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Motion in a Medium Composed of Particles and Antiparticles

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I. Introduction

It is known that the interchange of the virtual photon is sufficient to explain the central potential in electromagnetic interactions. This has been achieved by comparing the force between particles of given charge through a summation of diagrams with virtual photons and the Coulomb force. A major success of quantum electrodynamics is the prediction of the inverse square law in the classical limit from the exchange of virtual photons.

Furthermore, the creation of particles and antiparticles in the vacuum can affect the motion within the medium. This has been examined previously with respect to the Lorentz transformations and the constancy of the speed of light. It will established that there is an effect also on the rotation motion of objects as a result of developing couples. Exploring further the possibility of linking angular momentum couples, the particles and antiparticles can be combined to create a substantial torque that will convert linear motion into orbital motion. Laws for this motion then can be formulated including a relation for the radii of these orbitals.

The possibility of an electromagnetic component to the force between between the Sun and the planets has been considered previously (Nieto, 1972). The similarity in the constants of proportionality in the relation between the total angular momentum and the squared mass has been verified from microscopic to astronomical scales (Wesson, 1981; Tassie, 1987). Furthermore, a linear combination of the gravitational and electromagnetic gradients yields the value for planetary systems for a ratio that coincides with the percentage of mass that can be attributed to dark matter (Davis, 2007).

It is known also that the strength of the electromagnetic force would require a reduction in the size of the source. A theoretical explanation of the distances in the planetary orbits can be found found in models describing both gravitational and electromagnetic interactions and gravi-electromagnetic solitons (Belinski, V. and Verdaguer, E., 2001). An exponential scale factor in the metric yields a connection between the source of the electromagnetic force and the gravitational effect at larger distances.

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II. The Creation of Particles and Antiparticles in the Medium

While the creation of electrons and positrons in quantum electrodynamics results from the non-zero inner product of the vacuum state with a state consisting of these particles and antiparticles, the process also can be modelled semiclassically with a balance between the electric and magnetic components of the potential and the energy of the electron (Batchelor, 2002). The Heisenberg time predicted by the uncertainty principle is determined by the mass of the electron to be

$$t_{He} = \frac{\frac{\hbar}{2}}{2m_e c^2} \simeq 3.220221702 \times 10^{-22} sec \qquad (2.1)$$

The time also may be evaluated through an integral over the trajectories of the the electrons and positrons representing the splitting and joining of the two paths. Substituting the values of the magnetic moment of the electron and its mass, the semiclassical time may be computed to be

$$t_{ve}^{(1)} \doteq \frac{R_{max}}{(1.0625)^{\frac{1}{3}} c} \int_0^1 \frac{d\tilde{\zeta}}{\sqrt{1-\tilde{\zeta}^{\frac{3}{2}}}} + \frac{R_{max}}{c} \int_{\frac{1}{(1.0625)^{\frac{1}{3}}}} \frac{d\zeta}{\sqrt{1-\zeta^{\frac{3}{2}}}} \approx 3.0896 \times 10^{-22} sec \qquad (2.2)$$

with R_{max} being half the maximum separation between the electron and positron (Davis, 2007). Since this value is less than t_{H_e}, the process might be examined to determine if there are any other effects that might contribute to the time of existence of the particle-antiparticle pair. In particular, since these processes are field theory limits of string processes which may have genus greater than or equal to two, the sum over diagrams would give a larger average for the time t_{ve}. This has been computed under two conditions. The process can be regarded as entirely virtual with the squares of the absolute values of the amplitudes determining the coefficients in the weighted average for the time, or the process may viewed as real with the magnitudes of the amplitudes substituted for the coefficients. The two methods give different results in keeping with the nature of the reaction. In the first instance, the total time was found to be

