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 and $L_p = (\hbar G/c^3)^{1/2}$

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

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).

$$\eta \equiv \sqrt{\frac{G}{4\pi\varepsilon_o c^4}} = \frac{L_p}{q_p} \approx 8.61\times10^{-18}\ \ \text{m/C} \qquad \text{charge conversion constant}$$

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 <u>THROUGH</u> the empty void of spacetime. Photons are waves <u>IN</u> 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.