Force Relationships from Chapter 8

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

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

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

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

Calculation with Two Different Mass Particles: Until now we have assumed two of the same mass/energy particles when we calculated F_g and F_E. Now we will assume two different mass particles (m_1 and m_2), but we will keep the assumption that both particles have Planck charge. When we have two different mass particles, this means that we have two different reduced Compton wavelengths ($\lambdabar_{c1} = \hbar/m_1c$ and $\lambdabar_{c1} = \hbar/m_2c$). The single radial separation r now becomes two different values $\mathcal{N}_1 = r/\lambdabar_{c1}$ and $\mathcal{N}_2 = r/\lambdabar_{c2}$. Also, there would be two different strain amplitudes $A_{\beta1} = L_p/\lambdabar_{c1}$ and $A_{\beta2} = L_p/\lambdabar_{c2}$ as well as a composite area $\mathcal{A} = k\lambdabar_{c1}\lambdabar_{c2}$.

$$F_g = k\left(\frac{A_{\beta1}^2 A_{\beta2}^2}{\mathcal{N}_1\mathcal{N}_2}\right)\left(\frac{c^2}{ƛ_{c1}ƛ_{c2}}\right)\left(\frac{c^3}{G}\right)\left(\frac{ƛ_{c1}ƛ_{c2}}{c}\right) = k\,\frac{Gm_1m_2}{r^2}$$

$$F_E = k\left(\frac{A_{\beta1}A_{\beta2}}{\mathcal{N}_1\mathcal{N}_2}\right)\left(\frac{c^2}{ƛ_{c1}ƛ_{c2}}\right)\left(\frac{c^3}{G}\right)\left(\frac{ƛ_{c1}ƛ_{c2}}{c}\right) = k\frac{q_p^2}{4\pi\varepsilon_o r^2}$$

Note that the only difference between the intermediate portions of these two equations is that the gravitational force F_g has the strain amplitude terms squared ($A_{\beta1}^2A_{\beta2}^2$) and the electrostatic force F_E has the strain amplitude terms not squared ($A_{\beta1}A_{\beta2}$). The tremendous difference between the gravitational force and the electrostatic force is due to a simple difference in exponents.

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

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

Convert both equations: $F_E = q_p^2/4\pi\varepsilon_o r^2$ and $F_g = Gm^2/r^2$ into equations using $\underline{\boldsymbol{F}}_g$; $\underline{\boldsymbol{F}}_E$ and $\mathcal{N}$.
Substitutions: $r = \mathcal{N}\hbar c/E_i$; $m = E_i/c^2$; $E_i = \underline{\boldsymbol{E}}_i E_p = \underline{\boldsymbol{E}}_i\sqrt{\hbar c^5/G}$

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

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

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

The equation $(\underline{\boldsymbol{F}}_g\mathcal{N}^2) = (\underline{\boldsymbol{F}}_E\mathcal{N}^2)^2$ clearly shows that even with arbitrary separation distance the square relationship between F_g and F_E still exists. It is informative to state these same equations in terms of power because a fundamental assumption of this book is that there is only one truly fundamental force $F_r = P_r/c$. If this is correct, then we would expect that the force relationship between rotars would also be a simple function of the rotar's circulating power: $P_c = E_i\omega_c =$

$m^2c^4/\hbar$. To convert P_c to dimensionless Planck units $\underline{\boldsymbol{P}}_c = P_c/P_p$ we divide by Planck power $P_p = c^5/G$. Note the simplicity of the result.

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

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

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

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

It is informative to give a numerical example which illustrates this equation. Suppose that two electrons are separated by 68 nanometers (this distance simplifies explanations). The electrons experience both a gravitational force F_g and an electrostatic force F_e. The electrons have $\lambda\!\!\!^{-}_c = 3.86\text{x}10^{-13}$ m, therefore this separation is equivalent to $\mathcal{N} = 1.76\text{x}10^5$ reduced Compton wavelengths. The gravitational force between the two electrons at this distance would be $F_g = 1.2\text{x}10^{-56}$ N and the electrostatic force would be $F_e = 5\text{x}10^{-14}$ N. Also $\alpha^{-1} \approx 137$ so combining F_e, $\mathcal{N}$ and α^{-1} we have: $F_e\mathcal{N}\alpha^{-1} = 1.2\text{x}10^{-6}$ N. Also Planck force is $F_p = c^4/G = 1.2\text{x}10^{44}$ N. To summarize and see the symmetry between these forces, we will write the forces as follows:

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

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

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

$F_g = k(A_\beta^2/\mathcal{N})^2\omega_c^2 Z_s\mathcal{A}/c$ F_g = gravitational force between two of the same mass particles

$F_E = k(A_\beta/\mathcal{N})^2\omega_c^2 Z_s\mathcal{A}/c$ F_E = the electrostatic force between two particles with Planck charge

set common terms equal to each other: $(k\omega_c^2 Z_s\mathcal{A}/c) = (k\omega_c^2 Z_s\mathcal{A}/c)$

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

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

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

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

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

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

The equation $F_g/F_E = R_s/ƛ_c$ is very interesting because F_g/F_e is a ratio of forces and $R_s/ƛ_c$ is a ratio of radii. Recall that $R_s \equiv Gm/c^2$ is the Schwarzschild radius of a maximally rotating black hole (similar to a rotar) and $ƛ_c = \hbar/mc$ is the radius of the rotar model of a fundamental particle. For example, for an electron $R_s = 1.24 \times 10^{-54}$ m and an electron's rotar radius is: $ƛ_c = 3.85 \times 10^{-13}$ m. These two numbers seem completely unrelated, yet together they equal the electron's force ratio $F_g/F_e\alpha^{-1} = 1.75\text{x}10^{-45} = R_s/ƛ_c$.

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

$$R_sƛ_c = \left(\frac{Gm}{c^2}\right)\left(\frac{\hbar}{mc}\right) = \frac{\hbar G}{c^3}$$

$$R_sƛ_c = L_p^2$$

$$\underline{\boldsymbol{R}}_s = 1/\underline{ƛ}_c \qquad \text{equivalent to : } R_s/L_p = L_p/ƛ_c$$

The Schwarzschild radius comes from general relativity and is considered to be completely unconnected to quantum mechanics. A particle's reduced Compton wavelength comes from quantum mechanics and is considered to be completely unconnected to general relativity. However, when they are expressed in natural units (dimensionless Planck units) the two radii are just the inverse of each other $\underline{\boldsymbol{R}}_s = 1/\underline{ƛ}_c$. Also $R_sƛ_c = L_p^2$. The relationships between R_s and $ƛ_c$ are compatible with the wave-based rotar model of fundamental particles but they are incompatible with the messenger particle hypothesis of force transmission.

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

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

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