$$t_{ve}^{virt} \approx 3.09482893 \times 10^{-22} sec \qquad (2.3)$$

With the second technique,

$$t_{ve}^{real} \approx 3.227585405 \times 10^{-22} sec \qquad (2.4)$$

Since these times follow from an averaging procedure, in principle, there would be a distribution of values and the either process might occur. The reactions then would produce both virtual pairs and real particle-antiparticle pairs. The latter process would cause the medium to consist of these particle-antiparticle pairs, because the time exceeds t_{H_e} and the pair do not have the reaction does not have to be concluded by a pair annihilation (Davis, 2007). When the pair creation produces real electrons and protons, a moment $\vec{F} \times \vec{r}$ is generated, where $\vec{F}$ is generated by the magnetic force between the oppositely directed currents created by the moving charges and $\vec{r}$ is the position vector from the electron to the positron. Therefore, the particles and antiparticles form an electromagnetic couple which generates a torque. From the couplings of the electromagnetic and gravitational interactions and the size of the source of the centripetal force, it follows that the relative strengths of the forces are given by a factor

$$\alpha^3_{cent.} \frac{1}{1.3 \times 10^6} (1.216545 \times 10^{36}) \qquad \alpha_{cent.} = \frac{R_{cent.}}{R_E} \tag{2.5}$$

The classical Lagrangian of electromagnetism (Proca, 1936) and the Feynman diagrams of quantum electrodynamics may be used to deduce a $\frac{1}{r^2}$ Coulomb force in the classical limit through a Fourier transform of the momentum-space propagator (Feynman, 1949; 1965). While it is evident that scale of the effective interaction region in the Feynman diagram is the order of the Compton wavelength of the electron, the transition to a physical process would provide a realization of the $\frac{1}{r^2}$ electromagnetic force through a wave phenomena.

It follows that the model of a gravitational soliton in an electromagnetic field also would yield a description of material configurations a medium with pair creation and annihilation orbiting a central source. By choosing a metric

$$ds^2 = f_0(dz^2 - dt^2) + \alpha e^{2k\beta}(dx^1)^2 + \alpha e^{-2k\beta}(dx^2)^2 \tag{2.6}$$

and a potential $A^{(0)} = 0$, and dressing both the metric and potential through transformations constructed to give the soliton solution to the gravatitional and electromagnetic field equations (Garate and Gleiser, 1995; Belinski, V. and Verdaguer, E., 2001) the metric and potential are found to be

$$ds^2 = f(t,z)(dz^2 - dt^2) + g_{ab}(t,z)dx^a dx^b \tag{2.7}$$

where

$$g_{11} = \frac{q_0 sin\ t cosh\ z}{D_1}[(cosh\ t\ cosh\ \sigma - sin\ \sigma + \nu_0^2 sinh\ t)^2 + (sinh\ z sin\ \tau - cos\ \tau - \nu_0^2 cosh\ z)^2] e^{2kq_0 cosh\ t\ sinh\ z}$$

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$$g_{22} = \frac{q_0 sinh\ t\ cosh\ z}{D_1}[(cosh\ t\ cosh\ \sigma + sinh\ \sigma + \nu_0^2 sinh\ t)^2 + (sinh\ z\ sin\ \tau + cos\ \tau - \nu_0^2\ cosh\ z)^2]e^{-2kq_0 cosh\ t\ sinh\ z} \quad (2.8)$$

$$g_{12} = 2\frac{q_0\ sinh\ t\ cosh\ z}{D_1}[sinh\ zsinh\ \sigma\ sin\ \tau - cosh\ t\ cosh\ \sigma\ cos\ \tau - \nu_0^2(cosh\ zsinh\ \sigma + sinh\ t\ cos\ \tau)]$$

$$f = \frac{D_1}{\sqrt{q_0\ sinh\ t\ cosh\ z}} e^{k^2 q_0^2 sinh^2 t cosh^2 z}$$

and

$$D_1 = (sinh\ tcosh\ \sigma + \nu_0^2 cosh\ t)^2 + (cosh\ z\ sin\ \tau - \nu_0^2 sinh\ z)^2$$
$$\sigma = 2kq_0 sinh\ z - 2s_0 \quad (2.9)$$
$$\tau = 2kq_0\ cosh\ t - 2t_0 + \frac{\pi}{2}$$

