton angular frequency

$E_i = mc^2 = \omega_c\hbar = \frac{\hbar c}{R_q} = \frac{P_c}{\omega_c} = F_m R_q = H_\beta E_p$ E_i = internal energy

$m = \frac{E_i}{c^2} = \frac{\hbar}{R_q c} = \frac{\omega_c \hbar}{c^2} = T_p^2\omega_c Z_s = H_\beta m_p$ m = rotar mass

$P_c = E_i\,\omega_c = \omega_c^2\hbar = \frac{E_i^2}{\hbar} = \frac{\hbar c^2}{R_q^2} = \frac{m^2c^4}{\hbar} = H_\beta^2 P_p$ P_c = circulating power

$F_m = \frac{m^2c^3}{\hbar} = \frac{\hbar c}{R_q^2} = \frac{\hbar\omega_c^2}{c} = H_\beta^2 F_p$ F_m = maximum force at distance R_q

$U_q = \frac{E_i}{R_q^3} = \frac{m^4c^5}{\hbar^3} = \frac{a_g^2}{G} = H_\beta^4 U_p$ U_q = quantum volume energy density

$\beta_q = \frac{Gm^2}{\hbar c} = H_\beta^2$ β_q = gravitational magnitude at quantum radius

$\mathcal{N} = \frac{r}{R_q} = \frac{rmc}{\hbar}$ $\mathcal{N}$ = distance (r) from a rotar expressed as the number of R_q units

$H_e = \frac{\sqrt{\alpha}L_pR_q}{r^2} = \sqrt{\alpha}\,\frac{H_\beta}{\mathcal{N}^2}$ H_e = electromagnetic standing wave strain amplitude oscillating at ω_c

$H_\varepsilon = \sqrt{\alpha}\,\frac{L_p}{r} = \sqrt{\alpha}\frac{H_\beta}{\mathcal{N}}$ H_ε = electromagnetic non-oscillating strain amplitude

$H_g = \frac{L_p^2}{r^2} = \frac{H_\beta^2}{\mathcal{N}^2}$ H_g = gravitational standing wave strain amplitude oscillating at $2\omega_c$

$H_G = \beta = \frac{Gm}{c^2r} = \frac{H_\beta^2}{\mathcal{N}}$ H_G = gravitational non-oscillating strain amplitude

$H_f = \frac{L_p}{r}$ H_f = hypothetical fundamental amplitude before cancelation

5 Wave-Amplitude Equations

$\mathcal{I} = k\,H^2\,\omega^2\,Z$	$\mathcal{I}$ = intensity (w/m^2)	
$U = k\,H^2\,\omega^2\,Z/c = \mathbb{P}$	U = energy density (J/m^3)	($U = \mathcal{I}/c$) and $U = \mathbb{P}$
$E = k\,H^2\,\omega^2\,Z\,V/c$	E = energy (J)	($E = \mathcal{I}\,V/c$)
$P = k\,H^2\,\omega^2\,Z\,A$	P = power (J/s)	($P = \mathcal{I}A$)
$F = k\,H^2\,\omega^2\,Z\,A/c$	F = force (N)	($F = \mathcal{I}A/c$)

