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 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 converts these electrical characteristics into properties of spacetime. Like gravity, we might be looking for both an oscillating component and a non-oscillating strain in the spacetime field caused by the oscillating component (waves in spacetime). It will be recognized that there are two types of electric field: 1) The electric field associated with a charged particle which appears to be only static but must also have an oscillating component 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.

To obtain an insight into the electrical properties of nature, we will start by expressing the electrical potential $\mathbb{V}$ (the voltage relative to neutrality) for a single particle which has Planck charge $\left(q_p = \sqrt{4\pi\varepsilon_o \hbar c}\right)$ at distance r is:

$$\mathbb{V}_E \equiv \frac{q_p}{4\pi\varepsilon_o r} = \frac{\sqrt{4\pi\varepsilon_o \hbar c}}{4\pi\varepsilon_o r}.$$

The symbol $\mathbb{V}_E$ will be used to signify that we are assuming Planck charge q_p. Next we will express electrical potential of Planck charge in dimensionless Planck units. This is done because dimensionless Planck units are fundamentally based on the properties of spacetime. We are attempting to gain an insight into the distortion of spacetime caused by electric charge. If we express this electrical potential in dimensionless Planck units $\underline{\mathbb{V}}_E$ (note underlined), then we are converting to dimensionless Planck units which in this case makes a ratio relative to the largest possible electrical potential, Planck voltage $\mathbb{V}_p = \left(c^4/4\pi\varepsilon_o G\right)^{1/2} = 1.043\times10^{27}$ Volts

$$\underline{\mathbb{V}}_E = \mathbb{V}_E/\mathbb{V}_p = \frac{\sqrt{4\pi\varepsilon_o \hbar c}}{4\pi\varepsilon_o r}\sqrt{\frac{4\pi\varepsilon_o G}{c^4}} = \frac{1}{r}\sqrt{\frac{\hbar G}{c^3}} = \frac{L_p}{r}$$

Before commenting, we will next calculate the electric field in dimensionless Planck units at distance r from Planck charge q_p. The symbol used will be: $\underline{\mathbb{E}}_E = \mathbb{E}_E/\mathbb{E}_p$ where $\mathbb{E}_E \equiv q_p/4\pi\varepsilon_o r^2$ and Planck electric field is $\mathbb{E}_p = \sqrt{c^7/4\pi\varepsilon_o \hbar G^2}$

$$\underline{\mathbb{E}}_E = \mathbb{E}_E/\mathbb{E}_p = \frac{\sqrt{4\pi\varepsilon_o \hbar c}}{4\pi\varepsilon_o r^2}\sqrt{\frac{4\pi\varepsilon_o \hbar G^2}{c^7}} = \frac{\hbar G}{c^3 r^2} = \frac{L_p^2}{r^2}$$

What is the physical interpretation of $\underline{\mathbb{V}}_E = L_p/r$ and $\underline{\mathbb{E}}_E = L_p^2/r^2$? Expressing electrical potential and electric field in dimensionless Planck units is expressing these in the natural units of spacetime. Therefore, we will mine this to extract hints about the effect that Planck charge has on spacetime.

1) Since there is no time term in either equation, the implication is that an electrical charge only affects the spatial properties of spacetime. This is also reasonable since a gradient in the rate of time always implies gravitational acceleration. If electrical charge produced a rate of time gradient, then neutral objects such as a neutron would be accelerated by an electric field. Therefore, it is reasonable that an electric field affects only the spatial dimension (the L_p term)
2) The presence of Planck length term (L_p) in the voltage and electric field equations implies that Planck length is somehow associated with the electric field produced by Planck charge.
3) The dimensionless ratio L_p/r implies a slope. This will have to be a spatial strain of spacetime that can be expressed as a slope.
4) Only the radial spatial dimension (r) seems to be affected.

Charge Conversion Constant *η*: To quantify the magnitude of the effect on spacetime produced by a charge, we will attempt to find a new constant of nature which converts units of electrical charge (Coulomb) into a property of spacetime. Considering the previous 4 points, we would expect that charge might produce a polarized strain of space (radial length dimension) without affecting the rate of time. The validity of this approach will be established only if it passes numerous tests.

There are many ways to derive this charge conversion term. We will use one of the above equations: $V_E/V_p = L_p/r$ where V_E is the electrical potential generated by a Planck charge q_p at distance r. If we solve for Planck charge q_p, while retaining Planck length L_p, we will be able to deduce a charge conversion constant that converts charge into a spatial distortion of the spacetime field.

$$\mathbb{V}_E = \frac{q_p}{4\pi\varepsilon_o r} = \frac{L_p \mathbb{V}_p}{r}$$

$$q_p = \frac{L_p V_p 4\pi\varepsilon_o r}{r} = L_p\sqrt{\frac{4\pi\varepsilon_o c^4}{G}}$$

The proposed conversion between charge and a spatial distortion of spacetime will be designated as the "charge conversion constant" and designated as eta (η).

$$\eta \equiv \sqrt{\frac{G}{4\pi\varepsilon_o c^4}} = \frac{L_p}{q_p} \approx 8.61 \times 10^{-18} \ \text{m/C} \qquad \text{charge conversion constant}$$

Eta (η) has units of meters per Coulomb. This unit is reasonable because we are expecting to convert charge into a property of spacetime and the time dimension has been eliminated. The "meters" referenced in meters/coulomb are the radial direction if we are referring to the effect a charged particle has on the surrounding spacetime or if we are referring to an electric field, then the "meters" are in the direction of the electric field. We know that this constant (η) is compatible with the dimensionless voltage equation for Planck charge $\underline{\mathbb{V}}_E = L_p/r$ since that equation was used to define the constant. However, to test this further, we will use eta (η) to eliminate Coulomb from other constants and equations. We will start with two constants: 1) the Coulomb force constant $1/4\pi\varepsilon_o$ with units of m^3kg/s^2C^2 and 2) the magnetic permeability constant $\mu_o/4\pi$ with units of kg m/C^2. Both of these have $1/C^2$. To eliminate $1/C^2$ requires multiplying both of these by $1/\eta^2$.

$$\frac{1}{4\pi\varepsilon_o}\left(\frac{1}{\eta^2}\right) = \left(\frac{1}{4\pi\varepsilon_o}\right)\left(\frac{4\pi\varepsilon_o c^4}{G}\right) = \frac{c^4}{G} = F_p = 1.21\times10^{44}\ \text{N}$$

Coulomb force constant $\frac{1}{4\pi\varepsilon_o}$ converts to Planck force $\frac{c^4}{G}$ with units of Newton.

$$\frac{\mu_o}{4\pi}\left(\frac{1}{\eta^2}\right) = \left(\frac{1}{4\pi\varepsilon_o c^2}\right)\left(\frac{4\pi\varepsilon_o c^4}{G}\right) = \frac{c^2}{G} = 1.35\times10^{27}\ \text{kg/m}$$

Therefore, vacuum permeability $\frac{\mu_o}{4\pi}$ converts to $\frac{c^2}{G}$ with units of kg/m.

It is quite reasonable that the Coulomb force constant $1/4\pi\varepsilon_o$ gets converted to F_p Planck force. If electric charge and an electric field are distortions of the spacetime field, then it is reasonable that the Coulomb force constant converts to the largest force that the spacetime field can exert which is Planck force $F_p = c^4/G$. In fact, this conversion strongly supports the validity of eta (η). If the universe is only spacetime, then it is reasonable that all forces, including the electromagnetic force, should reference Planck force. The vacuum permeability also converts to an important property of spacetime which is c^2/G with units of kg/m. This is the constant that converts mass into length (the radius of a black hole). The next test is to see if $c^2 = 1/\varepsilon_o\mu_o$ is still correct when we substitute $\varepsilon_o = G/4\pi c^4$ and $\mu_o = 4\pi c^2/G$. We obtain: $(4\pi c^4/G)(G/4\pi c^2) = c^2$.

