Chapter 8

Gravitational Attraction and Unification of Forces

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 $\lambda\!\!\!^{-}_c$ from a rotar we calculated the gravitational force using one of the 5 wave-amplitude equations $F = A^2\omega^2 Z\mathcal{A}/c$. In this calculation we substituted $A = A_\beta{}^2 = (L_p/\lambda\!\!\!^{-}_c)^2 = (T_p\omega_c)^2$. Also the angular frequency ω is equal to the rotar's Compton frequency $\omega = \omega_c$. At distance $\lambda\!\!\!^{-}_c$ of two of the same rotars we obtained $F = Gm^2/\lambda\!\!\!^{-2}_c$. This is the correct magnitude of the gravitational force between two rotars of mass m, but there are two problems. First: the equation $F = A^2\omega^2 Z\mathcal{A}/c$ 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 we are dealing with dipole waves in spacetime which modulate both the rate of time and volume. There are two ways that we can express the amplitude of the dipole 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 $\Delta l/l = L_p/\lambda\!\!\!^{-}_c$ and $\Delta t/t = T_p\omega_c$.

In chapter 5 we imagined a hypothetical perfect clock placed at a point on the "Compton circle" of a rotar as illustrated in figure 5-1. This is the imaginary circle with radius equal to the rotar radius $\lambda\!\!\!^{-}_c$. 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 rotar volume, the strain of spacetime is designated by the strain amplitude $A_\beta = T_p\omega_c = L_p/ƛ_c$. 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 interesting questions: Does the dipole clock always return to perfect synchronization with the coordinate clock at the completion of each cycle? Does the volume oscillation of spacetime produce a net change in the average volume near a rotar? Since we are going to initially concentrate on explaining the gravitational force between two fundamental particles, we will initially concentrate on the effect on time. Therefore, does the rate of time oscillation cause the dipole clock to 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 = $A_\beta \sin\omega t + (A_\beta \sin\omega t)^2 \ldots$ (higher order terms ignored)

The linear component is "$A_\beta \sin\omega t$" and the first term in the nonlinear component is $(A_\beta \sin\omega t)^2$. There would also be higher order terms where A_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:

$$(A_\beta \sin\omega t)^2 = A_\beta^2 \sin^2\omega t = ½\, A_\beta^2 - ½\, A_\beta^2 \cos 2\omega t$$

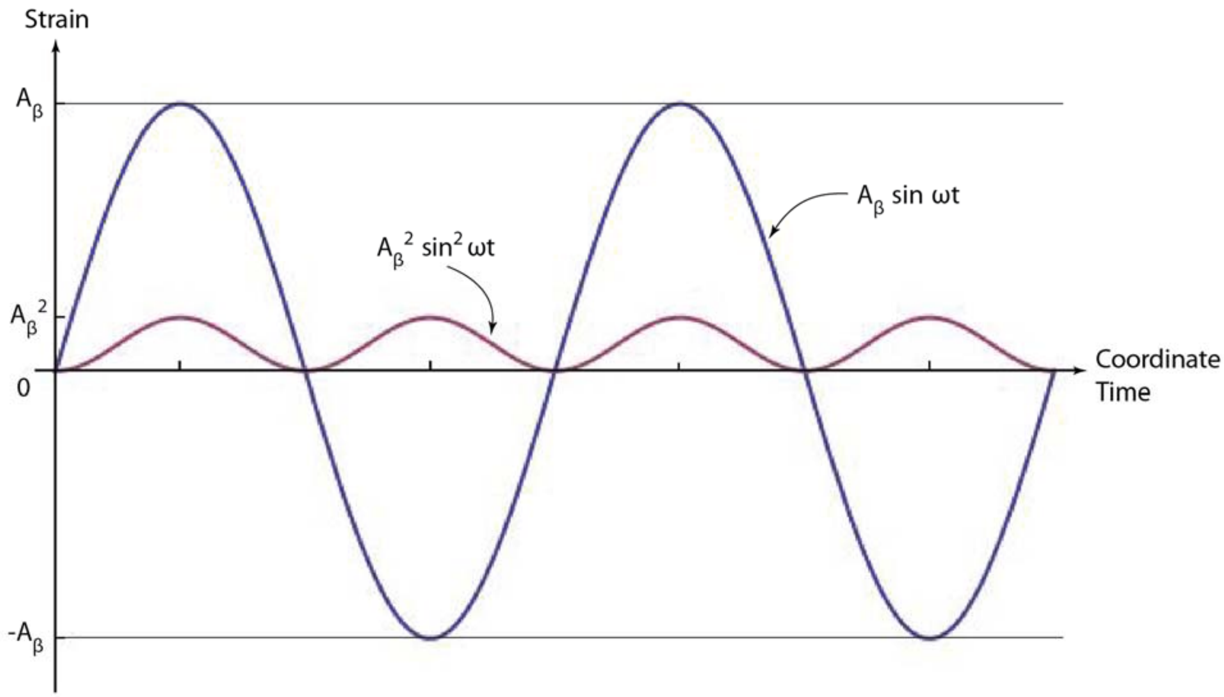

FIGURE 8-1

Figure 8-1 plots the linear component *(A_β sinωt)* and the nonlinear component *(A_β sinωt)^2* separately. It can be seen that the nonlinear component is a smaller amplitude because $A_\beta < 1$ 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 A_β is roughly in the range of 10^{-20}. This means that $A_\beta^2 \approx 10^{-40}$ and therefore A_β is approximately 10^{20} times larger than A_β^2. It would be impossible to see the plot of $A_\beta^2 \sin^2\omega t$ without artificially increasing this relative amplitude. Therefore, the assumed value in this figure is $A_\beta = 0.2$. In this case the difference between A_β and A_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}.

