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Research Article

Analyzing the large number problem and Newton's G via a relativistic quantum loop model of the electron

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ABSTRACT

The long standing problem of large numbers ~ 10^{44} in physics is addressed by analyzing a conceptual electron model whereby a single photon propagates adjacent to a closed space-time metric of toroidal geometry. The quantum loop based model generates the major particle characteristics: a magnetic dipole, a radial electric field, and a gravitational effect consistent with the electron rest mass. The large number value obtained by this analysis closely matches that from empirical data and clarifies the nature of Newton's constant, G_N. The particle concept provides a basis from which development of a detailed electron model should be possible.

Keywords: Large numbers, Gravity, Quantum loop electron model

INTRODUCTION

Einstein's General Relativity Theory (GRT) is widely accepted as a valid description of gravity at the cosmological scale, having replaced Newtonian gravity. But unifying GRT with Quantum Electro-Dynamics (QED), essentially a particle scale theory, is problematic as GRT lacks a scaling factor. In consequence, Newton's gravity relation is still used for practical applications, and provides a scaling factor for the gravitational effect via his empirical constant G_N. Newton's gravity relation is often stated to be an approximation to GRT, but the two descriptions of gravity are fundamentally incompatible. Newtonian gravity describes radial attractive force acting on mass in the observer domain whereas GRT describes gravity as acting via curved space-time. The curved space-time of GRT is not in the observer domain as evidenced by the extreme flatness of observer space shown by astronomical observations. The theoretical dissimilarities are substantial, for example, Newtonian gravity assumes the moon orbits under constant radial acceleration in flat space, whereas in GRT the moon orbits earth by propagating un-accelerated in curved space-time.

Newton's gravity equation has historically been used to obtain the ratio of the strong force to the gravitational attraction between electrons, resulting in a large number of about 10^{44}, which has remained unexplained and bedeviled physics for almost a century. This large number problem is analyzed here and the results clarify the nature of Newton's equation and G_N.

The difference between the two gravitational concepts is analyzed via a simple model of the electron as electromagnetic (EM) energy localized in the observer domain by propagating rectilinearly at relativistic velocity in a highly curved local space-time of closed geometry. This concept is consistent with GRT and enables derivation of Newton's equation and thereby resolves the large number problem.

Basic considerations show the curved space-time in the electron near field is the source of the gravitational effect experienced in the observer domain and an expression quantifying the effect is derived. A conceptual electron model based on relativistic quantum loops produces a scaling factor for the gravitational effect experienced in the observer domain. The derived expression is essentially Newton's equation and includes a theoretical value for G via resolution of the large number problem.

The large number historically obtained by the classical ratio strong force/gravity for electrons is $Fs/F_g = 5.7084 \times 10^{44}$, and the first order value derived via the electron model is $Fs/A_g \sim \alpha^{-4/3}\underline{c}^4 = 5.70684 \times 10^{44}$, alpha is the fine structure constant, where $\underline{c}$ is the numerical value of c in cgs units and A_g is the apparent gravitational attraction, but is not force in the observer domain. The c^4 factor arises as gravity acts not between electron masses but between localized EM energies, each propagating in curved space-time and dimensionally c^2 remote from the observer domain as described below. A small adjustment based on internal electron dynamics is discussed which brings the derived values for the large number and G into precise agreement with empirical data.

DISCUSSION AND ANALYSIS

In the 1920's both Dirac and Einstein recognized "all matter is no more than localized electromagnetic energy". This has long since been experimentally validated by the mutual annihilation of low energy electrons and positrons to form only EM photons. Interactions between electrons must therefore be considered as interactions between localized EM energies, and with the advent of QED it is apparent these interactions are likely quantized. The energy quantum E, for a photon of wavelength λ, with h Planck's constant and c the velocity of light in charge free space, is given by E = hc/λ. Using the reduced form of Planck's constant ħ = h/2π, and with λ = 2πr this gives;

$$E = \hbar c/r \qquad (1)$$

Application of Force F through a distance r requires energy E i.e. F x r = E; substituting for E in (1) gives the expression for the strong force, Fs.

$$Fs = \hbar c/r^2 \qquad (2)$$

The strong force Fs, although not evident in the observer domain, can be expressed as an inverse square law force between energies by inserting E^2 in both numerator and denominator, giving

$$Fs = (\hbar c/E^2)(E/r)^2 \qquad (3)$$

Where $\hbar c/E^2$ is a force constant in the domain in which the strong force acts.