Next we will also convert elementary charge e and Planck charge q_p to a distortion of spacetime by multiplying by η.

$e\eta = \sqrt{\alpha}L_p$ conversion of elementary charge e where: $\alpha = \frac{e^2}{4\pi\varepsilon_o\hbar c}$

$q_p\,\eta = L_p$ conversion of Planck charge q_p

We can now do a more revealing test. We will calculate the force between two electrons (charge e) two different ways. First we will use the conventional Coulomb law equation to calculate this force, then we will calculate the force using the above conversions.

$$F_e = \frac{e^2}{4\pi\varepsilon_o r^2} = \frac{\alpha\hbar c}{r^2}$$ Coulomb law force between two electrons: charge $e \approx 1.6\times10^{-19}$ C

$$F_e = \frac{F_p\alpha L_p^2}{r^2} = \frac{c^4}{G}\frac{\alpha}{r^2}\frac{\hbar G}{c^3} = \frac{\alpha\hbar c}{r^2}$$ Force equation which converts e and ε_o to spacetime strain

This is a successful test. It is interesting to see how $1/4\pi\varepsilon_o$ converts to Planck force and still gives the same answer as the Coulomb law equation which utilizes electrical charge and the permittivity of free space. It is interesting to make other tests of η. It always works correctly.

Impedance Calculation

Before proceeding with the following test 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 with units of ohms is a physical constant that relates the magnitudes of the electric field $\mathbb{E}$ and the magnetic field strength $\mathbb{H}$ of electromagnetic radiation propagating in a vacuum.

$$Z_o \equiv \mathbb{E}/\mathbb{H} = \mu_o c = \frac{1}{\varepsilon_o c} = \sqrt{\frac{\mu_o}{\varepsilon_o}} \approx 376.7\ \Omega \quad \text{impedance of free space}$$

Planck impedance Z_p is:

$$Z_p = \frac{Z_o}{4\pi} = \frac{1}{4\pi\varepsilon_o c} \approx 29.98\ \Omega \quad \text{Planck impedance}$$

The units of the impedance of free space Z_o and Planck impedance Z_p are both L^2M/Q^2T. Therefore to eliminate $1/Q^2$ we must multiply Z_p *and* Z_s *by* $1/\eta^2$.

$$Z_p\left(\frac{1}{\eta^2}\right) = \left(\frac{1}{4\pi\varepsilon_o c}\right)\left(\frac{4\pi\varepsilon_o c^4}{G}\right) = \frac{c^3}{G} = Z_s$$

$$Z_o\left(\frac{1}{\eta^2}\right) = \left(\frac{1}{\varepsilon_o c}\right)\left(\frac{4\pi\varepsilon_o c^4}{G}\right) = 4\pi\frac{c^3}{G} = 4\pi Z_s$$

$$Z_p\left(\frac{1}{\eta^2}\right) = Z_s \quad \text{and} \quad Z_o\left(\frac{1}{\eta^2}\right) = 4\pi Z_s$$

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!**

Impedance of free Space Converts to the Impedance of Spacetime: When we convert the impedance of free space $Z_o \equiv \mathbb{E}/\mathbb{H}$ using the charge conversion constant, Z_o becomes the impedance of spacetime Z_s times a constant (4π). We can ignore the 4π and in fact Planck impedance does eliminate this numerical factor. This is a fantastic outcome because it implies that electromagnetic radiation is some form of wave in the spacetime field. Here is the reasoning. From gravitational wave equations we know that waves propagating in the medium of the spacetime field experience 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, and has transverse waves like 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 propagating in the medium of the spacetime field.

The equation $Z_s = c^3/G$ is only applicable when waves use the spacetime field as the propagation medium. This is understandable and fully expected for gravitational waves, but now we find that electromagnetic radiation must also use the spacetime field as a propagation 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 a strain of spacetime with dimensions of length (ignore 4π). This says that photons are not packets of energy that travel THROUGH the empty void of spacetime. Photons are waves IN the medium of the spacetime field. They appear to also have particle properties because photons possess quantized angular momentum. The superfluid spacetime field quarantines angular momentum into quantized units of $\hbar$ for bosons or ½ $\hbar$ for fermions. It is not possible to break apart a unit of quantized angular momentum. The transfer of quantized angular momentum is all or nothing (100% or 0%). The photon's energy also becomes quantized because the energy of a photon is fundamentally associated with the 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 photons.

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 the spacetime field's sea of superfluid dipole waves in different ways, but they both are transverse disturbances in the spacetime field that do not modulate the rate of time and propagate at the speed of light. Recall from chapter 4 that the spacetime field 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.

Light waves are not dipole waves in spacetime since we can detect light waves as discrete waves. Recall that it is impossible to detect dipole waves in spacetime. Dipole waves in spacetime modulate the rate of time and proper volume. Their amplitude must be limited to Planck amplitude ($\pm L_p$ and $\pm T_p$). A larger amplitude would produce effects that violate the conservation of momentum and energy. Also, a light wave cannot cause an oscillation in the rate of time because a gradient in the rate of time produces gravitation-like effects. For example, a strong light wave would cause a neutron to undergo a detectable transverse oscillatory displacement similar to the effect on an electron. Therefore, light waves are a spacial wave distortion of the homogeneous spacetime field. Each individual photon has quantized angular momentum and other special properties which will be discussed later.

Constant Speed of Light: Is it reasonable that light waves are propagating in the medium of spacetime? For example, if the propagation medium is the spacetime field, would we expect that it should be impossible to detect motion relative to this medium? First, we know that ε_o and μ_o are properties of the spacetime field. We also know that ε_o and μ_o remain constant in all frames of reference. Since $c = \sqrt{1/\varepsilon_o \mu_o}$ it follows that a wave propagation speed that scales with ε_o and μ_o should also be independent of the frame of reference.

Second, gravitational waves are definitely propagating in the medium of the spacetime field and they always propagate at the speed of light in all frames of reference. If it was possible to do a Michelson-Morley experiment using gravitational waves, this experiment would obtain the same result as the experiment using light. In both cases there would be a null result – no motion would be detected relative to the propagation medium. The spacetime field is a sea of dipole waves propagating at the speed of light but also strongly interacting. No motion is able to be detected relative to this medium. Also all observable objects (all particles, fields and forces) are obtained from the single building block of 4 dimensional spacetime. Therefore, all particles, fields and forces compensate with a Lorentz transformation which makes the locally measured speed of light constant. Therefore, the spacetime field possesses the properties required to make the speed of light constant in all accessible frames of reference. (At the end of chapter 14 we will explore the limits of extreme frames of reference where this breaks down.)

Cosmic Speed Limit: The following question has puzzled physicists: Why is there a cosmic speed limit? Now we can answer this question. A photon is not a quantized packet of energy propagating through the empty void of the vacuum. A truly empty vacuum would not dictate any speed limit to a "packet of energy" that is merely propagating through it. However, if a photon is a wave propagating in the spacetime field medium, then the impedance and energy density characteristics of this medium dictate a specific speed of wave propagation. The medium named the "spacetime field" consists of strongly interacting dipole waves in spacetime propagating at the speed of light at all frequencies up to Planck angular frequency ($\omega_p \approx 10^{43}$ s^{-1}). Photons disturb the homogeneity of this medium and this disturbance also propagates at the speed of light. Photons appear to be particles because photons possess angular momentum and angular momentum is quarantined into ħ or ½ ħ units by the superfluid spacetime field. Since angular momentum is only transferred in quantized units, this gives particle-like properties to quantized waves. The phrase "wave – particle duality" cannot be conceptually understood since "wave" implies a periodic variation over a volume and "particle" implies a point discontinuity. They are mutually exclusive terms. I propose that bosons and fermions are fundamentally waves which act like particles because they possess angular momentum which is quantized by the superfluid spacetime field.