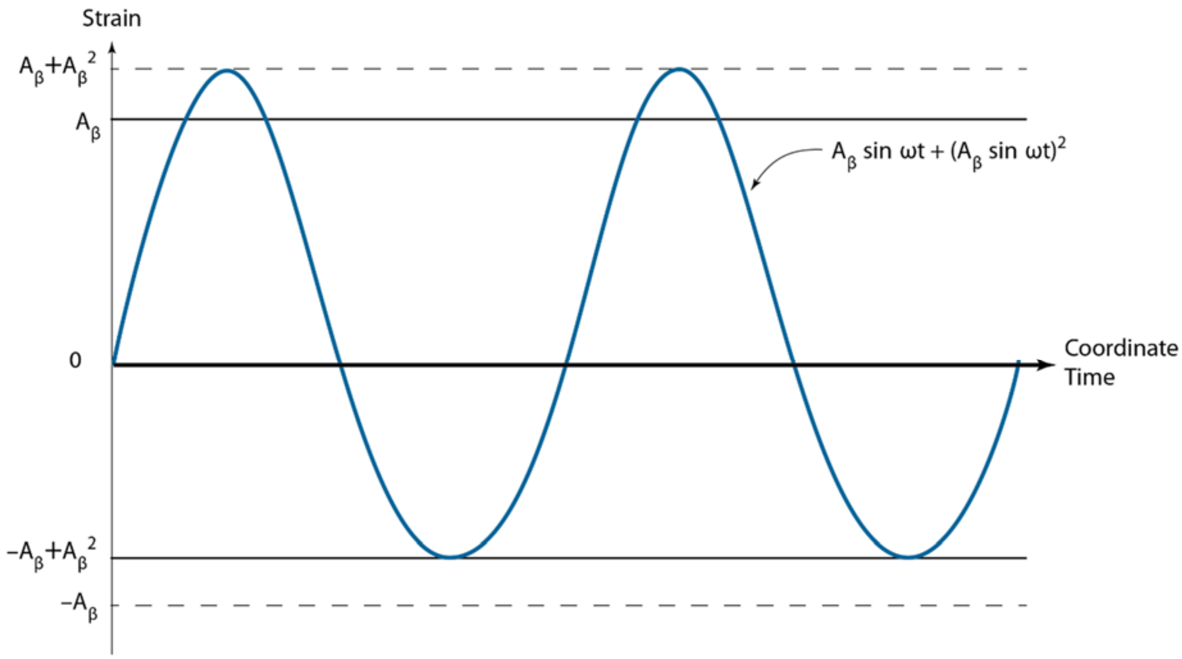

FIGURE 8-2

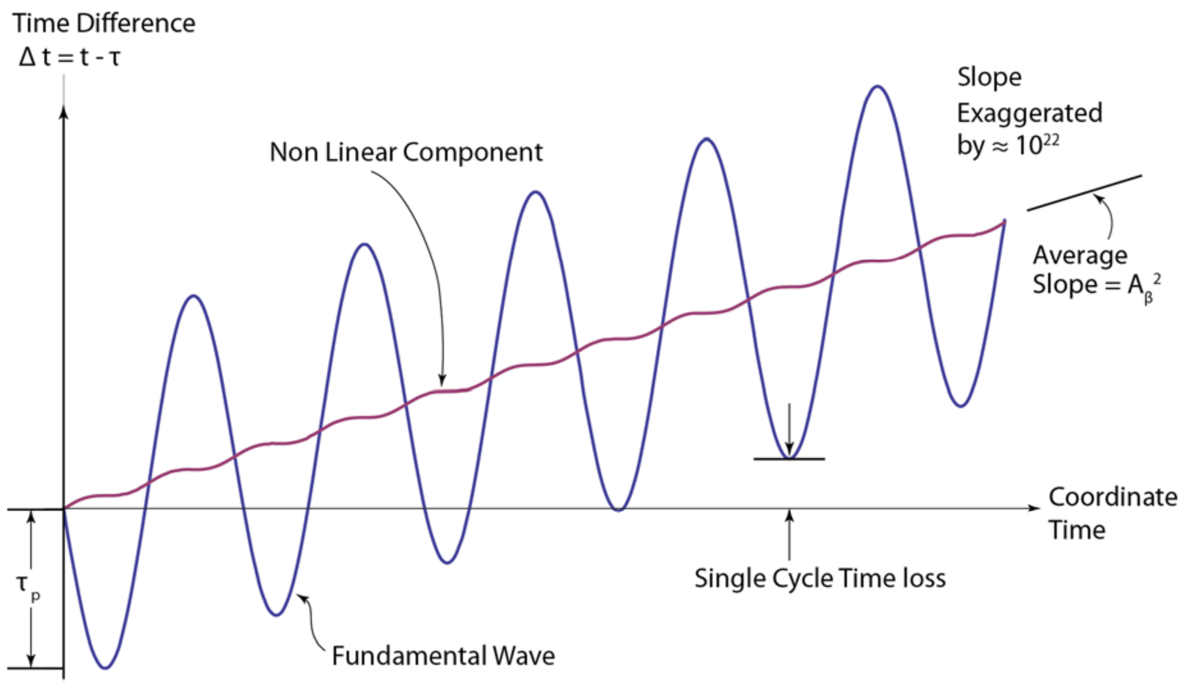

FIGURE 8-3

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 $A_\beta + A_\beta^2$ while the negative portion has peak negative amplitude of: $-A_\beta + A_\beta^2$. 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 2.2×10^{-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 $A_\beta^2 sin^2\omega t$ at distance $\lambda\!\!\!^-_c$ 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 $A_\beta sin\omega t$) is shown as the wavy line labeled "nonlinear component". The average slope of this line is equal to the gravitational magnitude for the rotar volume which has been designated as $A_\beta^2 = \beta_q$. For an electron this slope is about $1.75\text{x}10^{-45}$ 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 $4\text{x}10^{21}$ 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 A_β^2 at distance $\lambda\!\!\!^-_c$ which is obtained from the strain equation – the important part is highlighted bold

$$A_\beta sin\omega t + (A_\beta sin\omega t)^2 = A_\beta sin\omega t - ½ A_\beta^2 cos2\omega t + ½ \mathbf{A_\beta^2}$$

Derivation of Curved Spacetime: The DC equivalent term (non-oscillating term) is A_β^2. This is the nonlinear strain in spacetime produced by the rotar at distance $\lambda\!\!\!^-_c$. This is an important concept since it relates to curved spacetime. Before perusing this thought further it is necessary to introduce a new symbol: $\mathcal{N}$. The natural unit of length for a rotar is $ƛ_c$. Therefore we will designate the radial distance from a rotar not in units of length such as meters, but as the number $\mathcal{N}$ of reduced Compton wavelengths (number of rotar radius units).

$$\mathcal{N} \equiv \frac{r}{ƛ_c} = \frac{mcr}{\hbar}$$

For example, the non-oscillating strain in spacetime produced by a rotar should decrease proportional to $1/\mathcal{N}$. We can test this idea since the proposal is that the non-oscillating strain in spacetime at distance $ƛ_c$ (where $\mathcal{N} = 1$) is equal to $A_\beta{}^2$ and this decreases as $1/\mathcal{N}$. We will evaluate $A_\beta{}^2/\mathcal{N}$ and call this the gravitational amplitude A_g.

$$A_g = \frac{A_\beta^2}{\mathcal{N}} = \left(\frac{L_p^2}{ƛ_c^2}\right)\left(\frac{ƛ_c}{r}\right) = \frac{Gm}{c^2 r}$$

Therefore we have succeeded in producing the previously discussed weak gravity gravitational magnitude $\beta \approx Gm/c^2r$. This is the curvature of spacetime that we associate with gravity.