EM energy propagates rectilinearly in free space at velocity c. But localization in the observer domain in a stable manner to form an electron is only possible if the local space-time is sufficiently highly curved to enable formation of a quantum loop of at least one wavelength circumference, i.e. of nominal radius r. For the electron's EM energy to localize as a three dimensional particle it must consist of two orthogonal quantum loops propagating rectilinearly in a curved metric of closed geometry. The magnetic dipole evidenced by the electron suggests a curved metric of toroidal geometry with the particle EM energy apparent to the observer by virtue of being relativistic at v<c and propagating near a toroidal Event Horizon (EH) in a metric of index n>1.

To form a particle the EM energy must localize in the curved metric area, i.e. the strong force must act circumferentially in a two dimensional curved domain rotating close to velocity c in two orthogonal directions, both of which are orthogonal to all toroid radials in the near field and thereby orthogonal in the far field to observer space and all other particles. By virtue of this double orthogonality, as shown conceptually in Figure 1, EM energy circulating near the EH will be evident to the observer as an effect reduced by c^2 and thus appear as mass, i.e. $E/c^2 = m$. The magnitude of the observed mass effect will also depend on the relativistic state of the circumferentially propagating energy, with higher velocities evidencing lower rest masses for a given energy E.

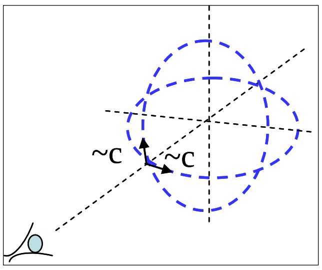

Figure 1: Quantized EM loop energy E propagating in two directions in curved space-time of metric index n >1 generates a gravitational effect E/c^2 which an observer interprets as due to mass.

As $E = mc^2$, an apparent attractive inverse square law between masses, each of m and assumed located in the observer domain, is obtained from (3) by dividing by c^4, where the energy interaction force constant is unchanged as shown in (4).

$$Fs/c^4 = (\hbar c/E^2)(m/r)^2 \qquad (4)$$

To the observer the evident attraction appears far weaker than the strong force to a degree determined by the value of c^4 on the left hand side. The effect apparent in the observer domain along radii connecting particles as in (4) can be written;

$$Fs/c^4 = (\hbar c/(mc^2)^2)(m/r)^2 \qquad (5)$$

And for $\hbar c/(mc^2)^2 = K$ we obtain:

$$Fs/c^4 = Km^2/r^2 \quad (6)$$

The interaction between two particles, e.g. electrons, occurs in the frame of each particle's energy rotating at a relativistic close to velocity c, but is evident to the observer as an attraction of dimension Fs/c^4 between static masses.

If the apparent attraction between masses, of dimension Fs/c^4 in the observer domain, is mistaken for force F_g, the c^4 in the denominator of Fs/c^4 will not be recognized. Dimensionally balancing the erroneously presumed "force equation" (7), causes the c^4 in the denominator of K to not be recognized, and K will therefore be mistaken for a 'force' constant of dimension $\hbar c/m^2$.

For K to consistently masquerade as a 'force constant' regardless of the units used for (6), the c^4 within K must assume a fixed numerical value and therefore so must the c^4 term in Fs/c^4. An observer unaware of the c^4 on each side of the equation will erroneously conclude a very weak attraction exists between masses, A_g, say, where

$$A_g = Km^2/r^2 \quad (7)$$

This is the form of Newton's gravitational attraction equation $A_g = Gm_1m_2/d^2$ for two masses, m_1, m_2 distance d apart, and where $K = G_N$. The hidden c^4 on the left of (7) will greatly reduce the magnitude of the effect experienced in the observer domain and that on the right will be inadvertently hidden in K. With c^4 on both sides of (7), in K (i.e. G) and A_g, the choice of c scales both values. The initial empirical measurement of A_g set a numerical value for c^4, which with its presence unrecognized, remained as a fixed number when (7) was converted into other measurement units.

The initial empirical value of G_N was obtained by Cavendish (1798) using cm.gm.sec. (cgs) units, then in vogue wherein $c = 2.998 \times 10^{10}$cms/sec. Unfortunately this set a numerical value for both hidden factors of c^4. This resulted in inclusion of a dimensionless numerical factor of c^4 in cgs units 8.0776×10^{41}, (= $\underline{c}^4$, say), within the false constant K and thus also within the ratio Fs/A_g. The double orthogonality of the strong force to particle radials, the erroneous presumption of gravity as radial force between masses, and the use of cgs units by Cavendish, caused the effect of gravity as described by Newton to appear some forty orders of magnitude weaker than the strong force. Gravity is not a radial force between masses as described by Newton but an interaction between EM energies spatially localized by relativistic propagation in curved space-time metrics.