All particles, fields and forces are also distortions of the spacetime field. There is a single speed limit for all frames of reference because all particles fields and forces compensate their size and other characteristics in a way that achieves a Lorentz transformation which keeps the laws of physics constant. Even the forces between particles compensate to maintain the distance between particles that preserves the locally measured constant speed of light.

Accuracy Check: There is another more subtle implication from the equation $Z_o/\eta^2 = 4\pi Z_s$. and the success of the charge conversion constant. These equations imply to me that the many steps that started with gravitational wave equations and ended with these relationships are 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: $\eta \equiv (G/4\pi\varepsilon_o c^4)^{1/2}$. This resulted in $Z_o/4\pi\eta^2 = Z_s$. These apparently dissimilar impedances are the same when we assume that the universe is only spacetime. This unification of impedances supports the starting assumption.

Spacetime Model of an Electric Field

Electric Field Conversion: Next we will attempt to gain additional insights into electric fields. We had some success describing the voltage and electrical field produced by Planck charge $\underline{\mathbb{V}}_E = L_p/r$ and $\underline{\mathbb{E}}_E = L_p^2/r^2$. However the underlying mechanism by which a charged particle produces an electric field is somewhat more complex than an electric field produced by a photon. 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 $(\mathcal{I} = kA^2\omega^2 Z)$ 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. Electromagnetic radiation commonly uses electric field to quantify wave amplitude of EM radiation. Also, the impedance of free space ($Z_o \approx 377$ ohms) is used to quantify the impedance encountered by EM radiation. This way of stating amplitude and impedance is not compatible with the other units of 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 A, 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: $\mathcal{I} = kA^2\omega^2 Z_s$ and $\mathcal{I} = ½\, \mathbb{E}^2/Z_o$. We will equate these and solve for $\mathbb{E}$ and $\mathbb{H}$. 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 $\mathbb{E}_\gamma$ and the magnetic field of EM radiation as $\mathbb{H}_\gamma$.

$\mathbb{E}_\gamma^2/Z_o = kA^2\omega^2 Z_s$ intensity equations ignoring numerical factors near 1

$\mathbb{E}_\gamma = kA\omega\sqrt{Z_s Z_o}$ $\mathbb{E}_\gamma$ = Electric field of EM radiation expressed utilizing A, ω, Z_s and Z_o

$\mathbb{H}_\gamma = kA\omega\sqrt{\frac{Z_s}{Z_o}}$ $\mathbb{H}_\gamma$ = magnetic field of EM radiation obtained from $\mathbb{H}_\gamma = k\mathbb{E}_\gamma/Z_o$

This is interesting, but it still uses Z_o which implies charge. Next we will convert the electric field and magnetic field of EM radiation into a distortion of spacetime using η. This results in Z_o being converted to Z_s. Applying this to $\mathbb{E}_\gamma = kA\omega\sqrt{Z_s Z_o}$ and $\mathbb{H}_\gamma = kA\omega\sqrt{Z_s/Z_o}$ we obtain:

$\mathbb{E}_\gamma/\eta = kA\omega Z_s$ $\qquad$ $\mathbb{E}_\gamma$ = electric field strength of EM radiation
$\mathbb{H}_\gamma \eta = kA\omega$ $\qquad$ $\mathbb{H}_\gamma$ = magnetic field strength of EM radiation

These equations express $\mathbb{E}$ and $\mathbb{H}$ in terms of A, ω and Z_s. However, the remaining task is to be able to define the electromagnetic wave amplitude as a strain in spacetime (define amplitude A). 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 using k to represent the unknown numerical factor 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. However, an electric field has energy density, therefore it has a tangible quality. The energy density implies that an electric field must also have inertia and generate its own gravitational field. This implies that an electric field has more of a physical presence than implied by the concept of virtual photons. One of the characteristics of a virtual photon is that it is undetectable; therefore it is not "falsifiable". Sometimes an electric field is described as a cloud of virtual photons. More often, physicists prefer to describe the effects of an electric field and avoid addressing the question of what an electric field is. Still, the closest answer usually involves a vague reference to virtual photons.

If we require virtual photons to describe an electric field, this leaves many unanswered questions. For example, 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 must average out to equal zero? How exactly do virtual photons achieve attraction? What prevents the implied pressure associated with the energy density of a static electric field from dissipating? If an electron is smaller than the classical electron radius ($\sim 10^{-15}$ m), then what prevents the energy in its electric field from exceeding the total energy of the electron?

Some physicists freely admit that virtual photons are merely a mathematical tool. The path-integral formulation of quantum mechanics assumes that virtual photons take all possible paths between two charged particles. In the calculation, paths are allowed where the virtual photon is going faster than the speed of light or violating energy conservation. These calculations give correct answers, but the physical model is lacking.

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: We will first look at the simplified case of a photon confined in 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 circularly polarized electromagnetic radiation, a cylindrical waveguide slightly more than ½ wavelength in diameter is the smallest waveguide which has good transmission. 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 the spacetime field 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 over the central volume of $\lambda\!\!\!^{-3}$ and assume zero electric field in the remainder of the maximum confinement cavity. 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 $U = A^2\omega^2 Z_s/c$ and solve for ΔL in $A = \Delta L/\lambda\!\!\!^{-}$.

$$U = \frac{\hbar\omega^4}{c^3} = \frac{H^2\omega^2 Z_s}{c} = \left(\frac{\Delta L^2\omega^2}{c^2}\right)\omega^2\left(\frac{c^3}{G}\right)\left(\frac{1}{c}\right) = \frac{\Delta L^2\omega^4}{G} \qquad \text{solve for } \Delta L$$

$\Delta L = \sqrt{\frac{\hbar G}{c^3}} = L_p$ displacement amplitude of a single photon in "maximum confinement"

$A = L_p/\lambda\!\!\!^{-}$ the strain amplitude A 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 that ΔL is over 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 $\lambda\!\!\!^{-}$. 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 $\lambda\!\!\!^{-3}$. In this calculation we will use "n_γ" as the number of photons occupying the volume. Therefore $U = n_\gamma\hbar\omega/\lambda\!\!\!^{-3} = n_\gamma\hbar\omega^4/c^3$.

$$U = \frac{\Delta L^2\omega^4}{G} = \frac{n_\gamma\hbar\omega^4}{c^3} \qquad \text{Solve for } \Delta L$$

$\Delta L = \sqrt{n_\gamma}\, L_p$ displacement amplitude of n_γ 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 $\lambda\!\!\!^{-}$, therefore the strain in spacetime produced by n_γ coherent photons in maximum confinement is:

$A = \frac{\Delta L}{L} = \frac{\sqrt{n_\gamma} L_p}{\lambda\!\!\!^{-}}$ strain produced by n_γ coherent photons in maximum confinement

The equation $\Delta L = \sqrt{n_\gamma} L_p$ is very revealing. First, it incorporates Planck length L_p. Previously we found that Planck length was also associated with Planck charge ($\mathbb{V}_E = L_p/r$ and $\mathbb{E}_E = L_p^2/r^2$)

Therefore, the fact that a photon exhibits this amplitude in maximum confinement supports the model.

Also, it is not possible to actually measure the electric field or magnetic field produced by a single photon. Now we can understand this because measuring the electric field produced by a single photon would be attempting to measure 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 and measure the oscillating electric field produced by many photons ($n_\gamma >> 1$ photons) because many coherent photons produces $\Delta L >> L_p$. Now we can conceptually understand this effect.