This simple evaluation is another success of this model because the term Gm/c^2r is the weak gravity curvature of spacetime produced by mass m at distanced r. For example, the previously defined gravitational magnitude is $\beta \equiv 1 - (d\tau/dt)$. The weak gravity temporal distortion of spacetime is: $dt/d\tau \approx 1 + (Gm/c^2r)$. In flat spacetime $dt/d\tau = 1$, so the weak gravity curvature term is $\beta \approx (Gm/c^2r)$. For fundamental particles (rotars) at distance $ƛ_c$ this term is in the range of 10^{-40}, so this is virtually exact.

The question of how matter "causes" curved spacetime has been a major topic in general relativity and quantum gravity. Now we see the mechanism of how dipole waves in spacetime produce both matter and curved spacetime. This uses equations from quantum mechanics to derive an equation from general relativity. This is not only a successful test of the spacetime based model, but it is also a prediction of this model of the mechanism that achieves curved spacetime.

Oscillating Component of Gravity: There is proposed to be another residual gravitational effect that has not been observed because it is a very weak oscillation at a frequency in excess of 10^{20} Hz. 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 $ƛ_c$ this oscillating component has amplitude $A_\beta{}^2$ and frequency $2\omega_c$. What happens to this oscillating component beyond $ƛ_c$ 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 $A_\beta^2/\mathcal{N}$, 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 $A_\beta^2/\mathcal{N}^2$. This would be an extremely small amplitude and furthermore it is a standing wave that does not radiate energy. However, this oscillating component would theoretically give energy density to a gravitational field. The energy density of a gravitational field and its contribution to producing curved spacetime will be discussed at the end of chapter 10. The oscillating component of a gravitational field may also be important in the evolution of the universe. This will be discussed in chapters 13 and 14.

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 rotar volume, the cancelation wave generated in the vacuum energy must have an outward propagating component of 64 million watts attempting to leave the rotar's volume 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 outward or inward propagating waves. We would only see the sum of these two waves which is a standing wave which decreases in amplitude with distance from the central rotar. A standing wave in the rotar's external volume means that no power is being radiated. These standing waves cause the rotar's electric field (discussed later). We would also see that there was a slight non-oscillating residual strain in spacetime with strain amplitude of $A_\beta^2/\mathcal{N} = gm/c^2 r$.

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 the pressure of the spacetime field 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 $d\beta/dr$ that exists across the rotar 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 $\lambda\!\!\!^-_c$) 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 rotar radius $\lambda\!\!\!^-_c$ 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 $r + ƛ_c$ from a rotar of mass m.

$$\Delta\beta = \left(\frac{Gm}{c^2 r}\right) - \left(\frac{Gm}{c^2 (r + ƛ_c)}\right) \approx \frac{Gmƛ_c}{c^2 r^2} \qquad \text{approximation valid if } ƛ_c << r$$

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:

$$F = \Delta\beta\, F_m = \left(\frac{Gmƛ_c}{c^2 r^2}\right)\left(\frac{m^2 c^3}{\hbar}\right) = \left(\frac{Gm}{c^2 r^2}\right)\left(\frac{\hbar}{mc}\right)\left(\frac{m^2 c^3}{\hbar}\right) = \frac{Gm^2}{r^2}$$

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, $ƛ_c$ and F_m are for mass m_1 and $\Delta\beta$ is change in the gravitational magnitude from mass m_2 across the rotar radius $ƛ_c$ from mass m_1.

$$F_g = \Delta\beta\, F_m \approx \left(\frac{Gm_2 ƛ_{c1}}{c^2 r^2}\right)\left(\frac{m_1^2\, c^3}{\hbar}\right) = \left(\frac{Gm_2}{c^2 r^2}\right)\left(\frac{\hbar}{m_1 c}\right)\left(\frac{m_1^2 c^3}{\hbar}\right)$$

$$F_g \approx \frac{\mathrm{Gm_1 m_2}}{\mathrm{r^2}} \qquad \text{Newtonian gravitational force equation derived from a dipole wave model}$$

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 E_i = 8.19x10^{-14} J and a rotar radius of λ_c = 3.86x10^{-13} m. Ignoring dimensionless constants, this gives an energy density of about $E_i/\lambda_c^3 \approx$ 1.4x10^{24} J/m^3. This rotar model of an electron is exerting a pressure of roughly 1.4x10^{24} N/m^2. This pressure over area λ_c^2 produces the rotar's maximum force which for an electron is F_m = 0.212 N (obtained from $\mathbb{P}_q\lambda_c^2 \approx$ 1.4x10^{24} N/m^2 ×(3.86x10^{-13} m)^2 = 0.212 N).

The weak gravity gravitational magnitude is: $\beta \approx Gm/c^2r$. For the earth m = 5.96x10^{24} kg and the equatorial radius is: r = 6.37x10^6 m. Therefore, at the surface of the earth the gravitational magnitude is: $\beta \approx$ 6.95x10^{-10}. To obtain the gradient in this magnitude we divide by the earth's equatorial radius 6.37x10^6 m to obtain a gradient of $d\beta/dr$ = 1.091x10^{-16}/m. The change in gravitational magnitude $\Delta\beta$ across the rotar radius (3.862 x 10^{-13} m) of an electron is:

$\Delta\beta$ = (1.091x10^{-16}/m) (3.862x10^{-13} m) = 4.213x10^{-29} $\Delta\beta$ across an electron's λ_c

The electron's internal pressure is being stabilized by the pressure being exerted by the spacetime field. However, the homogeneous spacetime field in zero gravity is modified by the earth's gravitational field. As previously calculated, gravity affects not only the rate of time and proper volume, but also the unit of force, energy, etc. The previously calculated normalized force transformation is: $F_o = \Gamma F_g$. The gradient in the earth's gravitational field means that a slightly different value of Γ exists on opposite sides of the electron. This is more conveniently expressed as a difference in the gravitational magnitude $\Delta\beta$ that exists across the electron's radius λ_c. There will be a slight difference in the force exerted by the spacetime field exerted on opposite hemispheres of the electron (rotar). Calculating this difference should equal the magnitude of the gravitational force on the electron.

$F = \Delta\beta F_m$ = 4.213x10^{-29} x 0.212 N = 8.89x10^{-30} N

We will now check this by calculation the force exerted on an electron by the earth's gravity using $F = mg$ where the earth's gravitational acceleration is: g = 9.78 m/s^2

$F = mg$ = 9.1x10^{-31} kg x 9.78 m/s^2 ≈ 8.89x10^{-30} N

Success! The answer obtained from the calculation using $F = \Delta\beta F_m$ is exactly correct. 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.