with

$$A_a = 4\frac{q_0\nu_0}{D_1} Re\left\{ e^{i\delta_0}\bar{p}_a[\nu_0^2(sinh^2 z + cosh^2 t) + sinh\ t\ cosh\ t\ cosh\ \sigma - sinh\ z\ cosh\ z\ sin\ \tau - i(sinh\ t\ sinh\ z\ cosh\ \sigma + cosh\ z\ cosh\ t\ sin\ \tau)] \right\}$$

$$\bar{p}_1 = \frac{i}{2\sqrt{2}} e^{k\beta}\left(\frac{cosh[kq_0 sinh\ z - s_0 + i(kq_0\ cosh\ t - t_0)]}{\sigma_-} - \frac{sinh[kq_0 sinh\ z - s_0 + i(kq_0\ cosh\ t - t_0)]}{\sigma_+} \right)$$

$$\bar{p}_2 = \frac{i}{2\sqrt{2}} e^{-k\beta}\left(\frac{cosh[kq_0 sinh\ z - s_0 + i(kq_0\ cosh\ t - t_0)]}{\sigma_-} + \frac{sinh[kq_0 sinh\ z - s_0 + i(kq_0\ cosh\ t - t_0)]}{\sigma_+} \right)$$

$$\sigma_+ = \frac{\sqrt{q_0}}{2}\left[e^{\frac{(z+t)}{2}} + ie^{-\frac{(z+t)}{2}} \right]$$
$$\sigma_- = \frac{\sqrt{q_0}}{2}\left[e^{\frac{(z-t)}{2}} + ie^{-\frac{(z-t)}{2}} \right] \quad (2.10)$$

with the pole in dressing matrix occurring at $w_= iq_0$ and ν_0 and δ_0 are constants arising in T_{11}, which is derived from the expansion of this matrix (Belinski, V. and Verdaguer, E., 2001).

Consider the large-σ dependence of A_a. It is given by

$$lim_{\sigma\to\infty} 4q_0\nu_0 \left\{ Re\left(e^{i\delta_0}\bar{p}_a\right) \frac{sinh\ tcosh\ tcosh\ \sigma}{sinh^2 t\ cosh^2\sigma} + Im\left(e^{i\delta_0}\bar{p}_a\right) \frac{sinh\ t\ sinh\ z\ cosh\ \sigma}{sinh^t\ cosh^2\sigma} \right\}$$
$$\sim 4q_0\nu_0 lim_{\sigma\to\infty}\left\{ \frac{coth\ t}{cosh\ \sigma} Re\left(e^{i\delta_0}\bar{p}_a\right) + \frac{sinh\ z}{sinh\ t\ cosh\ \sigma} Im\left(e^{i\delta_0}\bar{p}_a\right) \right\} \quad (2.11)$$

Since

$$Re(e^{i\delta_0}\bar{p}_a) = cos\ \delta_0\ Re\ \bar{p}_a - sin\ \delta_0\ Im\ \bar{p}_a$$
$$Im(e^{i\delta_0}\bar{p}_a) = sin\ \delta_0\ Re\ \bar{p}_a + cos\ \delta_0\ Im\ \bar{p}_a, \tag{2.12}$$

and

$$Re\ \bar{p}_1 = -\frac{1}{2\sqrt{2}} e^{kq_0 cosh\ tsinh\ z} \left\{ \frac{sinh\ (kq_0 sinh\ z - s_0) sin(kq_0 cosh\ t - t_0) e^{\frac{z-t}{2}}}{\sqrt{2q_0} cosh(z-t)} - \frac{cosh(kq_0 sinhz - s_0) cos(kq_0 sinh\ t - t_0) e^{-\frac{z-t}{2}}}{\sqrt{2q_0} cosh(z-t)} - \frac{cosh(kq_0 sinh\ z - s_0) sin(kq_0 cosh\ t - t_0) e^{\frac{z+t}{2}}}{\sqrt{2q_0} cosh(z+t)} + \frac{sinh(kq_0 sinh\ z - s_0) cos(kq_0 sinh\ t - t_0) e^{-\frac{z+t}{2}}}{\sqrt{2q_0} cosh(z+t)} \right\}$$