Planck Units

l_p = Planck length	$l_p = t_p c = \sqrt{\hbar G/c^3}$	1.616 x 10^{-35} m
m_p = Planck mass	$m_p = \sqrt{\hbar c/G}$	2.176 x 10^{-8} kg
t_p = Planck time	$t_p = l_p/c = \sqrt{\hbar G/c^5}$	5.391 x 10^{-44} s
q_p = Planck charge	$q_p = e/\sqrt{\alpha} = \sqrt{4\pi\varepsilon_o \hbar c}$	1.876 x 10^{-18} Coulomb
E_p = Planck energy	$E_p = m_p c^2 = \sqrt{\hbar c^5/G}$	1.956 x 10^9 J
ω_p = Planck angular frequency	$\omega_p = 1/t_p = \sqrt{c^5/\hbar G}$	1.855 x 10^{43} s^{-1}
F_p = Planck force	$F_p = E_p/l_p = c^4/G$	1.210 x 10^{44} N
P_p = Planck power	$P_p = E_p/t_p = c^5/G$	3.628 x 10^{52} w
p_p = Planck momentum	$p_p = m_p c = \sqrt{\hbar c^3/G}$	6.525 kg m/s
U_p = Planck energy density	$U_p = E_p/l_p^3 = c^7/\hbar G^2$	4.636 x 10^{113} J/m^3
$\mathbb{P}_p$ = Planck pressure	$\mathbb{P}_p = F_p/l_p^2 = c^7/\hbar G^2$	4.636 x 10^{113} N/m^2 (= U_p)
$\mathbb{T}_p$ = Planck temperature	$\mathbb{T}_p = E_p/k_B = \sqrt{\hbar c^5/G k_B^2}$	1.417 x 10^{32} °K
A_p = Planck acceleration	$A_p = c/t_p = \sqrt{c^7/\hbar G}$	5.575 x 10^{51} m/s^2
ρ_p = Planck density	$\rho_p = m_p/l_p^3 = c^5/\hbar G^2$	5.155 x 10^{96} kg/m^3
V_p = Planck electrical potential	$V_p = E_p/q_p = \sqrt{c^4/4\pi\varepsilon_o G}$	1.043 x 10^{27} V
Z_p = Planck impedance	$Z_p = \hbar/q_p^2 = 1/4\pi\varepsilon_o c$	29.98 Ω
$\mathcal{E}_p$ = Planck electric field	$\mathcal{E}_p = F_p/q_p = \sqrt{c^7/4\pi\varepsilon_o \hbar G^2}$	6.450 x 10^{61} V/m
$\mathcal{B}_p$ = Planck magnetic field	$\mathcal{B}_p = Z_s/q_p = \sqrt{\mu_o c^7/4\pi\hbar G^2}$	2.152 x 10^{53} Tesla
I_p = Planck current	$I_p = q_p/t_p = \sqrt{4\pi\varepsilon_o c^6/G}$	3.480 x 10^{18} amp

Gravitational Γ and *β* (excludes cosmology equalities)

$\Gamma \equiv \frac{dt}{d\tau} = \frac{1}{\sqrt{1-\left(\frac{2Gm}{c^2 R}\right)}} = \frac{1}{1-\beta}$ Γ = gravitational gamma

$\Gamma \approx 1 + \frac{Gm}{c^2 r} \approx 1 + \beta$ (weak gravity approximations)

$\beta \equiv 1 - \frac{d\tau}{dt} = 1 - \sqrt{1 - \frac{2Gm}{c^2 R}} = 1 - 1/\Gamma$ β = gravitational magnitude

$\beta \approx \frac{Gm}{c^2 r} \approx \frac{gr}{c^2} \approx \frac{R_s}{r}$ (weak gravity approximation)

$\beta_q = H_\beta^2 = \frac{Gm^2}{\hbar c}$ β_q = gravitational magnitude in a rotar at R_q

Properties of Spacetime

$Z_s = \frac{c^3}{G} = 4.038 \times 10^{35}$ kg/s Z_s = impedance of spacetime

$K_s = \frac{F_p}{\lambda^2}$ K_s = bulk modulus of spacetime ($K \equiv \frac{\Delta\mathbb{P}}{\Delta V/V}$)

$U_i = \frac{c^2\omega^2}{G} = \frac{F_p}{\lambda^2} = \left(\frac{\omega}{\omega_p}\right)^2 U_p$ U_i = interactive energy density of spacetime

$H_{max} = \frac{L_p}{\lambda} = T_p\omega$ H_{max} = maximum displacement amplitude of a dipole wave in spacetime

Acceleration Equations

$g = c^2\left(\frac{d\beta}{dr}\right) = -\,c^2\frac{d\left(\frac{d\tau}{dt}\right)}{dr}$ g = gravitational acceleration

$g_q = \frac{H_\beta^3 c}{T_p} = A_g H_\beta = H_\beta^3 A_p = \frac{Gc^2m^3}{\hbar^2}$ g_q = gravitational acceleration at R_q

$A_g = H_\beta \omega_c c = L_p \omega_c^2 = \frac{g_q}{H_\beta} = H_\beta^2 A_p = \sqrt{\frac{m^4c^5G}{\hbar^3}}$ A_g = grav acceleration (inside rotar)

Normalized Transformations (assumes proper length is coordinate length)