Electrostatic Force at Arbitrary Distance: The strain amplitude of the spacetime wave inside the rotar volume has been designated with the symbol $A_\beta = L_p/\lambda\!\!\!^{-}_c = T_p\omega_c$. We have just shown that the gravitational effect external to the rotar volume scales with $A_g = A_\beta^2/\mathcal{N} = gm/c^2r$. This is the gravitational curvature of spacetime produced by a rotar with radius $\lambda\!\!\!^{-}_c$ and angular frequency ω_c. Now we will examine the electromagnetic effect on spacetime produced by the effect of the fundamental wave with amplitude A_β (not squared). From chapter 6 we know that this amplitude is associated with the electrostatic force. Now we will extend this to arbitrary distance. As before, we need to match the known amplitude at distance $\lambda\!\!\!^{-}_c$. This is achieved by scaling distance using $\mathcal{N} \equiv r/\lambda\!\!\!^{-}_c$ because $\mathcal{N} = 1$ at distance $\lambda\!\!\!^{-}_c$. We will again assume that the electrostatic amplitude A_E decreases as $1/\mathcal{N}$ for the electrostatic force we assume $A_E = A_\beta/\mathcal{N} = (L_p/\lambda\!\!\!^{-}_c)(\lambda\!\!\!^{-}_c/r)$. We will use the equation $F = kA^2\omega^2 Z\mathcal{A}/c$ and also insert the following: $F = F_E$, $\omega = \omega_c$, $Z = Z_s = c^3/G$, $\mathcal{N} = r/\lambda\!\!\!^{-}_c$, $= k\lambda\!\!\!^{-}_c{}^2$ and $\hbar c = q_p^2/4\pi\varepsilon_o$

$$F_E = A_E^2\omega_c^2 Z_s\mathcal{A}/c = \left(\frac{L_p}{\lambda\!\!\!^{-}_c}\right)^2\left(\frac{\lambda\!\!\!^{-}_c}{r}\right)^2\left(\frac{c}{\lambda\!\!\!^{-}_c}\right)^2\left(\frac{c^3}{G}\right)\left(\frac{\lambda\!\!\!^{-}_c{}^2}{c}\right) = k\frac{\hbar c}{r^2} = k\frac{q_p^2}{4\pi\varepsilon_o r^2}$$

Therefore, we have generated the Coulomb law equation where the charge is $q = q_p$ (Planck charge). It should not be surprising that the charge obtained is Planck charge rather than elementary charge e. Planck charge is $q_p = \sqrt{4\pi\varepsilon_o\hbar c}$ (about 11.7 times charge e) and is based on the permittivity of free space ε_o. Planck charge is known to have a coupling constant to photons of 1 while elementary charge e has a coupling constant to photons of α, the fine structure constant. This calculation is actually the maximum possible electrostatic force which would require a coupling constant of 1. The symbol F_E implies the electrostatic force between two Planck charges while F_e implies the electrostatic force between two elementary charges e. The conversion is $F_E = F_e\,\alpha^{-1}$.

We will continue to use the equation: $F = kA^2\omega_c^2 Z_s\mathcal{A}/c$ even though it implies the emission of power which is striking area $\mathcal{A}$ and exerting a repulsive force. This is not happening but the use of $F = kA^2\omega_c^2 Z_s\mathcal{A}/c$ gives the correct magnitude of forces. This simplified equation allows a lot of quick calculations to be made which give correct magnitude.

Calculation with Two Different Mass Particles: Until now we have assumed two of the same mass/energy particles when we calculated F_g and F_E. Now we will assume two different mass particles (m_1 and m_2), but we will keep the assumption that both particles have Planck charge. When we have two different mass particles, this means that we have two different reduced Compton wavelengths ($ƛ_{c1} = \hbar/m_1 c$ and $ƛ_{c1} = \hbar/m_2 c$). The single radial separation r now becomes two different values $\mathcal{N}_1 = r/ƛ_{c1}$ and $\mathcal{N}_2 = r/ƛ_{c2}$. Also, there would be two different strain amplitudes $A_{\beta 1} = L_p/ƛ_{c1}$ and $A_{\beta 2} = L_p/ƛ_{c2}$ as well as a composite area $\mathcal{A} = kƛ_{c1}ƛ_{c2}$.

$$F_g = k\left(\frac{A_{\beta 1}^2 A_{\beta 2}^2}{\mathcal{N}_1 \mathcal{N}_2}\right)\left(\frac{c^2}{ƛ_{c1}ƛ_{c2}}\right)\left(\frac{c^3}{G}\right)\left(\frac{ƛ_{c1}ƛ_{c2}}{c}\right) = k\frac{Gm_1 m_2}{r^2}$$

$$F_E = k\left(\frac{A_{\beta 1} A_{\beta 2}}{\mathcal{N}_1 \mathcal{N}_2}\right)\left(\frac{c^2}{ƛ_{c1}ƛ_{c2}}\right)\left(\frac{c^3}{G}\right)\left(\frac{ƛ_{c1}ƛ_{c2}}{c}\right) = k\frac{q_p^2}{4\pi\varepsilon_o r^2}$$

Note that the only difference between the intermediate portions of these two equations is that the gravitational force F_g has the strain amplitude terms squared ($A_{\beta 1}^2 A_{\beta 2}^2$) and the electrostatic force F_E has the strain amplitude terms not squared ($A_{\beta 1} A_{\beta 2}$). The tremendous difference between the gravitational force and the electrostatic force is due to a simple difference in exponents.

Unification of Forces: In chapter 6 we found that there is a logical connection between the gravitational force and the electromagnetic force. However, those calculations were done only for separation distance equal to $ƛ_c$. Now we will generate some more general equations for arbitrary separation distance expressed as $\mathcal{N}$, the number of reduced Compton wavelengths. The following equations could be made assuming two different mass particles, but it is easier to return to the assumption of both particles having the same mass because then we can designate a single value of $\mathcal{N}$ separating the particles. Some of the following equations assume Planck charge q_p with force designation F_E rather than charge e designated with force F_e. The conversion is $F_E = F_e\alpha^{-1}$.

We will start by converting the Newton gravitational equation and the Coulomb law equation so that they are both expressed in natural units. This means that both the forces and the particle's energy will be in Planck units ($\underline{\boldsymbol{F}}_g = F_g/F_p$, $\underline{\boldsymbol{F}}_E = F_E/F_p$, $\underline{\boldsymbol{E}}_i = E_i/E_p$). Also separation distance will be expressed in the particles natural unit of length, the number $\mathcal{N} = r/ƛ_c$ of reduced Compton wavelengths. Also, we assume two particles each have the same mass/energy and they both have Planck charge.

Convert both equations: $F_E = q_p^2/4\pi\varepsilon_o r^2$ and $F_g = Gm^2/r^2$ into equations using $\underline{\boldsymbol{F}}_g$; $\underline{\boldsymbol{F}}_E$ and $\mathcal{N}$.