The large number problem

Comparing the strong force Fs (= $\hbar c/r^2$), in the particle's curved metric circumference with the classical radial effect of gravity for electrons as described by Newton ($F_g = G_N m_e^2/r^2$), gives:

$$Fs/F_g = \hbar c/G_N m_e^2 \quad (8)$$

Inserting the standard values for ħ, c, m_e, and G_N gives the large number $Fs/F_g = 5.7084 \times 10^{44}$, which has not heretofore been explained and is thereby referred to as the large number problem. With $\underline{c}^4 = 8.07761 \times 10^{41}$ the large number problem is substantially reduced, however, the empirical ratio Fs/F_g is greater than $\underline{c}^4$ by 706.695, which requires explanation.

Consider (5) and (6) where m occurs both within K and in m^2/r^2. With the static electron mass m_e apparent in the observer domain, $m^2/r^2 = m_e^2/r^2$, but the effective internal electron mass in K (= $(\hbar c/(mc^2)^2)$), is rotating very close to velocity c and thus differs significantly from m_e due to relativistic effects. A mass m_q (say), rotating in the particle circumference at v, near velocity c, will appear reduced to $m_e = m_q(1-v^2/c^2)^{1/2}$ in the observer domain, and would evidence zero mass if v were c exactly. Thus from (5) it is likely $(m_q/m_e)^2 = 706.695$, giving $m_q = 26.5837m_e$, about 13.583MeV. The effective increase in the mass energy rotating within the electron is posited as due to a mass energy rotational relativistic factor of 26.5837.

A dimensionless number closely associated with electron is the Fine Structure Constant, α, at α ~ 1/137.036. For reasons described below we note $(137.036)^{2/3} = 26.5801$, close to the value 26.5837 calculated above. We therefore expect the derived ratio strong force/gravity for electrons, Fs/A_g, to be nominally

$$Fs/A_g \sim \alpha^{-4/3}\underline{c}^4 = 5.706835 \times 10^{44} \quad (9)$$

This differs from empirical large number 5.70840×10^{44} by only 1.000274. The exact difference between the rotating mass energy m_qc^2 and the electron rest mass energy m_ec^2 is the likely source of the small mismatch and arises via the squared mass terms in K, hence the mass m_q must differ from $\alpha^{-2/3}m_e$ by $(1.000274)^{1/2}$, about 1.000137. The classical value of Fs/F_g depends on the empirical value of G_N, which is known to somewhat greater accuracy than this small difference. This suggests a further small adjustment is required in calculating m_q and indicates the simple model, although substantially valid, is insufficiently detailed to allow for effects such as orbit precession or cross axis energy coupling. This is discussed further below.

The conceptual electron model

The above analysis is based on the electron as a single EM quantum propagating in a closed two dimensional boundary enclosing a three dimensional volume. The electron internal energy must therefore propagate simultaneously in all three dimensions to localize the particle in the observer domain. The electron was classically described by Ampere as a unit charge circulating an axis (z) to form a magnetic dipole, with symmetry about the x and y axes. Thus in this model the relativistic velocities about the x and y axes must be the same. Unit charge e is given in the far field by $e^2 = \alpha\hbar c/r_e$, where r_e is the classical electron radius, implying localizing a quantity ħc in three dimensions results in a particle volume increase by α^{-1} relative to the EH volume. Hence the far field relativistic factor over three dimensions is α, but by geometry in the near field those in the curved metric about the x and y particle axes are $\alpha^{2/3}$, and $\alpha^{2/3}$, giving the factor about the z axis as $\alpha^{-1/3}$, i.e. $\alpha^{2/3}.\alpha^{2/3}.\alpha^{-13} = \alpha$. The relativistic factor about the particle's x and y axes determines the energy wavelength and thus the curvature of the quantum loop and metric in those axes and thereby scales the emergent gravitational effect.

The energy path about the z axis is the evolute of a helical toroid as shown in Figure 2, where the EM energy propagates mostly about the z axis while oscillating along the axis.