$$Im\ \bar{p}_1 = \frac{1}{2\sqrt{2}} e^{kq_0 cosh\ t\ sinh\ z} \left\{ \frac{cosh(kq_0 sinh\ z - s_0) cos(kq_0\ cosh\ t - t_0) e^{\frac{z-t}{2}}}{\sqrt{2q_0} cosh(z-t)} + \frac{sinh(kq_0 sinh\ z - s_0) sin(kq_0 cosh\ t - t_0) e^{-\frac{z-t}{2}}}{\sqrt{2q_0} cosh(z-t)} - \frac{sinh(kq_0 sinh\ z - s_0) cos(kq_0 sinh\ t - t_0) e^{\frac{z+t}{2}}}{\sqrt{2q_0} cosh(z+t)} - \frac{cosh(kq_0 sinh\ z - s_0) sin(kq_0 cosh\ t - t_0) e^{-\frac{z+t}{2}}}{\sqrt{2q_0} cosh(z+t)} \right\} \tag{2.13}$$

$$Re\ \bar{p}_2 = -\frac{1}{2\sqrt{2}} e^{-kq_0 cosh\ t\ sinh\ z} \left\{ \frac{sinh(kq_0 sinh\ z - s_0) sin(kq_0 cosh\ t - t_0) e^{\frac{z-t}{2}}}{\sqrt{2q_0} cosh(z-t)} - \frac{cosh(kq_0 sinh\ z - s_0) cos(kq_0 sin\ t - t_0) e^{-\frac{z-t}{2}}}{\sqrt{2q_0} cosh(z-t)} + \frac{cosh(kq_0 sinh\ z - s_0) sin(kq_0 cosh\ t - t_0) e^{\frac{z+t}{2}}}{\sqrt{2q_0} cosh(z+t)} - \frac{sinh(kq_0 sinh(kq_0 sinh\ z - s_0) cos(kq_0 sin\ t - t_0) e^{-\frac{z-t}{2}}}{\sqrt{2q_0} cosh(z+t)} \right\}$$

$$Im\ \bar{p}_2 = \frac{1}{2\sqrt{2}} e^{-kq_0 cosh\ t\ sinh\ z} \left\{ \frac{cosh(kq_0 sinh\ z - s_0) cos(kq_0 cosh\ t - t_0) e^{\frac{z-t}{2}}}{\sqrt{2q_0} cosh(z-t)} + \frac{sinh(kq_0 sinh\ z - s_0) sin(kq_0 cosh\ t - t_0) e^{-\frac{z-t}{2}}}{\sqrt{2q_0} cosh(z-t)} + \frac{sinh(kq_0 sinh\ z - s_0) cos(kq_0 sinh\ t - t_0) e^{\frac{z+t}{2}}}{\sqrt{2q_0} cosh(z+t)} + \frac{cosh(kq_0 sinh\ z - s_0) sin(kq_0 cosh\ t - t_0) e^{-\frac{z+t}{2}}}{\sqrt{2q_0} cosh(z+t)} \right\}.$$

when $\alpha = q_0 sinh\ t\ cosh\ z$ and $\beta = q_0 cosh\ t\ sinh\ z$,

$$lim_{\sigma\to\infty} A_1 =$$

$$4q_0\nu_0 lim_{\sigma\to\infty}\left\{\frac{coth\ t}{cosh\ \sigma}\left[cos\ \delta_0\left(-\frac{1}{4\sqrt{q_0}}\right)e^{kq_0 cosh\ t\ sinh\ z}\right.\right.$$