Substitutions: $r = \mathcal{N}\hbar c/E_i$; $m = E_i/c^2$; $E_i = \underline{\boldsymbol{E}}_i E_p = \underline{\boldsymbol{E}}_i\sqrt{\hbar c^5/G}$

$$\underline{\boldsymbol{F}}_E = \frac{F_E}{F_p} = \left(\frac{q_p^2}{4\pi\varepsilon_o r^2}\right)\frac{1}{F_p} = \left(\frac{4\pi\varepsilon_o\hbar c}{4\pi\varepsilon_o}\right)\left(\frac{E_i}{\mathcal{N}\hbar c}\right)^2\left(\frac{G}{c^4}\right) = \frac{E_i^2 G}{\hbar c^5 \mathcal{N}^2} = \underline{\boldsymbol{E}}_i^2/\mathcal{N}^2$$

$$\underline{\boldsymbol{F}}_g = \frac{F_g}{F_p} = \left(\frac{Gm^2}{r^2}\right)\frac{1}{F_p} = \left(\frac{GE_i^2}{c^4}\right)\left(\frac{E_i}{\mathcal{N}\hbar c}\right)^2\left(\frac{G}{c^4}\right) = E_i^4\left(\frac{G^2}{\hbar^2 c^{10}\mathcal{N}^2}\right) = \frac{E_i^4}{E_p^4\mathcal{N}^2} = \underline{\boldsymbol{E}}_i^4/\mathcal{N}^2$$

$(\underline{F}_g\mathcal{N}^2) = (\underline{F}_E\mathcal{N}^2)^2 = \underline{E}_i^4$

The equation $(\underline{F}_g\mathcal{N}^2) = (\underline{F}_E\mathcal{N}^2)^2$ clearly shows that even with arbitrary separation distance the square relationship between F_g and F_E still exists. It is informative to state these same equations in terms of power because a 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: $P_c = E_i\omega_c = m^2c^4/\hbar$. To convert P_c to dimensionless Planck units $\underline{P}_c = P_c/P_p$ we divide by Planck power $P_p = c^5/G$. Note the simplicity of the result.

$\underline{F}_E = \underline{P}_c/\mathcal{N}^2$
$\underline{F}_g = \underline{P}_c^2/\mathcal{N}^2$

So far we have used dimensionless Planck units because they show the square relationship between forces most clearly. However, we will now switch and use equations with standard units. The next equation will first be explained with an example. We will assume either two electrons or two protons (both charge e) and we hold them apart at an arbitrary separation distance r. As before, this separation distance will be designated using the number $\mathcal{N}$ of reduced Compton wavelengths, therefore $r = N\lambda\!\!\!^-_c$. Protons are composite particles, but we can still use them in this example if we use the proton's total mass when calculating $\mathcal{N}$.

Now we imagine a log scale of force. At one end of this force scale we place the largest possible force which is Planck force $F_p = c^4/G$. At the other end of this log scale of force we place the gravitational force F_g which is weakest possible force between the two particles (either 2 electrons or 2 protons). Now for the magical part! Exactly half way between these two extremes on the log scale of force is the composite force $F_e\mathcal{N}\alpha^{-1}$. In words, this is the electrostatic force F_e between the two particles times the number $\mathcal{N}$ of reduced Compton wavelengths times the inverse of the fine structure constant ($\alpha^{-1} \approx 137$). Particle physicists like to talk about various symmetries. I am claiming that there is a force symmetry between the gravitational force, Planck force and the composite force $F_e\mathcal{N}\alpha^{-1}$. The equation for this is:

$$\frac{F_g}{F_e\mathcal{N}\alpha^{-1}} = \frac{F_e\mathcal{N}\alpha^{-1}}{F_p}$$

It is informative to give a numerical example which illustrates this equation. Suppose that two electrons are separated by 68 nanometers (this distance simplifies explanations). The electrons experience both a gravitational force F_g and an electrostatic force F_e. The electrons have $\lambda\!\!\!^-_c = 3.86\text{x}10^{-13}$ m, therefore this separation is equivalent to $\mathcal{N} = 1.76\text{x}10^5$ reduced Compton wavelengths. The gravitational force between the two electrons at this distance would be $F_g = 1.2\text{x}10^{-56}$ N and the electrostatic force would be $F_e = 5\text{x}10^{-14}$ N. Also $\alpha^{-1} \approx 137$ so combining

F_e, $\mathcal{N}$ and α^{-1} we have: $F_e\mathcal{N}\alpha^{-1} = 1.2\text{x}10^{-6}$ N. Also Planck force is $F_p = c^4/G = 1.2\text{x}10^{44}$ N. To summarize and see the symmetry between these forces, we will write the forces as follows:

$F_g = 1.2x10^{-56}$ N	F_g for two electrons at $6.8\text{x}10^{-8}$ m is 10^{50} times smaller than $F_e\mathcal{N}/\alpha$
$F_e\mathcal{N}\alpha^{-1} = 1.2x10^{-6}$ N	$F_e\mathcal{N}/\alpha$ for two electrons at $6.8\text{x}10^{-8}$ m
$F_p = 1.2x10^{44}$ N	F_p (Planck force) is 10^{50} times larger than previous $F_e\mathcal{N}/\alpha$

Another way of stating this relationship would set Planck force equal to 1. Therefore when $F_p = 1$ then $F_e\mathcal{N}\alpha^{-1} = 10^{-50}$ and $F_g = 10^{-100}$. The numerical values are not important because different mass particles or different separation distance could be used. The important point is the symmetry between F_p, F_e and F_g when we include $\mathcal{N}$ and α^{-1} in the composite force $F_e\mathcal{N}\alpha^{-1}$.

Force Ratios F_g/F_E and $F_g/F_e\,\alpha^{-1}$: Next we will show how the wave structure of particles and forces directly leads to equations which connect the electrostatic force and gravity. Previously we started with the wave-amplitude equation $F = kA^2\omega_c^2Z_s\mathcal{A}/c$ which is applicable to waves in spacetime. In this equation A is strain amplitude, ω_c is Compton angular frequency, Z_s is the impedance of spacetime $Z_s = c^3/G$ and $\mathcal{A}$ is particle area. We have shown that the inserting the strain amplitude term $A = A_\beta/\mathcal{N}$ into $F = kA^2\omega_c^2Z_s\mathcal{A}/c$ gives the electrostatic force between two Planck charges F_E,. We have also shown that gravity is a nonlinear effect which scales with strain amplitude squared (A_β^2). Inserting $A = A_\beta^2/\mathcal{N}$ into this equation gives the gravitational force F_g between two equal mass particles. Since we have equations which generate F_E and F_g, we should be able to generate new equations which give the ratio of forces F_g/F_E. In the following $A_\beta = L_p/ƛ_c = T_p\omega_c$. For gravity, $A = A_g = A_\beta^2/\mathcal{N}$ and for electrostatic force $A = A_E = A_\beta/\mathcal{N}$.