$L_o = L_g$	unit of length	$\omega_o = \Gamma\ \omega_g$	frequency
$T_o = T_g/\Gamma$	unit of time	$k_o = \Gamma\ k_g$	Boltzmann's constant
$M_o = M_g/\Gamma$	unit of mass	$\sigma_o = \Gamma^2\ \sigma_g$	Stefan-Boltzmann constant
$Q_o = Q_g$	charge (coulombs)	$I_o = \Gamma I_g$	electrical current
$\Theta_o = \Theta_g$	temperature	$V_o = \Gamma\ V_g$	electrical potential
$C_o = \Gamma\ C_g$	normalized speed of light	$\varepsilon_{oo} = \varepsilon_{og}/\Gamma$	permittivity of vacuum
$dL = \Gamma\ dR$	circumferential radius	$\mu_{oo} = \mu_{og}/\Gamma$	permeability of vacuum
$E_o = \Gamma\ E_g$	energy	$p_o = p_g$	momentum
$v_o = \Gamma\ v_g$	velocity	$\alpha_o = \alpha_g$	fine structure constant
$F_o = \Gamma\ F_g$	force	$\Omega_o = \Omega_g$	electrical resistance
$P_o = \Gamma^2\ P_g$	power	$\mathcal{B}_o = \mathcal{B}_g$	magnetic flux density
$G_o = \Gamma^3\ G_g$	gravitational constant	$Z_{oo} = Z_{og}$	impedance of free space
$U_o = \Gamma\ U_g$	energy density	$Z_{so} = Z_{sg}$	impedance of spacetime
$\mathbb{P}_o = \Gamma\ \mathbb{P}_g$	pressure		
$\rho_o = \rho_g/\Gamma$	density		

Some Useful Dimensional Analysis Conversions

$U \rightarrow M/LT^2$	U = energy density	Dimensional Analysis Symbols:
$G \rightarrow L^3/MT^2$	G = gravitational constant	M = mass
$\hbar \rightarrow ML^2/T$	$\hbar$ = Planck constant	L = length
$Z_s \rightarrow M/T$	Z_s = impedance of spacetime	T = time
$Z_o \rightarrow ML^2/TQ^2$	Z_o = impedance of free space	Q = charge
$E \rightarrow ML^2/T^2$	E = energy	
$F \rightarrow ML/T^2$	F = force	
$\varepsilon_o \rightarrow T^2Q^2/ML^3$	ε_o = permittivity	
$\mu_o \rightarrow ML/Q^2$	μ_o = permeability	
$\mathcal{E} \rightarrow ML/T^2Q$	$\mathcal{E}$ = electric field	
$\mathcal{H} \rightarrow Q/LT$	$\mathcal{H}$ = "H" magnetic field (ampere/meter)	
$\mathcal{B} \rightarrow M/TQ$	$\mathcal{B}$ = "B" magnetic field (Tesla)	
$\Omega \rightarrow ML^2/TQ^2$	Ω = resistance	
$V \rightarrow ML^2/T^2Q$	V = electrical potential (voltage relative to neutral)	

Transformation of Planck Units into Spacetime Units

Planck Units	Standard Conversion	Spacetime Conversion
Planck length	$l_p = \sqrt{\hbar G/c^3}$	$l_p = cT_p$
Planck mass	$m_p = \sqrt{\hbar c/G}$	$m_p = Z_s T_p$
Planck frequency	$\omega_p = \sqrt{c^5/\hbar G}$	$\omega_p = 1/T_p$
Planck impedance	$Z_p = 1/4\pi\varepsilon_o c$	$Z_p = Z_s$
Planck charge	$q_p = \sqrt{4\pi\varepsilon_o \hbar c}$	$q_p = cT_p$
Planck energy	$E_p = \sqrt{\hbar c^5/G}$	$E_p = c^2 T_p Z_s$
Planck force	$F_p = c^4/G$	$F_p = cZ_s$
Planck power	$P_p = c^5/G$	$P_p = c^2 Z_s$
Planck energy density	$U_p = c^7/\hbar G^2$	$U_p = Z_s/cT_p^2$

Useful Cosmic Information

$\mathcal{H} = 2.29 \times 10^{-18}$ m/s/m $= 70.8$ km/s/Mpc $\mathcal{H} =$ Hubble parameter
1 parsec (pc) = 3.086×10^{16} m = 3.262 light years
1 light year (ly) = 9.4607×10^{15} m = 6.3241×10^{4} AU
Solar mass 1.989×10^{30} kg Solar radius 6.96×10^{8} m
Earth mass 5.974×10^{24} kg
Earth radius 6.378×10^{6} m (equator) and 6.357×10^{6} m (polar)
Earth: average acceleration of gravity 9.807 m/s^2 at equator: 9.78 m/s^2
Earth – Sun (mean radial distance) 1.496×10^{11} m = 1 AU
Milky Way galaxy; mass: (1.2 to 3) x 10^{42} kg; radius: ~50,000 ly; rotation rate ~ 200,000 years
Sun distance to galactic center ~ 27,000 ly
CMB ~ 2.735 °K, ~ 4×10^{8} photons/m^3, CMB energy density 4.2×10^{-14} J/m^3
Sun's motion relative to the CMB ≈ 369 km/s
Planck spacetime: $U_{ps} = 5.53 \times 10^{112}$ J/m^3, quantized energy units: ½$E_p = 9.78 \times 10^{8}$ J