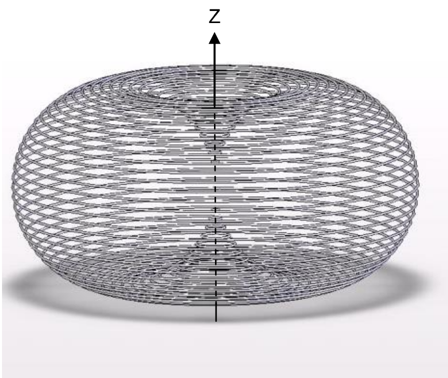

Figure 2: The EM energy in the electron circulating about the z axis traces the evolute of a helical toroid by sinusoidal oscillation along the z axis at a rate lower by α.

The electron is considered as a single photon rotating about the particle's z axis with the E field necessarily propagating at the local velocity of light. But the relativistic velocity implies the localized energy density has changed the local metric index to n>1. And the E field propagates slower than the H field, establishing a phase difference, and a recurring phase match once every 1/α turns about the z axis, i.e. a phase mismatch of α/2π per radian.

As shown above, the energy about the z axis is greater than those about the other axes by 1/α, i.e. the z axis energy couples into the x and y axes reduced by the coupling factor α. It is posited the energy about the x and y axes then couples back about the z axis further reduced and contributes to the above small factor of 1.000137.

Consider a coupling from about the x and y axes to about the z axis and back. If, for example, the second coupling factor from about the z axis to about the x and y axes is the same as the first at α, and the initial and second couplings combined reduce the recoupling back about x and y axes to 0.000137, the initial coupling from the x and y axes to about the z must be close to 0.000137/α, nominally 0.01877. It is perhaps a coincidence that $½.\alpha^{2/3}$ = 0.01881, however, an adjustment of this magnitude brings both the derived Large Number in (9) and a calculated nominal value for G (= $\hbar c/(\alpha^{-2/3} m_e c^2)^2$), within the empirical CODATA standard uncertainties.

In the proposed model a single EM wave initiates at the origin of all the axes with zero amplitude and spirals up the inside of the toroid about the z axis with the E field vector always oriented radial outward toward the z axis and normal to the toroid 'surface', thus emulating Ampere's original ring charge model. The E field rotates as the wave passes through the inflexion point at the top of its z axis and starts down the outside of the toroid, diminishing in amplitude until it returns to the origin. The wave H field is everywhere normal to the E field and lies in the toroid 'surface' and forms a magnetic dipole. Passing around the toroid the E field rotates through 180° and on crossing the origin the E field direction reverses and thus repeats the prior path and field orientations. The wave rotates about the z axis 1/α turns for each full EM wavelength so the cycle rate along the z axis is α that about the x and y axes. This provides a far field effect of a point charge with a magnetic dipole and sinusoidal oscillation along the z axis.

By reason of stability the electron must be a system in dynamic equilibrium. It is therefore posited equilibrium exists between a circumferential metric strain and a radial metric strain. The radial strain is induced by the EM energy path moving outward from the EH with the circumferential strain induced by the EM energy becoming relativistic with a consequent increase of wavelength, i.e. the metric strain is effectively a wavelength increase. The relativistic energy state near the EH is a consequence of the localization of the EM energy which increases the local energy density and thereby the metric index, resulting in a lower local velocity of light.

The radial metric strain projects directly into the observer domain, reduced only by the relativistic rotational factor, and forms the particles electric field, leading to the classical concept of 'charge'. By symmetry the net effect of a circumferential metric strain is radial, and the particle energy is in balance between a radial electric strain and 'strong gravity' in the curved metric.

The EM energy is relativistic about the particle x and y axes with the local metric circumferentially strained to the extent indicated by the relativistic factor. By reason of continuity this circumferential metric strain permeates into the surrounding metric and constitutes the particles gravitational field, which in the far field is normal to all particle radials. Both the radial and circumferential metric strains in the metric diminish with distance from the particle as $1/r^2$ and are in equilibrium everywhere in observer space.

CONCLUSION

The analysis reconciles Newton's gravity relation with GRT and resolves the large number problem, but contrary to prevailing beliefs shows G_N is not a natural constant. The model shows how the localization of EM energy to form an electron produces the emergent effects of unit charge, a magnetic dipole, and a gravitational effect, leading to the impression of mass.

The electron concept described should thereby enable QED and GRT to be merged in a more detailed particle model.

It seems evident GRT should be regarded as fundamentally a particle scale theory and applied to cosmology when the appropriate scaling factors for orthogonal metrics and relativistic factors are invoked.

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