$F_g = k(A_\beta^2/\mathcal{N})^2\omega_c^2Z_s\mathcal{A}/c$ $\quad F_g$ = gravitational force between two of the same mass particles
$F_E = k(A_\beta/\mathcal{N})^2\omega_c^2Z_s\mathcal{A}/c$ $\quad F_E$ = the electrostatic force between two particles with Planck charge
Set common terms equal to each other: $(k\omega_c^2Z_s\mathcal{A}/c) = (k\omega_c^2Z_s\mathcal{A}/c)$

$$\frac{F_g}{F_E} = \left(\frac{A_\beta^2}{\mathcal{N}}\right)^2\left(\frac{\mathcal{N}}{A_\beta}\right)^2$$ where: $A_\beta = L_p/\lambda_c = T_p\omega_c$ = rotar strain amplitude

$$\frac{F_g}{F_E} = A_\beta^2 = \left(\frac{L_p}{ƛ_c}\right)^2 = \left(T_p\omega_c\right)^2 = \frac{F_g}{F_e\alpha^{-1}}$$

The equation $F_g/F_E = A_\beta^2$ shows most clearly the validity of the spacetime based model of the universe proposed here. Recall that all fermions and bosons are quantized waves which produce the same displacement of spacetime. The spatial displacement is equal to Planck length L_p and the temporal displacement is Planck time T_p. Even though all waves produce the same displacement of spacetime, different particles have different wave strain amplitudes because the strain amplitude is the maximum slope (maximum strain) produced by the wave. Therefore a rotar's strain amplitude is $A_\beta = L_p/ƛ_c = T_p\omega_c$. **Now we discover that the force produced by particles with strain amplitude A_β reveal their connection to the underlying physics because $F_g/F_E = A_\beta^2$.**

All the previous equations relating F_g and F_E either specified either a specific separation or specified separation distance using $\mathcal{N}$. However, $F_g/F_E = A_\beta^2$ does not specify separation. This is possible because the ratio of the gravitational force to the electrostatic force is independent of distance. For example, the ratio for an electron is $F_g/F_e = 2.4\text{x}10^{-43}$. However, when we adjust for the coupling constant associated with charge *e,* the ratio becomes: $F_g/F_e\alpha^{-1} = 1.75\text{x}10^{-45}$. The rotar strain amplitude for an electron is $A_\beta = L_p/\lambda\!\!\!^{-}_c \approx 4.185\text{x}10^{-23}$. Therefore $A_\beta^2 = 1.75\text{x}10^{-45}$ Clearly, the derivation of this equation and the physics behind it give strong proof of the wave-based structure of particles and forces. Next we will extend the relationship between these forces one more step to bring a new perspective.

$$\frac{F_g}{F_E} = \frac{L_p^2}{\lambda\!\!\!^{-}_c^2} = \left(\frac{\hbar G}{c^3}\right)\left(\frac{mc}{\hbar}\right)^2 = \left(\frac{Gm}{c^2}\right)\left(\frac{mc}{\hbar}\right)$$

$$\frac{F_g}{F_E} = \frac{R_s}{\lambda\!\!\!^{-}_c} \quad \text{or:} \quad \frac{F_g}{F_e\alpha^{-1}} = \frac{R_s}{\lambda\!\!\!^{-}_c}$$

The equation $F_g/F_E = R_s/\lambda\!\!\!^{-}_c$ is very interesting because F_g/F_e is a ratio of forces and $R_s/\lambda\!\!\!^{-}_c$ is a ratio of radii. Recall that $R_s \equiv Gm/c^2$ is the Schwarzschild radius of a rotar because it would form a black hole rotating at the speed of light. Such a black hole has half the Schwarzschild radius of a non-rotating black hole therefore $R_s = Gm/c^2$. Also, $\lambda\!\!\!^{-}_c = \hbar/mc$ is the radius of the rotar model of a fundamental particle. For example, for an electron $R_s = 1.24 \text{ x } 10^{-54}$ m and an electron's rotar radius is: $\lambda\!\!\!^{-}_c = 3.85 \text{ x } 10^{-13}$ m. These two numbers seem completely unrelated, yet together they equal the electron's force ratio $F_g/F_e\alpha^{-1} = 1.75\text{x}10^{-45} = R_s/\lambda\!\!\!^{-}_c$.

However, as the following equations show, there are two amazing connections between R_s and $\lambda\!\!\!^{-}_c$. First, $R_s\lambda\!\!\!^{-}_c = L_p^2$. The second is $\underline{\boldsymbol{R}}_s = \underline{\lambda\!\!\!^{-}}_c^{-1}$ In words, this says that the rotar's Schwarzschild radius ($R_s \equiv Gm/c^2$) is the inverse of the reduced Compton radius when both are expressed in the natural units of spacetime which are dimensionless Planck units ($\underline{\boldsymbol{R}}_s$ and $\underline{\lambda\!\!\!^{-}}_c$ underlined).

$$R_s\lambda\!\!\!^{-}_c = \left(\frac{Gm}{c^2}\right)\left(\frac{\hbar}{mc}\right) = \frac{\hbar G}{c^3}$$

$$R_s\lambda\!\!\!^{-}_c = L_p^2$$

$$\underline{\boldsymbol{R}}_s = \underline{\lambda\!\!\!^{-}}_c^{-1} \qquad \text{equivalent to : } R_s/L_p = L_p/\lambda\!\!\!^{-}_c$$

The Schwarzschild radius comes from general relativity and is considered to be completely unconnected to quantum mechanics. A particle's reduced Compton wavelength comes from quantum mechanics and is considered to be completely unconnected to general relativity. However, when they are expressed in natural units (dimensionless Planck units) the two radii are just the inverse of each other $\underline{\boldsymbol{R}}_s = 1/\underline{\lambda\!\!\!^{-}}_c$. Also $R_s\lambda\!\!\!^{-}_c = L_p^2$. The relationships between R_s and

$ƛ_c$ are compatible with the wave-based rotar model of fundamental particles but they are incompatible with the messenger particle hypothesis of force transmission.