Transformation of Standard Units into Spacetime Units

$\eta \equiv \frac{L_p}{q_p} = \frac{\sqrt{\alpha}L_p}{e} = \sqrt{\frac{1}{4\pi\varepsilon_o F_p}} = 8.617 \times 10^{-18}$ m/Coulomb $\eta =$ charge conversion constant

Name	Spacetime Conversion
Elementary charge (e)	$e = \sqrt{\alpha}L_p/\eta = \sqrt{\alpha}\ cT_p/\eta$
Planck charge (q_p)	$q_p = L_p/\eta$
Coulomb force constant ($1/4\pi\varepsilon_o$)	$1/4\pi\varepsilon_o = cZ_s/\eta^2$
Permeability of free space (μ_o)	$\mu_o/4\pi = \eta^2 Z_s/c$
Electric field of EM radiation ($\mathcal{E}_\gamma$)	$\mathcal{E}_\gamma = H\omega\sqrt{Z_s Z_o} = H\omega Z_s \eta$
Magnetic field of EM radiation ($\mathcal{H}_\gamma$)	$\mathcal{H}_\gamma = H\omega\sqrt{Z_s/Z_o} = H\omega/\eta$
Impedance of free space (Z_o)	$Z_o = \eta^2 4\pi Z_s$
Planck impedance (Z_p)	$Z_p = \eta^2 Z_s$
Planck constant ($\hbar$)	$\hbar = c^2 T_p^2 Z_s = L_p^2 Z_s$
Gravitational constant (G)	$G = c^3/Z_s$

Cosmology

$\Gamma_u(t) = a_u(t) = \frac{dt}{d\tau_u}$ Γ_u = background gamma of the universe

$\mathbb{C} = \frac{c}{\Gamma_u^2(t)} = \frac{d\mathbb{R}}{dt}$ $\mathbb{C}$ = coordinate speed of light in the universe

$\boldsymbol{C} \equiv \frac{d\mathbb{R}}{d\tau_u} = c/\Gamma_u$ $\boldsymbol{C}$ = hybrid speed of light

$\mathcal{H} = \frac{\frac{da_u}{d\tau_u}}{a_o} = \frac{\frac{d\Gamma_u}{d\tau_u}}{\Gamma_{uo}}$ or $\mathcal{H} = \frac{\dot{a_u}}{a_o} = \frac{\dot{\Gamma_u}}{\Gamma_{uo}}$ $\mathcal{H}$ = Hubble parameter

$\Gamma_u(t) = \frac{a_u(t)}{a_p} = \frac{dL}{d\mathbb{R}}$

$\frac{\lambda_2}{\lambda_1} = \frac{\Gamma_{u1}}{\Gamma_{u2}} = \frac{\upsilon_2}{\upsilon_1} = \frac{a_2}{a_1} = 1 + z$

$\frac{U_{ps}}{U_{obs}} = \Gamma_{uo}^3 \times \Gamma_{eq}$ $\frac{U_{ps}}{U_{obs}}$ = energy density ratio - Planck spacetime /observable

$U_{ps} \equiv \left(\frac{3}{8\pi}\right)\left(\frac{c^7}{\hbar G^2}\right) \approx 5.53 \times 10^{112}$ J/m³ U_{ps} = Planck spacetime energy density

Characteristics of an Electron

$H_\beta = 4.1851 \times 10^{-23}$ H_β = strain amplitude

$R_q = 3.8616 \times 10^{-13}$ m R_q = quantum radius

$\omega_c = 7.7634 \times 10^{20}$ s^{-1} ω_c = Compton angular frequency

$\upsilon_c = 1.2356 \times 10^{20}$ Hz υ_c = Compton frequency

$E_i = 8.1871 \times 10^{-14}$ J E_i = internal energy

$m_e = 9.1094 \times 10^{-31}$ kg m_e = electron's mass

$e = 1.6022 \times 10^{-19}$ Coulomb e = elementary charge

$P_c = 6.3560 \times 10^7$ w P_c = circulating power

$F_m = 0.21201$ N F_m = maximum force at distance of R_q

$R_s = 6.7635 \times 10^{-58}$ R_s = classical Schwarzschild radius

$U = E_i/R_q^3 = 1.4218 \times 10^{24}$ J/m³ U = energy density (cubic – ignores constant)

$U = (3/4\pi)E_i/R_q^3 = 3.3942 \times 10^{23}$ J/m³ U = energy density (spherical)

$A_q = 9.7404 \times 10^6$ m/s² A_g = grav acceleration at center of quantum volume