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 the spacetime field A equal to $A = \sqrt{n_\gamma}\, L_p/\lambda\!\!\!^{-}$. 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 spacetime field. They both experience the same impedance therefore electromagnetic waves must also be waves in spacetime. The quantum mechanical description of the spacetime field is vacuum fluctuations with Planck length/time displacements at all frequencies up to Planck frequency. This description of the spacetime field has a high energy density. The spacetime field has elasticity and very large impedance. Waves in the spacetime field propagate at the speed of light but the displacement of the spacetime field is very small because the spacetime field also has an incredibly large impedance and bulk modulus. A single photon in maximum confinement (volume $\lambda\!\!\!^{-3}$) only affects the spacetime field 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 the spacetime field 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. The points themselves are not accelerated and physically moved by the gravitational wave. The spatial properties of the spacetime field are affected in a way that increases or decreases proper distance as might be measured by a tape measure. With gravitational waves there is no polarization vector that distinguishes between opposite directions along either of these two axes. The effect on the spacetime field by gravitational waves is symmetrical (reciprocal). 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 waves in the spacetime field which scale with the proper speed of light.

Proposed Model of an Electric Field: 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. 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 not reciprocal (electric and magnetic fields vectors) while the gravitational wave is a reciprocal transverse wave. Reversing direction along either the long or short axis distortion produced by a gravitational wave produces the same distance between points. We will designate the unsymmetrical (non-reciprocal) effect on the spacetime field produced by EM radiation as "polarized spacetime". Both EM radiation and gravitational waves do not modulate either the rate of time or proper volume.

If we are going to explain electromagnetic fields using only the properties of spacetime, it is necessary to incorporate into the explanation a nonreciprocal (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 non-reciprocal (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).

A gravitational wave does not produce a net change in proper volume. An increase in one dimension is offset by a decrease in the orthogonal transverse dimension to keep the total volume constant. If there was a detectable change in volume, there would also be a detectable change in the rate of time and this would create conditions where there can be a violation of the conservation of momentum (see dipole wave discussion in chapter 4). An oscillating electric field must modulate distance between points without modulating proper volume. The way this is accomplished is even simpler than the mechanism used by a gravitational wave. In an oscillating electric field the dimensional increase and decrease happens in only one 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 therefore there is no change in proper volume.

This is the simplest possible way that produces a net polarization of the spacetime field 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.

It is proposed that an electric field is an asymmetric distortion of the spatial dimension of the spacetime field parallel to the electric field direction. This results in a slight asymmetric distance between points propagating in the positive electric field direction compared to propagating in the negative electric field direction. There is neither a net volume change nor a rate of time change because the round trip time between the points is unchanged (except for the slight gravitational effect).

The proposed model of an electric field implies that n_γ photons in maximum confinement produce an effect on space that results in a distortion of $\Delta L = \sqrt{n_\gamma} L_p$ over distance ƛ. The vector distortion implies that if the rotating electric is imagined as being momentarily frozen, there would be a difference in the distance of $\Delta L = \sqrt{n_\gamma} L_p$ progressing from + to – compared to progressing in the opposite direction (– to +). It is not known which polarization direction produces the longer distance, but hypothetically this is experimentally measurable.

This non-reciprocal property seems strange, but another example of a non-reciprocal effect is a Faraday rotator. When a magnetic field is imposed on any transparent material, circularly polarized light experiences a different path length depending on whether it is propagating in the North magnetic direction compared to propagating in the South magnetic direction. This difference in path length between the two opposite directions can be expressed as $\Delta L/L$. It also causes linearly polarized light to exhibit a different rotation direction when propagating in opposite directions. This effect is commonly used to form an optical isolator that only allows laser beams to propagate one direction.

Charged Particles: Since EM radiation has an oscillation at frequency ω, it is easy to imagine that that the oscillating electric field (oscillating distortion of the spacetime field) produced by EM radiation has energy density. However, the electric field produced by a charged particle appears to be static and yet it also possesses energy density. Of we insert $\omega = 0$ into the energy density equation $U = kA^2\omega^2 Z$, we obtain that there should be no energy density if there is no oscillation. Yet we know that the electric field produced by charged particles also has energy density. It will be proposed in chapter 10 that all particles (charged and neutral) produce an oscillating disturbance in the surrounding volume of spacetime. This will be shown to be oscillating standing waves at the particle's Compton frequency. These standing waves produce not only particle's de Broglie waves but also they are required for the production of a non-oscillating portion of the electric field and also gravitational effects.

Electric Field Produced by Charged Particles: Earlier in this chapter we derived the electrical potential for Planck charge in dimensionless Planck units as: $\underline{\mathbb{V}}_E = L_p / r$. When we assume elementary charge e (designated with subscript "e") the equation becomes:

$$\underline{\mathbb{V}}_e = \frac{\mathbb{V}_e}{\mathbb{V}_p} = \frac{\sqrt{\alpha} L_p}{r}$$

Therefore the voltage expressed in dimensionless Planck units is a dimensionless number that is describing the slope of the polarized strain of spacetime. As previously explained, an electric field produces polarized spacetime where there is a difference in distance progressing in opposite directions. The difference in distance is designated ΔL so the ratio $\Delta L / \Delta r$ can be thought of as a type of slope designating the difference in distance between opposite directions ΔL over radial line segment Δr. For example, we will start with a single radial vector pointing away from a charged particle. We will designate distances r_1 and r_2 along this radial vector and specify that $r_2 > r_1$. The distance between r_1 and r_2 is slightly different if a time of flight distance measurement is made progressing from r_1 to r_2 compared to progressing in the opposite direction. This difference ΔL produced by a particle with elementary charge e, is 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 $\Delta L = \sqrt{\alpha} \times L_p \times 27.6 \approx 3.26 \times 10^{-36}$ m. While this seems like a very small net distance, it must be remembered that the strain is affecting the enormously large energy density, impedance and bulk modulus of the spacetime field. Later it will be shown that this type of polarized 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: $\Delta L = n_e \sqrt{\alpha} L_p \ln(r_2/r_1)$.

Thus far we have dealt with the distortion produced by a spherical electric field such as is produced by a single electron of a charged sphere. However, what about the distortion of spacetime produced by a parallel plate capacitor? We will assume a vacuum capacitor made with parallel plates of dimensions DxD and separated by distance D. This is an idealized vacuum capacitor which forms a cube. We will ignore the effects of fringing electric fields in this exploratory discussion. The same way that expressing voltage (electrical potential) in dimensionless Planck units $\underline{\mathbb{V}}$ for a single charged particle gave strain $\Delta L / r$, so also expressing the voltage on a vacuum capacitor with separation distance D gives the strain of spacetime produced by the electric field generated by a vacuum capacitor.

$$\underline{\mathbb{V}} = \frac{\mathbb{V}}{\mathbb{V}_p} = \frac{\Delta L}{D}$$

$$\Delta L = \underline{\mathbb{V}} D$$

For example, a time of flight distance measurement along the electric field of a vacuum capacitor might be made if a small hole is provided in the center of both plates. The prediction is that the time of flight distance proceeding from positive to negative should differ by $\Delta L = \underline{\mathbb{V}}D$ compared to proceeding the opposite direction. However, this would be hard to measure. For example, if $D = 1$ m and voltage was 1,000,000 volts, then since $\mathbb{V}_p \approx 10^{27}$ volts, $\underline{\mathbb{V}} \approx 10^{-22}$ and $\Delta L \approx 10^{-22}$ m. This is much smaller than current interferometer technology can measure. However, there is also another problem which will be discussed later relating to whether light can ever be used to measure the ΔL effect.