To summarize all the equations equal to F_g/F_E, plus a few more we have:

$$F_g/F_e\alpha^{-1} = F_g/F_E = R_s/ƛ_c = A_\beta^2 = \underline{\boldsymbol{R}}_s^{\,2} = \underline{ƛ}_c^{\,-2} = \underline{\boldsymbol{\omega}}_c^{\,2} = \underline{\boldsymbol{E}}_i^{\,2} = \underline{\boldsymbol{P}}_c$$

All the previous force equations also work with composite particles such as protons if the proton's total mass is used to calculate the various terms such as $ƛ_c = \hbar/mc$. For example, two protons have $F_g/F_e\alpha^{-1} = 5.9\text{x}10^{-39}$ at any separation distance. Also for protons $R_s/ƛ_c = 5.9\text{x}10^{-39}$ and $(L_p/ƛ_c)^2 = 5.9\text{x}10^{-39}$.

I want to pause for a moment and reflect on the implications of all the previous equations which show the relationship between the electrostatic force and the gravitational force. To me, they clearly imply several things. These are:

1) Gravity can be expressed as the square of the electrostatic force when separation distance is expressed as $\mathcal{N}$ multiples of the reduced Compton wavelength $ƛ_c$.
2) The equations relating the gravitational and electrostatic forces imply that they both scale as a fundamental function of a particle's quantum mechanical properties such as Compton wavelength or Compton frequency.
3) All the connections between the gravitational force and the electrostatic force are proposed to be traceable to a rotar generating a Compton frequency standing wave in the surrounding volume. Spacetime is a nonlinear medium, so a single standing wave has both a fundamental component (electrostatic) and a nonlinear component (gravity).
4) The electromagnetic force is universally recognized as being a real force. The equations show that gravity is closely related. Therefore, gravity is also a real force.
5) These equations are incompatible with virtual photons transferring the electrostatic force or gravitons transferring the gravitational force. The equations also appear to be incompatible with string theory.
6) There is a quantum mechanical connection between a particle's rotar radius and its Schwarzschild radius.

Derivation of the Equations: I want to relate a brief story about the first time that I proved a relationship between the gravitational and electrostatic forces. As previously stated, the initial idea that led to this book was that light confined in a hypothetical 100% reflecting box would exhibit the same inertia as a particle with the same energy. The other ideas in chapter 1 followed quickly and I was struck with the idea that these connections between confined light and particles were probably not a coincidence. I will now skip ahead several years when I was methodically inventing a model of the universe using only the properties of 4 dimension spacetime. I had the idea of dipole waves in spacetime and quantized angular momentum forming a "rotar" that was one Compton wavelength in circumference and rotating at the particle's Compton frequency. This implied a spherical volume with radius of $\lambda_c = 3.86\text{x}10^{-13}$. I had independently derived $Z_s = c^3/G$ which was key to all the other equations. I had developed the dimensionless wave amplitude for an electron which was $A_\beta = 4.185\text{x}10^{-23}$. An important success was to substitute these values into $E = A^2\omega^2 ZV/c$ and I obtained $E_i = 8.19\text{x}10^{-14}$ J for an electron.

The next logical step was to find the force that would exist between two electrons at a distance equal to λ_c. This distance was implied because I was using the only amplitude that I knew which corresponded to a distance equal to λ_c. When I made numerical substitutions for an electron into the equation $F = A^2\omega^2 Z\mathcal{A}/c$ I obtained $F = 0.212$ N. This was about 137 times greater than the electrostatic force between two electrons at the separation distance λ_c. I was quite happy because I realized that this would be the correct force if the charge was Planck charge q_p rather than elementary charge e. This was actually a preferable result because it corresponded to a coupling constant of 1, which was reasonable for this calculation. This was understandable and it was quite exciting.

Next I thought about gravity. I knew that gravity was vastly weaker than the other forces and only had a single polarity. I was reminded about the optical Kerr effect discussed in the last chapter. This nonlinear effect scales with amplitude squared (electric field squared) and always produces an increase in the index of refraction of the transparent material (a single polarity effect). Gravity has a single polarity and is vastly weaker than the electrostatic force. Therefore, I decided to calculate the force using $F = A^2\omega^2 Z\mathcal{A}/c$. and set: $A = A_\beta^2 \approx 1.75\text{x}10^{-45}$, $\omega_c = 7.76\text{x}10^{20}$ s^{-1}, $Z_s = 4.04\text{x}10^{35}$ kg/s and $\mathcal{A} = \lambda_c^2 = 1.49\text{x}10^{-25}\ \text{m}^2$. Using a pocket calculator, there was a ***Eureka*** moment when I got the answer which exactly equaled the gravitational force between two electrons at this separation ($F = 3.71\text{x}10^{-46}$ N).

This story is told because I want to support the claim that the prediction came first. It is often said that the proof of the accuracy of a new idea lies in whether it can make a prediction revealing some previously unknown fact. Usually the proof requires an experiment, but in this case it was a simple calculation. To my knowledge this is the first time that the gravitational force has been calculated from first principles without referencing acceleration.

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:

$$v = c\sqrt{1 - \left(\frac{dt_1}{dt_2}\right)^2} \qquad \text{set} \quad dt_1/dt_2 = 1 - 1.09 \times 10^{-16}$$

$$v = 4.4 \text{ m/s}$$

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. This is associated with the geometric interpretation of gravity. A corollary to this is that an inertial frame of reference eliminates gravity. The implication is that gravity is not as real as the electromagnetic force which cannot be made to disappear merely by choosing a particular frame of reference. It is common for experts in general relativity to consider gravity to be a geometric effect rather than a true 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. The previous pages have shown that it is possible to derive the gravitational force using wave properties and the impedance of spacetime. This is completely different than acceleration. Numerous equations in this book have shown that there is a close connection between the gravitational force and the electrostatic force. In particular, I will reference the two equations which dealt with two different mass particles (m_1 and m_2). The concluding statement in this analysis was:

> "*Note that the only difference between the intermediate portions of these two equations is that the gravitational force F_g has the strain amplitude terms squared ($A_{s1}^2 A_{s2}^2$) and the electrostatic force F_E has the strain amplitude terms not squared ($A_{s1} A_{s2}$). The tremendous difference between the gravitational force and the electrostatic force is due to a difference in exponents.*"

Surely this qualifies as proof that gravity is closely related to the electrostatic force and therefore gravity is also a real force. The implication is that when we get down to analyzing waves in spacetime there is a difference between gravity and acceleration.

An argument not involving dipole waves in spacetime goes as follows: A particle in free fall in a gravitational field has not eliminated the effect of gravity. The particle is just experiencing offsetting forces. The gravitational force is still present in free fall but it is being offset by the inertial pseudo-force caused by the accelerating frame of reference. These two opposing "forces" just offset each other and give the impression that there is no force. The acceleration also produces an offsetting rate of time gradient and an offsetting spatial effect. The pseudo-force of inertia has not been eliminated and the gravitational force has not been eliminated. Einstein obtained the correct equations of general relativity by assuming that gravity was the same of acceleration. Since they exactly offset each other in free fall, this assumption gave the correct equations but the physical interpretation is wrong. On the quantum mechanical scale involving waves, gravity is different than acceleration. One way to prove that gravity is a true force is to show that a gravitational field possess energy density. This will be discussed in chapter 10.