$g_q = 4.0764 \times 10^{-16}$ m/s² g_q = gravitational acceleration at R_q

$I_e = e\upsilon_c \approx 19.796$ amps I_e = equivalent circulating current

$\mathscr{B}_e = 3.22 \times 10^7$ Tesla $\mathscr{B}_e$ = internal magnetic field

Symbol Definitions (Roman alphabet):

a_o = cosmological comoving scale factor at the present time
a_p = cosmological scale factor of Planck spacetime (when $\underline{\boldsymbol{t}}_u = 1$)
a_u = cosmological scale factor of the universe relative to Planck spacetime
a_{em} = cosmological scale factor at emission
a_{obs} = cosmological scale factor at observation
A_g = rotar's grav acceleration at the center of the quantum volume
A_o = original area before stress applied in Young's modulus definition
$\mathscr{B}$ = "B" magnetic field; magnetic flux density; magnetic induction
$\mathscr{B}_e$ = electron's internal magnetic field $\mathscr{B}_e \approx 3.22 \times 10^7$ Tesla
$\mathscr{B}_o$ and $\mathscr{B}_g$ = normalized magnetic flux density
c = speed of light (3×10^8 m/s)
C_o = normalized speed of light in zero gravity $C_o = c$
C_g = normalized speed of light in gravity $C_o = \Gamma\ C_g$
C_r = speed of light in the radial direction relative to C_o
C_t = speed of light in the tangential direction relative to C_o
$\boldsymbol{C}$ = hybrid coordinate speed of light $\boldsymbol{C} = d\mathbb{R}/d\tau_u$
$\mathbb{C}_u$ = cosmological coordinate speed of light $\mathbb{C}_u = d\mathbb{R}/dt = c/\Gamma_u^2$
$\mathbb{C}_1$ = cosmological coordinate speed of light for $\Gamma_u = 1$
$\mathcal{C}_T$ = coordinate speed of light in the tangential direction (Schwarzschild metric $dR = 0$)
$\mathcal{C}_R$ = coordinate speed of light in the radial direction (Schwarzschild metric $d\Omega = 0$)
d_m = dipole moment
e = elementary electrical charge ($e = 1.6 \times 10^{-19}$ coulomb)
E = energy
$\underline{\boldsymbol{E}}$ = energy in Planck units $\underline{\boldsymbol{E}} = E/E_p$
$\mathcal{E}$ = electric field
$\mathcal{E}_\gamma$ = electric field strength in EM radiation
E_i = internal energy for a particle: $E_i = mc^2 = \omega_c\hbar$
E_p = Planck energy $E_p = \sqrt{\hbar c^5/G} = 1.956 \times 10^{9}$ J
$E_{\mathcal{E}}$ = energy in the electric field external to "r" for charge e $E_{\mathcal{E}} = \alpha\hbar c/2r$
E_{el} = elastic potential energy in the context of bulk modulus
E_g = energy of the mass in gravity but measured using the zero gravity standard of energy
E_g = normalized energy of an object in gravity but measured using zero gravity standards
E_k = kinetic energy of mass falling from zero gravity to distance r from mass M
E_o = energy of a mass in zero gravity measured using the zero gravity standard of energy
E_y = Young's modulus E_y = stress/strain = $FL_o/A_o\Delta L$
E_u = Cosmological unit of energy for $\Gamma_u > 1$
E_1 = Cosmological unit of energy for $\Gamma_u = 1$
F = force
F_e = electromagnetic force - assumes charge e particles $F_e = e^2/4\pi\varepsilon_o r^2$
$\underline{\boldsymbol{F}}_e$ = electromagnetic force in dimensionless Planck units - assumes Planck charge particles
$F_{\mathcal{E}}$ = electromagnetic force - assumes Planck charge particles $F_e = q_p^2/4\pi\varepsilon_o r^2$
$\underline{\boldsymbol{F}}_{\mathcal{E}}$ = electromagnetic force in dimensionless Planck units - assumes charge e particles
F_g = gravitational force $F_g = (G\,mM)/r^2$
$\underline{\boldsymbol{F}}_g$ = gravitational force in Planck units