$$\left(sinh(kq_0 sinh\ z - s_0)sin(kq_0 sinh\ t - t_0)e^{-\frac{z-t}{2}}\right.$$

$$\left.- cosh(kq_0 sinh\ z - s_0)sin(kq_0 sinh\ t - t_0)e^{-\frac{z+t}{2}}\right)$$

$$- sin\ \delta_0\left(\frac{1}{4\sqrt{q_0}}\right)e^{kq_0 cosh\ t\ sinh\ z}$$

$$\left(cosh(kq_0 sinh\ z - s_0)cos(kq_0\ cosh\ t - t_0)e^{-\frac{z-t}{2}}\right.$$

$$\left.\left.- sinh(kq_0 sinh\ z - s_0)cos(kq_0 cosh\ t\ sinh\ z)e^{-\frac{z+t}{2}}\right)\right]$$

$$+\frac{sinh\ z}{sinh\ t\ cosh\ \sigma}\left[sin\ \delta_0\left(-\frac{1}{4\sqrt{q_0}}\right)e^{kq_0 cosh\ t\ sinh\ z}\right.$$

$$\left(sinh(kq_0 sinh\ z - s_0)cos(kq_0 sinh\ t - t_0)e^{-\frac{z-t}{2}}\right.$$

$$\left.- cosh(kq_0 sinh\ z - s_0)cos(kq_0 sinh\ t - t_0)e^{-\frac{z+t}{2}}\right)$$

$$+ cos\ \delta_0\left(\frac{1}{4\sqrt{q_0}}\right)e^{kq_0 cosh\ t\ sinh\ z}$$

$$\left(cosh(kq_0 sinh\ z - s_0)cos(kq_0\ cosh\ t - t_0)e^{-\frac{z-t}{2}}\right.$$

$$\left.\left.- sinh(kq_0 sinh\ z - s_0)cos(kq_0 cosh\ t\ sinh\ z)e^{-\frac{z+t}{2}}\right)\right]$$

$$lim_{\sigma\to\infty} A_2 = 4q_0\nu_0 lim_{\sigma\to\infty}\left\{\frac{coth\ t}{cosh\ \sigma}\left[cos\ \delta_0\left(-\frac{1}{4\sqrt{q_0}}\right)e^{-kq_0 cosh\ tsinh\ z}\right.\right.$$

$$\left(sinh(kq_0 sinh\ z - s_0)sin(kq_0 cosh\ t - t_0)e^{-\frac{z-t}{2}}\right.$$

$$\left.+ cosh(kq_0 sinh\ z - s_0)sin(kq_0 cosh\ t - t_0)e^{-\frac{z+t}{2}}\right)$$

$$- sin\ \delta_0\left(\frac{1}{4\sqrt{q_0}}\right)e^{-kq_0 cosh\ tsinh\ z}$$

$$\left(cosh(kq_0 sinh\ z - s_0)cos(kq_0 cosh\ t - t_0)e^{-\frac{z-t}{2}}\right.$$

$$\left.\left.+ sinh(kq_0 sinh\ z - s_0)cos(kq_0 sinh\ t - t_0)e^{-\frac{z+t}{2}}\right)\right]$$

$$+\frac{sinh\ z}{sinh\ t\ cosh\ \sigma}\left[sin\ \delta_0\left(-\frac{1}{4\sqrt{q_0}}\right)e^{-kq_0 cosh\ t\ sinh\ z}\right.$$

$$\left(sinh(kq_0 sinh\ z - s_0)sin(kq_0 cosh\ t - t_0)e^{-\frac{z-t}{2}}\right.$$
$$\left.+ cosh(kq_0 sinh\ z - s_0)sin(kq_0 cosh\ t - t_0)e^{-\frac{z+t}{2}}\right)$$
$$+ cos\ \delta_0 \left(\frac{1}{4\sqrt{q_0}}\right) e^{-kq_0 cosh\ tsinh\ z} \tag{2.14}$$
$$\left(cosh(kq_0 sinh\ z - s_0)cos(kq_0 cosh\ t - t_0)e^{-\frac{z-t}{2}}\right.$$
$$\left.\left. + sinh(kq_0 sinh\ z - s_0)cos(kq_0 sinh\ t - t_0)e^{-\frac{z+t}{2}}\right)\right]$$