Comparison of Electric Fields: The equation $\Delta L = \underline{\mathbb{V}}\, D$ for a cubic vacuum capacitor specifies the length difference in terms of $\underline{\mathbb{V}}$ and D. Since an electric field $\mathbb{E} = \mathbb{V}/L$ and in the case of a vacuum capacitor $L = D$, we can also express ΔL over distance L in a uniform electric field $\mathbb{E}$ as:

$$\Delta L = \frac{\mathbb{E}L^2}{\mathbb{V}_p}$$

With photons we were able to specify ΔL in terms of the number of photons n_γ in maximum confinement ($\Delta L = \sqrt{n_\gamma}\, L_p$). Next we will calculate ΔL in a cubic vacuum capacitor in terms of the number of electrons n_e on the vacuum capacitor with dimensions DxDxD. This calculation will make use of the following substitutions:

$\mathbb{V} = q/\mathrm{C}$, $q = n_e e$, $C = k\varepsilon_o D^2/D = k\varepsilon_o D$, $\mathbb{V} = kn_e e/\varepsilon_o D$, $\mathbb{V}_p = \sqrt{c^4/4\pi\varepsilon_o G}$, $L_p = \sqrt{\hbar G/c^3}$, , $e = \sqrt{\alpha 4\pi\varepsilon_o \hbar c}$, n_e = number of electrons

$$\Delta L = \underline{\mathbb{V}} D = \frac{\mathbb{V}D}{\mathbb{V}_p} = \frac{n_e D\sqrt{\alpha 4\pi\varepsilon_o \hbar c}}{\varepsilon_o D \mathbb{V}_p} = \frac{n_e\sqrt{\alpha 4\pi\varepsilon_o \hbar c}}{\varepsilon_o}\sqrt{\frac{4\pi\varepsilon_o G}{c^4}} = \sqrt{\alpha}\, 4\pi n_e L_p$$

$$\Delta L = k\sqrt{\alpha}\, n_e L_p$$

The above equation will be expressed in words. The non-reciprocal distortion of spacetime ΔL produced across the width of a cubic vacuum capacitor (D) is equal to 1.38×10^{-36} meters per electron. This holds for all size cubic vacuum capacitors (all values of D).

Converting elementary charge e to coulomb, the strain of spacetime produced by a coulomb of charge on a cubic vacuum capacitor is:

$\Delta L/q = \sqrt{\alpha}L_p/e = 8.62\times10^{-18}$ meters/coulomb = η (the charge conversion constant)

Therefore one of the physical interpretations of the charge conversion constant η is that this is the distortion of spacetime produced over the width (D) of a cubic vacuum capacitor by a coulomb of charge.

Previously it was calculated $\Delta L = \sqrt{n_\gamma}L_p$ for n_γ photons in the maximum confinement cavity approximately of volume $\lambda\!\!\!^-{}^3$. Now we have $\Delta L = \sqrt{\alpha}\, n_e L_p$ for a vacuum capacitor with dimensions DxDxD (ignoring numerical factors near 1). The electric field distortion produced by photons and electric charge become very similar if we have similar size ($\lambda\!\!\!^- \approx D$). The calculation is not shown here, but an electric field generated by photons produces the same polarized distortion of spacetime (ΔL) as an equal electric field strength produced by charged particles on a vacuum capacitor. In other words, $\Delta L = \mathbb{E}L^2/\mathbb{V}_p$ holds for electric fields generated by either photons or electrons. The photon field is oscillating and has an associated magnetic field, so there are also differences in the value of k which is being ignored. However, the point is that even though the photon equation scales with the square root of the number of photons $\sqrt{n_\gamma}$ and the capacitor equation scales with the number of electrons n_e (no square root), still when the effect is reduced to electric field of equal strength in equal volumes, the values of ΔL are the same (ignoring k).

Experiments Using Light: In earlier versions of this book and in an earlier technical paper, I discussed possible experiments using light in an attempt to measure the predicted non-reciprocal path length difference between opposite propagating directions. However, now I doubt that light can measure this effect. The doubt has nothing to do with the fact that all practical experiments produce a value of non-reciprocal length change ΔL in the range of 10^{-20} to 10^{-18} m. The best interferometers currently can see a modulated length change on the order of 10^{-18} m. Therefore, if the effects were measurable by interferometers, they would be near the detectable limit. However, the real problem is that it now appears as if the light from an interferometer will not be able to see any value of ΔL produced by an electric field no matter the magnitude. The problem has to do with the way that light propagates through spacetime. Before I explain the problem, I want to give some history about the understanding of light.

In the late 1600's one of the biggest mysteries of science was double refraction. When light passes through a crystal known as Iceland spar (a crystal of $CaCO_3$), the light is broken into two beams and double images appear. Isaac Newton proposed a corpuscular theory of light but his corpuscular theory could not explain double refraction. In 1690, Christian Huygens proposed a wave-based theory of light. Huygens also derived a partial explanation of double refraction. The Huygens Principle considers each point on a wavefront to be the source of a new wave. Huygens realized that if the velocity of light varied with the direction in the crustal, then the spheres would deform into ellipsoids and be able to partially explain double refraction of Iceland spar. Even though his explanation could be reduced to an equation which corresponded to experiment, the explanation did not give conceptual understanding of the fundamental difference between the two beams. He, and everyone else for the next 100 years, assumed that light waves were longitudinal waves like sound waves in air. The problem was that longitudinal waves could not explain double refraction.

The puzzle of double refraction was so iconic, that in 1807 the French Institute offered a cash prize to anyone who could explain this phenomena. The prize was initially awarded to a Frenchman, Etienne Malus, in 1810 and a second cash prize was awarded to a French woman, Sophie Germain, in 1816. However, these were only partial solutions. The most important insight was made by Thomas Young several years later when he showed that light is a transverse wave. The transverse waves of unpolarized light were being split into two orthogonal linear polarizations by the crystal. This gave an explanation of double refraction of light which was both conceptually understandable and mathematically rigorous. However, Thomas Young, an Englishman, was not awarded a third cash prize by the French Institute.

This story about double refraction and polarized light is told to prepare the reader for a more complex model of the distortion of spacetime produced by a photon. In earlier drafts of this book I proposed that the distortion of spacetime could be measured by an interferometer where the two beams propagate in opposite directions across the rotating electric field produced by microwave radiation in a maximum confinement cavity. One laser beam would experience a decrease in path length while the opposite propagation beam would experience an increase in path length. A half cycle later the rotating microwave electric field would have reversed polarity. If the intensity of the rotating EM radiation (probably microwaves) could be made high enough, the modulated path length might be detectable as an intensity modulation when the two laser beams are compared in an interferometer.

The problem with this experiment is that it does not properly address the transverse wave structure of light. As previously stated, a photon is not a packet of energy that propagates linearly through the empty void of spacetime. Instead, a photon is a transverse wave that is interacting with the properties of spacetime transverse to the direction of propagation. The speed of light for linearly polarized light is set by the speed of wave propagation in the plane of polarization. Therefore, light cannot be used to accurately measure distance in the direction of propagation if the medium being probed is not homogeneous. This transverse wave property creates a problem for any experiment that attempts to use light to measure the distortion of spacetime produced by an electric field.

When light propagates through homogeneous glass, it has a speed of light less than 1. The relative permittivity ε of the glass and the index of refraction are both homogeneous in all directions. However, suppose that the glass is stressed by a uniform compression along what we will consider to be the Z axis of the glass. The permittivity ε in the Z direction becomes different than the permittivity measured in the X and Y axis. Linearly polarized light with its electric field vector along the Z axis propagates through the glass at a different speed than light of the same wavelength but polarized along any orthogonal direction. When light is propagating through a uniform medium, then we can ignore the transverse wave nature of light. However, when the medium is not uniform in all directions, we have to be careful about the actual mechanics of wave propagation through the medium when attempting to make a distance measurement.

Normally, the vacuum is considered to be perfectly homogeneous. However, the proposal is that both gravitational waves and electric fields distort the vacuum (spacetime) so that it is not homogeneous in all directions. The inhomogeneity is extremely small, but we are attempting to devise experiments to measure this effect. Therefore, the experiment is specifically designed to enhance the inhomogeneity to a measurable level. However, there is a problem that will be illustrated with an example. Suppose that a vacuum capacitor contains two small holes in the middle of each flat plate of the capacitor. Sending a laser beam through the holes would have the laser beam propagating one way along the electric field of the capacitor. The prediction is that the distance along the electric field should be different for a "time of flight measurement" proceeding in the two opposite directions (positive to negative compared to negative to positive).