F_g = normalized force in gravity but using zero gravity standards (note symbol duplication)
F_o = normalized force in zero gravity
F_m = maximum force possible at a distance of $R_q = m^2c^3/\hbar$
F_s = the strong force at distance R_q
F_p = Planck force $F_p = c^4/G$ $F_p = 1.210 \times 10^{44}$ N
F_r = relativistic force $F_r = P/c$
F_w = weak force at distance R_q
g = acceleration of gravity
G = gravitational constant
G_o and G_g = normalized gravitational constant using zero gravity standards
$g_{oo}, g_{11}, g_{22}, g_{33}$ = general relativity matrix coefficients
H = wave amplitude
$\boldsymbol{\mathcal{H}}$ = "H" magnetic field; magnetic field strength; magnetic field intensity
$\boldsymbol{\mathcal{H}}_\gamma$ = magnetic field strength in EM radiation
$\mathcal{H}$ = Hubble parameter currently $\mathcal{H} \approx 2.29 \times 10^{-18}$ m/s/m
h = Planck constant $h = 6.626 \times 10^{-34}$ J s
$\hbar$ = reduced Planck constant: $h\ bar = \hbar = h/2\pi = 1.055 \times 10^{-34}$ J s
H_f = fundamental amplitude of a spacetime wave prior to any cancellation $H_f = L_p/r$
H_β = strain amplitude in the quantum volume of a rotar
$H_{\beta e}$ = wave amplitude required for a rotar's electromagnetic characteristics at R_q
$H_{\beta g}$ = amplitude of the nonlinear wave at distance R_q ($H_{\beta g} = H_\beta^2$)
$H_{\beta w}$ = speculative amplitude of the weak force
H_e = amplitude of the wave responsible for electric field of charge e $H_e = \sqrt{\alpha}\ L_pR_q/r^2$
H_{eq} = electric field standing wave amplitude at distance R_q $H_{eq} = \sqrt{\alpha}\ L_p/R_q$
H_{gw} = amplitude of a gravitational wave ($H_{gw} = 2\,\Delta L/L \approx k\,G\,\omega^2\mathbb{I}\,\varepsilon/c^4\,r$)
H_{max} = maximum strain amplitude permitted for a dipole wave
I_e = electron's equivalent circulating current $I_e = e\nu_c \approx 19.796$ amps
$\mathcal{I}$ = intensity
$\mathbb{I}$ = moment of inertia
k = dimensionless constants (k_1, k_2, etc.)
$k' = 3/8\pi$ (a constant used in cosmology)
K_b = bulk modulus
k_B = Boltzmann constant $\approx 1.38 \times 10^{-23}$ J/m^3
K_B = bulk modulus
K_p = Planck bulk modulus = $c^7/\hbar G^2$
K_s = bulk modulus of spacetime: $K_s = F_p/\lambda\!\!\!^{-2} = F_p(\omega/c)^2$
L = dimensional analysis symbol representing length
L_g = normalized length $dL_g = cd\tau$
L_o = normalized length $dL_o = cdt$
L_o = in the context of Young's modulus, L_o is the original length before stress
$\boldsymbol{\mathcal{L}}$ = angular momentum
$\boldsymbol{\mathcal{L}}_o$ and $\boldsymbol{\mathcal{L}}_g$ = normalized angular momentum
L_r & L_t = proper length in the radial or tangential direction respectively
l_p = Planck length = $\sqrt{\hbar G/c^3} = 1.616 \times 10^{-35}$ m (a static unit of length)
L_p = dynamic Planck length (wave amplitude of l_p)