While the exponential factor $e^{kq_0 cosh\ tsinh\ z}$ is larger than the other terms in A_1 for large t, it can be cancelled near $t = 0$. For $t \approx 0$,

$$\begin{aligned} lim_{\sigma\to\infty} A_1 &\to -\sqrt{q_0}\nu_0 \left(cos\ \delta_0 e^{-\frac{z-t}{2}} + sin\ \delta_0 e^{-\frac{z+t}{2}}\right) \\ lim_{z\to\infty} A_2 &\to -\sqrt{q_0}\nu_0 \left(cos\ \delta_0 e^{-2kq_0 sinh\ z} e^{-\frac{z-t}{2}} + sin\ \delta_0 e^{-2kq_0 sinh\ z} e^{-\frac{z+t}{2}}\right) \end{aligned} \tag{2.15}$$

The z-dependence is different for two directions, until rescaled coordinates $\hat{x}_1 = e^{kq_0 cosh\ tsinh\ z} x_1$ and $\hat{x}_2 = e^{-kq_0 cosh\ tsinh\ z} x_2$ are used. In these coordinates

$$lim_{z\to\infty} A_{\hat{a}} \to -\sqrt{q_0}\nu_0 e^{-kq_0 sinh\ z} \left(cos\ \delta_0 e^{-\frac{z-t}{2}} + sin\ \delta_0 e^{-\frac{z+t}{2}}\right) \tag{2.16}$$

when $t \approx 0$.

Interpreting $e^{kq_0 sinh\ z}$ as a radial distance $\mathcal{R}$ such that $A_{\hat{a}} \sim \frac{1}{\mathcal{R}}$, the Coulomb potential is recovered. It may recalled the pair annihilation length is $4.796 \times 10^{-14} cm$ (Davis, 2007). In units of this length, the planetary distance equals 2.9087×10^{26}. Equating the exponential factor with this value gives $kq_0 sinh\ z \simeq 60.9349212$. Then $z \approx 4.1098 - ln(kq_0)$ which defines a surface of bounded genus. The late-time behaviour of the metric and potential is consistent with and exponential decay $e^{-2kq_0 sinh\ z}$ as $\sigma \to \infty$ only in the coordinates $(\hat{x}_1, \hat{x}_2)$.

While this manifold possesses planar sections in the $(\hat{x}_1, \hat{x}_2)$ coordinates, the metric component g_{zz} distiguishes z coordinate. A metric which might allow approximate equivalence between the spatial coordinates is provided by the initial results on the gravitational soliton in an electromagnetic field. In the metric (2.6), with $f_0 = \frac{e^{k^2 t^2}}{\sqrt{t}}$ (Garate and Gleiser, 1995), g_{zz} is an exponential function of t^2 only in this metric, the identification is feasible when the other spatial coordinates are rescaled. By a similar calculation, e^{kz} may be chosen to represent a radial distance in rescaled coordinates, and the required value of z for planetary distances in terms of the pair annihilation length would be approximately 121.8698424.

III. The Elastic Medium and the Absorption of Energy of the Waves

Regarding matter at Planck scales as strings, an electron-positron pair can combine with other electromagnetic couples to create a macroscopic system which shall be described again through strings providing a theoretical basis for a linear relationship between the total angular momentum and the square of the mass at astronomical scales.