However, the speed of propagation of the laser beam is determined by the properties of spacetime <u>perpendicular</u> to the propagation direction. Even with an extremely strong electric field, it should be impossible for a beam of EM radiation to measure any effect. Even if the beam direction is changed so that it propagates perpendicular to the electric field with the polarization direction parallel to the probed electric field, there still should be almost no detectable effect. Recall that the round trip distance in an electric field should be unchanged compared to the round trip distance with no electric field. The EM radiation has an oscillating (reversing) electric field so it is probing the round trip properties of spacetime. One complete cycle of the oscillating electric field should produce no first order effect. There would be a very small second order nonlinear effect associated with the gravity produced by the electric field, but that would be vastly smaller than the first order effect. It would also be symmetrical.

There is another hypothetical way to probe the distortion of spacetime produced by an electric field that gets around to problems of EM radiation but has its own practical problems. Suppose that a neutral particle such as a neutron or neutrino could be sent along the electric field. If the speed was accurately known, then distance could theoretically be measured by a time of flight measurement. This is not subject to the transverse wave problems of light and it should hypothetically give the one way distance. The obvious problem is that neutron or neutrino beams are completely impractical to experimentally measure distance accurately.

Implied Maximum Energy Density for Photons: Even though experimental verification appears impractical, there are other ways of checking the validity of the predictions. The following calculations test the model at the highest energy density. When I first developed the equations for the distortion of the spacetime field produced by electromagnetic radiation, I quickly realized that there was an implied limit. The finite properties of the spacetime field implied that there should be a maximum intensity limit for EM radiation. This limit is set because EM radiation produces a distortion of the spacetime field which has finite properties. It should be impossible to exceed 100% distortion of any portion of the spacetime field if the model is correct. Initially, this prediction was counterintuitive and appeared to be revealing a flaw in the model.

This implied limit will be explained using the maximum confinement cavity but it applies even to a laser beam focused in a vacuum. For example, the equation $\Delta L = \sqrt{n_\gamma} L_p$ applies to a cavity of volume $ƛ^3$. This equation implies that there is a maximum possible value of ΔL that can be achieve. When $\Delta L = ƛ$, then the distortion ΔL equals the size ($ƛ$) of the maximum confinement cavity (ignoring numerical factors near 1). Therefore if the model of the distortion of spacetime produced by the electric field generated by photons was correct, it should be impossible to exceed the condition where $\Delta L = ƛ$ in a volume of $ƛ^3$ because this would require 100% modulation of the properties of the spacetime field within this volume.

As you probably have guessed, experimentally testing this prediction would require a peak power that is totally beyond human capability. For example, suppose that we attempted to exceed the 100% modulation of spacetime limit using a pulsed laser with a wavelength of 10^{-6} m (1 micron). If we assume a pulse length 1 wavelength long (3×10^{-15} s pulse has a length of 1 micron) and the beam focused to a spot 1 wavelength in diameter, then the volume of the focused pulse would be about 1 micron in diameter. To exceed the ability of the spacetime field to transmit this radiation, the peak power in the pulse would have to be about 10^{53} watts. The energy in the 3×10^{-15} s pulse would have to be about 10^{38} Joules to reach this theoretical transmission limit for a 1 micron diameter volume. To put this energy requirement in perspective, this required energy is equivalent to the annihilation energy of about 10^{21} kg which is about the mass of all the oceans on earth. An experiment is obviously not possible, but it is quite easy to check this prediction theoretically.

We will return to the maximum confinement resonator previously described which had a diameter of ½ wavelength and a length of ½ wavelength. Since the energy density inside is not uniform and maximum near the center, we loosely defined this volume as $ƛ^3$ by ignoring numerical factors near 1. For this condition, we previously determined the displacement amplitude ΔL as: $\Delta L = \sqrt{n_\gamma} L_p$. where n_γ equals the number of photons in the resonator. We will now designate n_c as the critical number of photons at frequency ω required to theoretically achieve 100% modulation at wavelength $ƛ$. This condition occurs at $\Delta L = ƛ$. This critical number of photons in volume $ƛ^3$ has a critical amount of energy of E_c. Therefore we will analyze the critical energy E_c in volume $ƛ^3$ to see if there is any obvious reason preventing electromagnetic radiation from exceeding the implied limit that would achieve 100% modulation (achieve $\Delta L = ƛ$.)

$n_c = \frac{E_c}{\hbar\omega} = \frac{E_c ƛ}{\hbar c}$ set $\Delta L^2 = n_c L_p^2$

$\Delta L^2 = n_c L_p^2 = \left(\frac{E_c ƛ}{\hbar c}\right)\left(\frac{G\hbar}{c^3}\right)$ set $\Delta L = ƛ$

$ƛ = \frac{GE_c}{c^4} = \frac{Gm}{c^2} = R_s$ where $R_s \equiv Gm/c^2$ the 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 would also make a black hole! The maximum confinement resonator can be considered to have a radius equal to $ƛ$. For the critical condition, $ƛ = R_s$, where $R_s \equiv Gm/c^2$ is the previously defined Schwarzschild radius of a black hole. Therefore, it is indeed impossible to exceed the implied limit that would achieve 100% modulation of spacetime because this is the condition that creates a black hole. If more energy than the transmission limit was provided, the energy density would form a black hole which would block transmission through the volume. While the calculation assumed a maximum confinement cavity, this same limit would apply if the laser beam achieved this size and energy density by merely being focused in a vacuum. This successful test has several profound implications.

1) The proposed quantum mechanical model of spacetime (dipole waves in the spacetime field) is strongly supported.
2) The concept that EM radiation is a wave propagating in the medium of spacetime is supported.
3) The displacement amplitude of n_γ photons in "maximum confinement" is: $\Delta L = \sqrt{n_\gamma} L_p$
4) The condition that creates a black hole can now be understood more completely than merely discussing vague terms such as "curved spacetime". Now the internal workings of spacetime that creates curved spacetime can be quantified.

We cannot exceed the intensity that would demand more than 100% modulation of the spacetime field. This field has all frequencies up to Planck frequency and a total energy density of about 10^{113} J/m^3. However, it is not necessary to exceed 10^{113} J/m^3 to achieve a black hole. That is the intensity required to achieve a black hole with wavelength equal to Planck length. To achieve a black hole using 1 micron light, it is only necessary to achieve 100% modulation of the portion of the spacetime field with frequency of about 3×10^{14} Hz in a volume about 1 micron in diameter (this example ignores numerical factors near 1).

Maximum Voltage on a Vacuum Capacitor: There is another prediction that will test the proposed model of the distortion of spacetime produced by an electric field. In the case of the cubic vacuum capacitor calculated earlier, we generated the equation $\Delta L = \underline{\mathbb{V}}\, D$ for a vacuum capacitor with dimensions $DxDxD$. In other words, the distance between the parallel plates of the vacuum capacitor is D. Therefore the maximum distortion of the spacetime field occur when $\Delta L = D$. This would also be 100% distortion of the properties of the spacetime field within the vacuum capacitor volume (*DxDxD*). This condition is reached when $\underline{\mathbb{V}} = 1$. Since the definition of $\underline{\mathbb{V}}$ is: $\underline{\mathbb{V}} \equiv \mathbb{V}/\mathbb{V}_p$, it should be impossible to exceed the condition where the voltage on the cubic vacuum capacitor equals Planck voltage $\mathbb{V} = \mathbb{V}_p$ because at this voltage $\underline{\mathbb{V}} = 1$. This limit seems strange because this fixed maximum voltage applies to any size cubic vacuum capacitor. Therefore, there is not a maximum electric field but a maximum voltage. We will calculate the energy contained in a cubic vacuum capacitor when it is charged to Planck voltage. Substitutions to be used: $\mathbb{V}_p = \sqrt{c^4/4\pi\varepsilon_o G}$, $E = kC\mathbb{V}^2$, $C = k\varepsilon_o D^2/D = k\varepsilon_o D$ *where:* C = capacitance

$$E = kC\mathbb{V}_p^2 = (k\varepsilon_o D)\left(\frac{c^4}{4\pi\varepsilon_o G}\right) = k\,\frac{c^4 D}{G}$$

$$D = \frac{GE}{c^4} = \frac{Gm}{c^2} = R_s$$

Therefore the equation $D = R_s$ says that the condition which achieves 100% modulation of the properties of spacetime within the vacuum capacitor also forms a black hole with radius R_s. It is impossible to exceed Planck voltage on a cubic vacuum capacitor because this requires energy which would form a black hole. (This statement ignores numerical factors near 1 and ignores fringing of the electric field around the edges of the plates.) Again, this analysis of the maximum voltage on any size vacuum capacitor is revealing something about the mechanics of the formation of a black hole beyond the standard gravitational explanations.