L_u = cosmological unit of length for $\Gamma_u > 1$
m = mass
$\underline{\boldsymbol{m}}$ = mass in dimensionless Planck units
m_p = Planck mass $m_p = \sqrt{\hbar c/G} = 2.176 \times 10^{-8}$ kg
m_e = mass of an electron = 9.1094×10^{-31} kg
m_r = pseudo rest mass when index of refraction $n > 1$
M = dimensional analysis symbol representing mass
M_o and M_g = normalized unit of mass
M_u = cosmological unit of mass for $\Gamma_u > 1$
$\mathbb{M}_1$ = cosmological unit of mass for $\Gamma_u = 1$
N = an integer number
$\mathcal{N}$ = the distance between two rotars expressed as a multiple of R_q (number of R_q units)
n_k = the index of refraction which includes the optical Kerr effect contribution
n_o = the index of refraction at zero intensity
p = momentum
p_p = Planck momentum $p_p = m_p c = \sqrt{\hbar c^3/G} \approx 6.525$ kg m/s
P = power
P_c = a Particle's circulating power $P_c = E_i\, \omega_c$
$\underline{\boldsymbol{P}}_c$ = circulating power in Planck units
$\mathbb{P}$ = pressure
$\mathbb{P}_p$ = Planck pressure $\mathbb{P}_p = c^7/\hbar G^2 = 4.636 \times 10^{113}$ N/m^2 $(= U_p)$
P_p = Planck power $P_p = c^5/G$
$\mathbb{P}_q$ = pressure generated by a rotar $\mathbb{P}_q = (\omega_c{}^4\hbar/c^3) = E_i/R_q{}^3 = U_q$
q = electrical charge
Q_o, & Q_g = dimensional analysis units of charge used in various transformations
Q_1 = cosmological unit of charge for $\Gamma_u = 1$
Q_u = cosmological unit of charge for $\Gamma_u > 1$
$Q_p \equiv \sqrt{4\pi\varepsilon_o \hbar c} = e/\sqrt{\alpha} \approx 11.7e \approx 1.876 \times 10^{-18}$ Coulomb
r = radial distance (proper length)
R = circumferential radius from general relativity (circumference/2π)
$\mathbb{R}$ = a unit of coordinate length pertaining to cosmology $d\mathbb{R} = dL_u/\Gamma_u$
$\mathbb{R}_1$ = cosmological unit of length for $\Gamma_u = 1$
r_h = radius of the Hubble sphere
r_{ph} = radius of the particle horizon
R_s = classical Schwarzschild radius: $R_s = Gm/c^2$
r_s = relativistic Schwarzschild radius $r_s = 2Gm/c^2$
$R_q \equiv$ quantum radius of a rotar $R_q \equiv \hbar/mc$
$\underline{\boldsymbol{R}}_q$ = quantum radius R_q in Planck units $\underline{\boldsymbol{R}}_q = R_q/l_p$
t = either time or coordinate time (depends on context)
t_c = time indicated on the coordinate clock
T = dimensional analysis symbol representing time
$\mathbb{T}$ = temperature
T_g = normalized unit of time in gravity
T_o = normalized unit of time in zero gravity
T_u = cosmological unit of time for $\Gamma_u > 1$

$\mathbb{T}_1$= cosmological unit of time for $\Gamma_u = 1$
t_p = Planck time $t_p = \sqrt{\hbar G/c^5} = 5.391 \times 10^{-44}$ s
T_p = dynamic Planck time (a wave amplitude with dimension of Plank time)
$\mathbb{T}_p$ = Planck temperature = $E_p/k_B \approx 1.4168 \times 10^{32}$ °K
u_d = de Broglie wave group velocity $u_d = v$
U = energy density
U_{el} = energy density of elastic potential energy (bulk modulus)
U_i = interactive energy density encountered by a wave in spacetime $U_i = c^2\omega^2/G$
U_o = energy density in coordinate units (assumes $\Gamma = 1$)
U_g = energy density in a location with gravity ($\Gamma > 1$)
U_u = energy density in the universe when $\Gamma_u > 1$
U_p = Planck energy density $U_p = c^7/\hbar G^2 = 4.636 \times 10^{113}$ J/m^3
U_{ps} = energy density of Planck spacetime $U_{ps} = (3/8\pi)(c^7/\hbar G^2) \approx 5.53 \times 10^{112}$ J/m^3
U_q = energy density of a rotar $U_q = E_i/R_q^3 = (\omega_c^4\hbar/c^3) = \mathbb{P}_q$
U_u = cosmological unit of energy density for $\Gamma_u > 1$
U_1 = cosmological unit of energy density for $\Gamma_u = 1$
v = velocity
v_e = escape velocity $v_e = (2Gm/R)^{1/2}$
V= Volume and Electrical potential
$\underline{V}$ = Voltage (electrical potential) in Planck units
V_q = quantum volume $V_q = (4\pi/3)\, R_q^3$
V_p = Planck electrical potential (voltage) $V_p = E_p/Q_p = \sqrt{c/4\pi\varepsilon_o G}$
w_d = de Broglie wave phase velocity $w_d = c^2/v$
w_m = velocity of the modulation wave envelope (moving resonator) $w_m = c^2/v$
$\mathbb{X}$ = maximum displacement produced by dipole wave in spacetime
z = cosmological redshift
z_{eq} = cosmological redshift since the radiation/matter equality transition
$\Gamma_{eq} = \Gamma_u$ at the radiation/matter equality transition
Z = impedance
Z_s = spacetime impedance $Z_s = c^3/G$
Z_{s1} = cosmological impedance of spacetime for $\Gamma_u = 1$
Z_{su} = cosmological impedance of spacetime for $\Gamma_u > 1$
Z_e = electromagnetic impedance of free space $Z_e \approx 377\ \Omega$
Z_a = acoustic impedance $Z_a = \rho c_a$ (density x speed of sound)
Z_{oo} = normalized impedance of free space (zero gravity)
Z_{og} = normalized impedance of free space (in gravity)
Z_p = Planck impedance $Z_p = 1/4\pi\varepsilon_o c \approx 29.98\ \Omega$