In contrast to a string fixed length, the equation of motion in an elastic medium will contain a damping factor μ dependent on the properties of an elastic medium. Since the Green function decays exponentially with a characteristic exponent containing μ, the medium will observe any initial force within a distance proportional to $\frac{1}{\mu}$ of the application of this force (Morse and Feshbach, 1953). Independence of the propagation of the wave along the string with respect to the endpoint of the string is consistent with strings of macroscopic lengths being formed from the initial electromagnetic couples.

In a medium consisting initially of pairs of particles and antiparticles, the development of these macroscopic strings would be accompanied by the propagation of an amplitude. If there is an amount of matter that accrues at given distances from a central source, this mass could serve as an endpoint of a string of astronomical lengths.

Consequently, a standing wave could be created which has the property that complete wavelengths are fit precisely within the distances from the central source to the mass. At other distances, the standing wave is reflected back to the center and the amplitudes would cancel. Therefore, the only configurations with non-negligible probabilities of existence are those that support the standing waves.

Given the form of the standing waves, only those that form a complete wavelength are initially allowed. With the absorption of energy by the medium, the wavelengths can be allowed to be longer, and the next possible configuration consists of a half-wavelength at the same distance as the massive object. This half-wavelength cannot be completed unless it is attached to a mass at twice the distance. With the amalgamation of mass at twice the distance, the new wave will produce a complete wavelength and another standing wave.

Since the interference of the amplitudes reduces the probability of other configurations from arising, a rule for the radii of orbits in a medium consisting of particles and and antiparticles forming macroscopic rotating systems results. It has been established for example that a scattered electromagnetic field off a one-dimensional roughly random surface is stationary only when the incidence is normal (de Oliviera, et. al., 2010). The standing wave could not be maintained for configurations of a different type. The masses in the favoured configurations would have orbits with radii increasing approximately as 2^n.

The description of the motion in a gravitational field in the classical limit through waves can be made plausible by considering the time-dependent Schrödinger equation

$$i\hbar\frac{\partial\psi}{\partial t} = \sqrt{-\hbar^2c^2\nabla^2 + m^2c^4}\psi - G\frac{mm'}{r}\psi. \tag{3.1}$$

which can be transformed to

$$\hbar^2c^2\Box^2\psi + 2i\hbar G\frac{mm'}{r}\frac{\partial\psi}{\partial t} + \left(G^2\frac{m^2m'^2}{r^2} - m^2c^4\right)\psi = 0 \tag{3.2}$$

With the wavefunction $\psi = Ae^{-i(k_xx+k_yy+k_zz-\omega t)}$,

$$-\hbar^2c^2\left(k_x^2 + k_y^2 + k_y^2 - \frac{\omega^2}{c^2}\right) - 2\hbar\frac{Gmm'}{r}\omega + \left(G^2\frac{m^2m'^2}{r^2} - m^2c^4\right) = 0. \tag{3.3}$$

Then

$$\omega^2 - \frac{2}{\hbar}G\frac{mm'}{r}\omega + \frac{1}{\hbar^2}\left(G^2\frac{m^2m'^2}{r^2} - \hbar^2c^2k^2 - m^2c^4\right) = 0 \tag{3.4}$$

which has the solution

$$\omega = \frac{1}{\hbar}G\frac{mm'}{r} \pm \frac{c}{\hbar}\sqrt{\hbar^2k^2 + m^2c^2}. \tag{3.5}$$

The wavelength would be

$$\frac{2\pi}{\lambda} = \frac{1}{\hbar c}G\frac{mm'}{r} \pm \frac{2\pi}{\lambda^{free}}. \tag{3.6}$$

For the wavefunction to describe an aggregate of mass at distances which are remaining relatively unchanged over time, the momentum must satisfy the inequality

$$c\sqrt{\hbar^2k^2 + m^2c^2} \ll G\frac{mm'}{r} \tag{3.7}$$

such that $\frac{2\pi}{\lambda} \approx \frac{1}{\hbar c}G\frac{mm'}{r}$. The wavelength satisfies

$$\frac{hc}{\lambda} = E^{wave} \approx G\frac{mm'}{r} \tag{3.8}$$

and

$$\frac{dE^{wave}}{dr} = -G\frac{mm'}{r^2}. \tag{3.9}$$

The reaction to the force in the direction of decreasing energy would be transformed into tension along the macroscopic string representing the standing wave and equals the gravitational force $G\frac{mm'}{r^2}$.