Gravitational Wave Detection: We are going to pause from the discussion of electric fields and briefly examine the implications for the detection of gravitational waves. For review, a gravitational wave is a transverse wave that propagates through the spacetime field at the speed of light. It causes a spherical volume of spacetime to become an oscillating ellipsoid. If the gravitational wave propagates in the Z axis direction, the elliptical elongation and contraction will occur perpendicular to the Z axis. We can define the X and Y axis to correspond to the transverse directions of maximum oscillation. There is no effect on the rate of time and no change in proper volume because an expansion of the X axis is offset by a contraction of the Y axis and vice versa.

The LIGO experiment will be used as an example of experiments around the world currently attempting to detect gravitational waves. This experiment is a power recycled Michelson interferometer. Massive mirrors suspended by wires are located at each of the corners of L-shaped evacuated tubes which are 4 km long. Suppose that a large gravitational wave passes with properties would produce the maximum difference in path length between the mirrors. What is physically happening? Is there a force exerted on the mirrors causing the mirrors to physically move (accelerate and decelerate)? Alternatively, does the change in the separation distance result from a change in the properties of the spacetime field with no force exerted on the mirrors (no acceleration and deceleration of the mirrors)?

This second alternative is proposed to be correct. The properties of spacetime change in way that affects the size of rotars, atoms, etc. This would make physical objects such as meter sticks and tape measured change their size. The distance between the mirrors would change according to physical measurements, but there would be no physical motion of the mirrors. There would be no force, and no acceleration of the mirrors. Here are two reasons for believing this.

1) Suppose that one of the two mirrors had vast mass, equivalent to the mass density of a neutron star. The force that must be exerted to achieve the required physical motion of this mirror would also have to be vast. Yet there is no offsetting mass accelerating in the opposite direction required to achieve the conservation of momentum. Assuming that the mirrors physically move is a violation of the conservation of momentum.
2) A gravitational wave does not affect the rate of time. If a gravitational wave achieves the acceleration of matter using gravity, the gravitational wave would have to affect the rate of time and possess a rate of time gradient. As discussed in chapter 2, all gravitational acceleration implies a rate of time gradient. Since a gravitational wave does not exert a gravitational force, is there any other force which might accelerate the mirrors?

Therefore, a gravitational wave affects the spatial properties of two of the three spatial dimensions. There is no effect on proper volume but the three orthogonal directions (X, Y and Z axis) of the spacetime field have received different distortions. Now the question is: what effect does this spatial change have on EM radiation? If you think of a photon as being a bullet-like packet of energy, then only one dimension (the propagation direction) is being probed and distance as measured by time of flight of photons in that one dimension should agree with the meter stick measurement. However, if the model of photons is a transverse wave propagating in the medium of the spacetime field, then it is not obvious what effect the two transverse dimensions might exert on the distance measurement.

To explore this question, we will temporarily shift from a gravitational wave affecting spacetime to a gravitational wave affecting a transparent cube made of a homogeneous material such as glass. The faces of the cube are aligned with the X, Y and X axis previously defined. A gravitational wave passing through this transparent cube will cause the cube to become an oscillating rectangle which exhibits both modulated birefringence and a modulation of the relative permeability ε.

The modulated birefringence and modulated permittivity in glass would cause a single beam of circularly polarized light propagating in any direction in the glass cube to become an oscillating elliptical polarized beam of light. The biggest effect on polarization of circularly polarized light would be for the beam propagating along the Z axis. This is the direction that does not experience any change in the time of flight path length. However, since light is a transverse wave, changes in ε_0 or the speed of light for light polarized in the X and Y directions convert circularly polarized light propagating in the Z direction into oscillating elliptically polarized light. If we consider the spacetime field to be a medium in which EM radiation propagates, then it should react to the passage of a gravitational wave similar to the way that a transparent homogeneous material such as glass would react. In particular, the propagation speed (inverse index of refraction) depends on the polarization direction, not the direction of propagation. There is some uncertainty in this, but if gravitational waves turn the spacetime field into an oscillating birefringent material, then there would be simpler and more sensitive ways of detecting gravitational waves.

Presently, the biggest source of noise using interferometers is the seismic noise. Interferometers are attempting to detect very small difference in optical path length between the two arms. Anything that produces even a very small vibration is a source of noise. Even the photon pressure of the light making the measurement is a source of noise. If the spacetime field becomes a birefringent medium, then it would be possible to detect gravitational waves without using an interferometer. For example, circularly polarized light propagating in the Z direction, should encounter a birefringence (difference in ε) in the X and Y directions. This would cause even a single beam of circularly polarized light to become an oscillating ellipsoid of polarized light. Other experiments can also be devised but the point is that it is much easier to detect changes in a single polarized beam than changes in the path length of two beams propagating in two widely separated arms of an interferometer.

Also, this proposed birefringence can also create problems for interferometers. If the two beams of an interferometer have the same polarization direction, then this would cause the same path length change to occur in both arms of the interferometer. Even if there was a large signal, both arms would experience the same path length change. The interferometer would detect no difference in path length and there would be no signal.

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 ($\mathbb{E} = c\mathbb{B}$). 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

[1] http://users.rcn.com/eslowry/elmag.htm

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 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 rotar radius $\lambda\!\!\!^{-}_c$. However, when $r \approx \lambda\!\!\!^{-}_c$, 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 the spacetime field. 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 the spacetime field 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 $\lambdabar_c$. 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 rotar radius $\lambdabar_c$. 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 $\lambdabar_c = 3.86 \times 10^{-13}$ m and an electron's Compton frequency is equal to: $\nu_c = c/\lambda_c = 1.23 \times 10^{20}$ Hz. The electron's equivalent circulating current (symbol I_e) is simply elementary charge $e = 1.602 \times 10^{-19}$ Coulomb times the electron's Compton frequency $\nu_c = 1.236 \times 10^{20}$ Hz.

$\mathbb{I}_e = e\nu_c \approx 19.796$ amps $\qquad \mathbb{I}_e =$ electron's equivalent circulating current $\sim$ 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 rotar radius $\lambdabar_c$. 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 $\mathcal{A} = \pi r^2$ and current is: $\mu_m = \mathcal{A}\mathbb{I}$. To simulate an electron, we will use: $\mathcal{A} = \pi\lambdabar_c^2$ and $\mathbb{I} = \mathbb{I}_c = e\nu_c$.