"Grav" Field in the Rotar 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 rotar volume of a rotar. Recall that the rotating dipole that forms the rotar 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 1.11×10^{-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 that has similarities to a rotating gravitational field.

We normally encounter the rate of time gradient in a gravitational field. This is the result of a nonlinearity that produces a static stress in spacetime. A static rate of time gradient has frequency of $\omega = 0$ and no energy density. However, in an actual gravitational field there is also the oscillating component of a gravitational field and this does have energy density that will be discussed later. If a rotating gravitational field is somehow generated, then such a rotating field would also have energy density. The rotating rate of time gradient (rotating grav field) that is present near the center 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 $2ƛ_c$. Therefore, in a time of $1/\omega_c$ there is a total time difference of $2T_p$ across a distance of $2ƛ_c$. The rate of time gradient per meter is:

$$\frac{dt - d\tau}{dtdr} = \frac{2T_p}{\left(\frac{2ƛ_c}{\omega_c}\right)} = \frac{L_p \omega_c^2}{c^2} = \frac{L_p}{ƛ_c^2}$$

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:

$$a_g = \left(\frac{dt - d\tau}{dtdr}\right)c^2 = L_p \omega_c^2 = A_\beta^2 a_p = \sqrt{\frac{m^4 c^5 G}{\hbar^3}}$$

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 rotar volume (a_g) compare with the non-rotating, gravitational acceleration (g_q) at the edge of the same rotar's rotar volume? .

$g_q = A_\beta^2 \omega_c c$ rotar's non-rotating gravitational acceleration at distance $ƛ_c$ from the center
$a_g = A_\beta \omega_c c$ rotar's rotating (ω_c) grav acceleration at the center of a rotar

$\frac{g_q}{a_g} = A_\beta$ ratio of g_q (static gravitational acceleration at $ƛ_c$) to rotating grav acceleration a_g

For an electron $A_\beta = 4.18 \times 10^{-23}$, so the rotating grav field at the center of the electron is about 2×10^{22} times stronger than the non-rotating gravitational field at distance $ƛ_c$. This results in an electron having a rotating grav acceleration of: $a_g = 9.73 \times 10^6$ m/s^2. The gravitational acceleration (not rotating) of an electron at distance $ƛ_c$ is: $g_q = 4.07 \times 10^{-16}$ m/s^2. Therefore the grav acceleration in the rotar 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 x 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 (~ 4 x 10^{-13} m). The rotating rate of time gradient inside a rotar is a first order effect related to A_β while the non-rotating gravitational field produced by the rotar is a second order effect related to A_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 rotar 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).

$$\mathcal{X} = \tfrac{1}{2}\, a\, t^2 = k\,\frac{H_\beta \omega_c\, c}{\omega_c^2} = \frac{\left(\frac{L_p}{\lambda_c}\right)\left(\frac{c}{\lambda_c}\right)c}{\left(\frac{c}{\lambda_c}\right)^2} = L_p$$

$\mathcal{X} = L_p$ $\qquad$ $\mathcal{X}$ = 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 $A_\beta = L_p/\lambda_c = T_p\omega_c = \omega_c/\omega_p$. 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 $A_\beta = L_p/ƛ_c = T_p\omega_c$. This amplitude A_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 $L_p/ƛ_c$. The rate of time gradient is still related to $T_p\omega_c$, although this is harder to see. Previously we substituted A_β, ω_c and Z_s into $U = A^2\omega^2 Z/c$ and obtained a rotar's energy density in the rotar volume $U_q = k\, mc^2/ƛ_c^3$ If we ignore the dimensionless constant k, this is the rotar's internal energy in the volume of a cube that is $ƛ_c$ on a side. Here are some other equalities for U_q.

$$U_q = \frac{m^4c^5}{\hbar^3} = \frac{E_i}{ƛ_c^3} = A_\beta{}^4 U_p \qquad \text{set}\ \frac{m^4c^5G}{\hbar^3} = a_g{}^2$$

$$U_q = \frac{a_g^2}{G}$$

Therefore the rotating "grav field" has the same energy density as the energy density of the entire rotar ($E_i/ƛ_c{}^3$). If we broaden the definition of A_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 $ƛ_c$, then we obtained an answer of angular momentum of $\hbar$. However, if we assumed that the energy was distributed more uniformly (like a disk) and also rotation in a single plane, 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 answer of ½ $\hbar$. However, as previously explained, there is also a chaotic rotation where there is an expectation rotational axis but other rotational directions are allowed with less probability. Also. the energy density distribution within a rotar does not end abruptly at a radial distance of $ƛ_c$. The details that result in net angular momentum of ½ $\hbar$ will have to be worked out by others.

If a rotating grav field has energy density, does a static gravitational field also have energy density? This question will be examined in chapter 10 after some additional concepts are introduced about the oscillating component of gravity

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 node regions between the pressure maximum and minimum. A kinetic energy graph depicting motion (velocity) left and right would have a 90° 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: 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 x 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 x 10^{11} radians per normalized second (7 x 10^{-10} x 7.76 x 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.

For another example, we will calculate the change in the internal energy of an electron when it is elevated 1 meter in the earth's gravitational field. In chapter 3 there is a section titled "Energy Transformation and Calculation" where the difference in the gravitational gamma was calculated for a 1 meter elevation change near the earth's surface. This was expressed as $\Gamma_2 - \Gamma_1 \approx 1.091\text{x}10^{-16} = dt_2/dt_1$. Since the reduced Compton frequency of an electron is about 7.76 x 10^{20} s^{-1}, this means a 1 meter elevation change will produce a frequency change:

$\Delta\omega_c = 7.7634 \times 10^{20}\ s^{-1} \times 1.0915 \times 10^{-16} = 84{,}737\ s^{-1}$
$\Delta E = \Delta\omega_c\hbar\ = 84{,}690\ s^{-1} \times \hbar\ \text{Js} = 8.936 \times 10^{-30}\ \text{J}$
We will compare this to the gravitational potential energy stored when an electron is elevated 1 meter in the earth's gravitational field with acceleration of $g = 9.81\ m/s^2$.
$\Delta E = m_e\, \Delta h\, g = 9.109\text{x}10^{-31}\ \text{kgx1 m x } 9.81\ m/s^2 = 8.936\times10^{-30}\ \text{J}$

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 gravitational potential energy to a change 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.

When we have looked at mass, energy, inertia and gravity from the point of view of a zero gravity observer, we have seen a difference not obvious locally. Since a change in Γ affects mass and energy differently (zero gravity observer perspective) and since gravity scales with energy (not rest 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 15 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.