For a gravitational system, it might be concluded that the radii of the orbits and the masses would increase because of the attraction of a larger amount of matter from the central source, which follows from the volume available at these distances. However, it is not evident that the dependence on n is predicted from a random rotation of uniformly distributed matter about a central source.

While an elliptical orbit can be predicted from the inverse square law, it may be noted that it also follows from the existence of a linear string from the central source to the planet such that the sum of the distances from two fixed points to the planet remains fixed. Verification for the rule of the increasing radius is provided by the solar system, where the Titius-Bode law (Titius, 1766; Bode, 1777) for the length of the semi-major axis of the elliptical orbit in astronomical units equals

$$\begin{aligned} r_0 &= \frac{4}{10} \\ r_n &= \frac{3 \cdot 2^{n-1} + 4}{10} \qquad n \geq 1 \end{aligned} \tag{3.10}$$

The anomaly of Mercury might be attributed to the relative amount of size of Sun with respect to the distance to this planet and that of Neptune, together with the inclinations of the axes of Pluto and Eris, could be viewed as the result of interference with the planar orbits. The asteroid belt is known to take the place of the planet for $n = 4$. It may be concluded, therefore, that the radii approximately have the dependence predicted by a connection with the central source formed from a macroscopic string in a medium containing dark matter.

The geometric progression has been attributed to the disk phase, and, in part, electromagnetic effects in the medium, while the commensurability of the radii of the orbits is determined by the gravitational interactions (Nieto, 1972). Further characteristics of the eventual configuration of the planets follow from a study of the n-body problem. The symmetries of the three-body problem admit an invariable plane (Wintner, 1947). For the system of the Sun and the two large planets, the gravitational potential is sufficient to ensure that the motion of the other planets is constrained nearly to this plane. The central force given by the negative of the gradient of the Newtonian potential requires Kepler's law and closed orbits to be elliptical.

The evolution of the radii of the orbits according to the observed geometric progression $r_n = A + (1.7275)^n[B + f(\alpha + n\beta)]$ (Blagg, 1913; Richardson, 1945) may be derived from a variational principle of least interaction (Ovenden, 1973; Areoli, et. al., 2000; Bass, 2005). An example is provided by the nodes of the velocity distribution of a thin disk, such that matter can aggregate, with $\frac{r_{k+1}}{r_k}$ being equal to $e^{\frac{2\pi}{3\mu}}$ (Nowotny, 1979) , where μ is equal to a ratio of a velocity related to the gravitational force and that of pressure in the gaseous disk, and it is found to be give a consistent value of this ratio.

IV. Conclusion

It has been conjectured that the effects of pair creation in a vacuum have considerably more consequences that of virtual particle-antiparticle pairs. Whereas previously, the effect had been estimated for the effects at atomic distances, the occurrence of real pairs of

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particles and antiparticles would have a large effect at macroscopic scales. The prediction of the increase of the radii of orbits around a central source has been found to be confirmed by observations of gravitational systems.

The scales of planetary motion require an extension of the mechanism of electromagnetic coupling of electron-positron pairs to large distances. This effect can be achieved through a gravi-electromagnetic soliton to the Einstein-Maxwell equations. An exponential expansion of the size of a real process of annihilation of particles and antiparticles yields the order of the distances to the planetary orbits. The spacing between the orbits reflects a geometric progression that is related to wave mechanics, with the planets located at the end of a standing wave. After the accumulation of matter at the harmonic progression resulting partially from the electromagnetic interaction, the commensurability of the orbits of the planets is attributed to gravitational force.

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