$\mu_m = \pi\lambdabar_c^2\mathbb{I}_c = \pi\,(3.8616 \times 10^{-13}\text{ m})^2 \times 19.796\text{ amp} = 9.274 \times 10^{-24}$ 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 $\lambdabar_c$, 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 rotar radius λ_c. From this postulate, the electron's magnetic field calculated from $\mathbb{I}_c$ and λ_c will be designated $\mathbb{B}_e$. The equation for the magnetic field at the center of a single circular loop of wire with radius r and current is:

$\mathbb{B} = \mu_0 \mathbb{I}/2r$ set $\mathbb{I} = \mathbb{I}_c$ and $r = \lambda_c$ for an electron ($\lambda_c = 3.86 \times 10^{-13}$ m)
$\mathbb{B}_e = 3.22 \times 10^7$ Tesla $\mathbb{B}_e$ = 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 rotar volume (external to λ_c)? The calculation is not shown here, but the energy in the electric field external to an electron's radius λ_c 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 rotar volume ($V_r = [4\pi/3]\, \lambda_c^3 \approx 2.41 \times 10^{-37}$ 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 (~3×10^{-16} J) comparable to, but more than, the energy in a 3.22×10^7 Tesla magnetic field filling the electron's rotar volume?

$E = UV_r = (B^2/2\mu_0)(4\pi/3)\lambda_c^3 \approx 10^{-16}$ J energy in the calculated magnetic field in volume V_r

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 3.22×10^7 Tesla magnetic field over a distance equal to the electron's rotar radius $\lambda_c = 3.86 \times 10^{-13}$ 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 3.22×10^7 Tesla over a distance equal to λ_c. For a uniform electric field $\mathbb{E}$ over distance L, we previously had $\Delta L = \mathbb{E}L^2/\mathbb{V}_p$ which converts to $\Delta\underline{L} = \underline{\mathbb{E}}\underline{L}^2$ (note underlines implying dimensionless Planck units). Now we will replace L with λ_c, 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 ($\underline{\mathbb{E}} = \mathbb{E}/\mathbb{E}_p$) can be considered equivalent to a magnetic field expressed in dimensionless Planck units ($\underline{\mathbb{B}} = \mathbb{B}/\mathbb{B}_p$). In this equation $\mathbb{B}_p$ is Planck magnetic field which is $\mathbb{B}_p = Z_s/q_p = 2.15 \times 10^{53}$ Tesla. This means that, ignoring numerical factors near 1, it is reasonable to convert $\Delta\underline{L} = \underline{\mathbb{E}}\underline{L}^2$ to $\Delta\underline{L} = \underline{\mathbb{B}}\underline{\lambda}_c^2$ when we are dealing with a fundamental particle with radius λ_c.

$\Delta\underline{L} = \underline{\mathbb{B}}\underline{\lambda}_c^2$ dimensionless Planck units
$\Delta L = \mathbb{B}\lambda_c^2/\mathbb{B}_p L_p$ converted from dimensionless Planck units to SI units
Set $\mathbb{B} = 3.22 \times 10^7$ Tesla, $\mathbb{B}_p = 2.15 \times 10^{53}$ Tesla, $L_p = 1.6 \times 10^{-35}$ m, $\lambda_c = 3.86 \times 10^{-13}$ m

$\Delta L \approx 1.38 \times 10^{-36}$ m $\approx \sqrt{\alpha}\, L_p$

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 λ_c 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 the spacetime field that produces a magnetic field.

As previously explained, the rotation of an electron's extremely small distortion of the spacetime field 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 the spacetime field that is producing a magnetic field of about 3×10^7 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 rotar volume compared to a typical volume of the spacetime field that is not inside an electron and does not have a magnetic field? The "typical" volume of the spacetime field 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 the spacetime field that has a small rotating component with strain amplitude equal to $A_\beta \approx 4.2 \times 10^{-23}$. For review, see figures 5-1 and 5-2 from chapter 5. This would produce a rotational path length difference that is difficult to articulate.

Recall that an electric field is proposed to be a distortion of one spatial dimension of the spacetime field (parallel to the electric field direction) that results in a slight asymmetric distance proceeding in opposite propagation directions. The round trip distance is unchanged. A magnetic field is similar except that the plane transverse to the magnetic field has a rotational distance asymmetry. The time required for a particle with known speed to proceed around the circumference of a circle proceeding clockwise in this plane would be slightly different than the time required to proceed counterclockwise. Since light is a transverse wave, it is not accurate to imply that a pulse of light propagating around a circle would be able to measure this subtle effect. Therefore terms like "speed of light" would be misleading.

However, since light is a transverse wave, the implication is that a total vacuum should exhibit a Faraday effect for light propagating parallel to the magnetic field direction. If a photon was a bullet-like energy packet, then we would not expect any effect if it propagates through a volume of space that is experiencing a rotational asymmetry of the spacetime field. However, a transverse wave propagating through a rotationally strained volume of spacetime would experience a polarization effect. Linearly polarized light propagating along a magnetic field should experience a slight rotation of the plane of polarization. Circularly polarized light would experience a path length change. The value ΔL can be thought of as the difference in path length exhibited by opposite circular polarizations propagating in a medium with a magnetic field. This is essentially a prediction that a complete vacuum containing a magnetic field should exhibit a Faraday effect.

The magnitude of the effect is difficult to predict since it is not clear how to treat the transverse size of a photon propagating along the magnetic field. If it is possible to make an analogy to an electric field, then here is one attempt at a calculation. The magnitude of ΔL can perhaps be calculated from $\Delta \underline{L} = \mathbb{B}\underline{\lambda}_c^2$ which converts to $\Delta \underline{L} = \underline{\mathbb{B}}\underline{L}^2 = \mathbb{B}L^2 / \mathbb{B}_p L_p^2$ when we set $\underline{\lambda} = \underline{L}$. Also $\mathbb{B}_p = 2.15\times10^{53}$ Tesla and $L_p = 1.6\times10^{-35}$ m.

$$\frac{\Delta L}{L_p} = \frac{\mathbb{B}}{\mathbb{B}_p}\frac{L^2}{L_p^2}$$

$$\Delta L = \frac{\mathbb{B}}{2\times10^{53}\,tesla}\frac{L^2}{1.6\times10^{-35}\,meter} = 3\text{x}10^{-19}\mathbb{B}L^2\ meter$$

There is a special way that the length term must be calculated explained in the analogous electric field experiment calculation. Without going into the details, the experiment is marginally detectable ($\Delta L \approx 10^{-18}$ or 10^{-19} m) for some hypothetical values. There are some possible effects which might hide the proposed vacuum effect. For example, any residual gas in the vacuum would exhibit a competing Faraday effect. However, the magnitude of the effect due to residual gas could be approximately offset by changing the gas pressure and attempting to subtract out this effect.

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 (~5×10^{-5} Tesla) at a distance of 3×10^{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 3.5×10^{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 5×10^{-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 3×10^{-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. While no energy is being extracted from the star's magnetic field, it would take 3×10^{10} watts of real photons to generate a 100 N force if this force was generated by photon pressure. A 100 Newton force lasting 10^{-8} s would require about 300 Joules if it was generated by deflecting real photons. 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 the spacetime field. Even the instantaneous generation of a 10^{21} Newton force can be explained. The magnetic field is a distortion of the spacetime field with its sea of dipole waves. The maximum force that the spacetime field 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.

$U = A^2 \omega^2 Z/c$ 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 A. We know that a general expression of the maximum permitted dipole wave in spacetime is: $A_{max} = L_p/\lambda\!\!\!^- = T_p\omega$. 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:

$$\eta \equiv \frac{L_p}{q_p} = \frac{\sqrt{\alpha}L_p}{e} = \sqrt{\frac{G}{4\pi\varepsilon_o c^4}} = 8.617 \times 10^{-18} \text{ meter/Coulomb}$$

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	$\mathbb{E}_p = c^4/G\sqrt{4\pi\varepsilon_o \hbar c}$	$\mathbb{E}_p = \eta Z_s/T_p$
Planck magnetic field	$\mathbb{B}_p = c^3/G\sqrt{4\pi\varepsilon_o \hbar c}$	$\mathbb{B}_p = \eta Z_s/cT_p$
Planck voltage	$\mathbb{V}_p = \sqrt{c^4/4\pi\varepsilon_o G}$	$\mathbb{V}_p = \eta cZ_s$

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, the spacetime field 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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