Greek Symbols

α = fine structure constant $\alpha = e^2/4\pi\varepsilon_o\hbar c \approx 1/137$

β = gravitational magnitude $\beta \equiv 1 - (1 - 2Gm/c^2R)^{1/2} = 1 - 1/\Gamma = 1 - d\tau/dt \approx gm/c^2r$
β_q = gravitational magnitude at distance R_q $\beta_q = H_\beta^2 = Gm^2/\hbar c$
β_u = background gravitational magnitude of the universe $\beta_u = 1 - 1/\Gamma_u = 1 - d\tau_u/dt$
Γ = gravitational gamma $\Gamma = (1-2Gm/rc^2)^{-1/2}$
Γ_q = gravitational gamma at distance of R_q $(\Gamma_q - 1) \approx (Gm^2/\hbar c)$
Γ_u = background gravitational gamma of the universe $\Gamma_u = dt/d\tau_u = a_u/a_p$
Γ_{uo} = the current value of Γ_u where $\Gamma_{uo} \approx 2.6 \times 10^{31}$
$\Gamma_{obs} = \Gamma_u$ at the time an observation of a photon is made
$\Gamma_{em} = \Gamma_u$ at the time of emission of a photon
$\Gamma_{eq} = \Gamma_u$ at the radiation/matter equality transition
γ = special relativity gamma $\gamma = (1 - v^2/c^2)^{-1/2}$
ε = asymmetry of an object - uniform sphere has $\varepsilon = 0$, two equal point masses have $\varepsilon = 1$
ε_o = permittivity of vacuum
ξ = spin axis probability
ξ_a = acoustic amplitude (particle displacement)
η = charge conversion constant $\eta \equiv L_p/Q_p = 8.617 \times 10^{-18}$ meters/Coulomb
Θ_o and Θ_g = normalized temperature
θ = angle symbol
λ = wavelength
$ƛ$ = reduced wavelength: lambda bar = $ƛ = \lambda/2\pi = c/\omega$
λ_d = De Broglie wavelength $\lambda_d = h/mv$
λ_{dd} = wavelength of confined photon in moving frame of reference (relativistic contraction)
λ_m = modulation envelope wavelength; $\lambda_m = \lambda_o c/v$
λ_c = Compton wavelength $\lambda_c = \hbar/mc$
λ_o = original wavelength or wavelength in zero gravity
λ_g = wavelength in gravity (blue shifted)
λ_{em} & λ_{obs} = wavelength at emission and observation respectively
λ_γ = wavelength of confined light (chapter 1)
$\boldsymbol{\lambda}$ = wavelength of light when measured in units of coordinate length.
Λ = cosmological constant
μ_B = Bohr magnetron = $e\hbar/2m_e = 9.274 \times 10^{-24}$ J/Tesla
μ_o = permeability of vacuum $\mu_o = 4\pi\times10^{-7}$ m kg/C^2 = 1.257×10^{-6} m kg/C^2
ν = frequency
ν_c = Compton frequency $\nu_c = mc^2/h$
υ_{obs} & υ_{em} = cosmological observed frequency & emitted frequency
ρ = matter density
ρ_p = Planck density $\rho_p = c^5/\hbar G^2$
σ = Stefan-Boltzmann constant
τ = proper time – time interval on a local clock
τ_d = time indicated on the dipole clock
τ_{obs} = (cosmological) proper age of the universe at the time an observation is made
τ_{em} = (cosmological) proper age of the universe at the time of emission of a photon
τ_u = (cosmological) proper age of the universe at arbitrary time (cosmic time)
τ_{uo} = (cosmological) current proper age of the universe (cosmic time)
$\underline{\boldsymbol{\tau}}_u$ = (cosmological) age of the universe in nondimensional Planck units $\underline{\boldsymbol{\tau}}_u = \tau_u/t_p$

$\mathcal{T}$ = emission lifetime
χ = distance in comoving coordinates
Ψ = psi function
ω = angular frequency
ω_c = Compton angular frequency of a Particle *($\omega_c = mc^2/\hbar$)*
$\underline{\boldsymbol{\omega_c}}$ = Compton angular frequency in Planck units $\underline{\boldsymbol{\omega_c}} = \omega_c/\omega_p$
ω_p = Planck angular frequency $\omega_p = \sqrt{c^5/\hbar G}$ = 1.855 x 10^{43} s^{-1}
Ω = a solid angle in a spherical coordinate system *($d\Omega^2 = d\theta^2 + \sin^2\theta\, d\Phi^2$)*
Ω = symbol representing electrical resistance
Ω_M = matter density parameter
Ω_Λ = cosmological constant density parameter

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