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Original Research Article

Enabling unification of the general theory of relativity and quantum electro-dynamics by visualizing a particle energy configuration

William S. Oakley*

San Jose 95129, California, USA

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***Correspondence:**
Mr. William S. Oakley
E-mail: willoakley@earthlink.net

ABSTRACT

The long standing major issue in physics has been the inability to unify the two main theories of quantum electro-dynamics (QED) and the general theory of relativity (GTR), both of which are well proven and cannot accommodate significant change. The problem is resolved by combining the precepts of GTR and QED in a conceptual model describing the electron as electromagnetic (EM) energy localized in relativistic quantum loops near an event horizon. EM energy is localized by propagating in highly curved space-time of closed geometry, the local metric index increases, and the energy is thus relativistic to the observer at velocity $v < c$, with the curved space-time thereby evidencing gravity. The presence of gravity leads to the observer notion of mass. Particle energy is in dynamic equilibrium with relativistic loop circumferential metric strain at the strong force scale opposed by radial metric strain. The resulting particle is a quantum black hole with the circumferential strong force in the curved metric orthogonal in two dimensions to all particle radials. The presence of energy E is thus evident in observer space reduced by c^2 to E/c^2 = mass. The circumferential strain diminishes as it extends into the surrounding metric as the particle's gravitational field. The radial strain projects outward into observer space and is therein evident as electric field. Gravity, unit charge, and their associated fields are emergent properties and Strong and electric forces are equal within the particle, quantizing gravity and satisfying the Planck scale criteria of force equality. A derived scaling factor produces the gravity effect experienced by the observer and the GRT-QED unification issue is thereby largely resolved.

Keywords: Gravity, Strong force, GTR-QED unification, Large numbers, Planck scale

INTRODUCTION

Progress in physics has been continuous throughout the last century and the recent discovery of the predicted Higgs particle further validates the hugely successful Standard Model. But in recent decades progress has slowed and a major problem exists as physics remains divided into two main theories, quantum electrodynamics (QED), and the general theory of relativity, (GTR). Both theories have essentially been completely verified by multiple successful predictions but appear to remain incompatible.

QED covers essentially all aspects of physics except gravity and is mostly a theory of phenomena at the very small scale, i.e. atomic. In contrast GTR is entirely a gravitational theory and mostly relates to phenomena at the very large scale. The huge scale difference is but one problem impeding unification of the two theories. As described here, progress toward unification is achieved by an electron concept which indicates GTR can be considered a particle scale theory, with a scaling factor which enables gravity quantification at the particle scale and its extension to the macroscopic and cosmological scales.

Several issues are impeding the merger of QED and GTR into a single unified theory, these are:

1. Why is gravity so weak in comparison to the strong and electric forces?
2. What causes the electron mass to be so precisely defined at a scale where the uncertainty principle is a major consideration?
3. How is gravity to be quantized for compatibility and consistency with QED?
4. Why is there a very large gap between the known particle masses and the notional Planck mass at about 1.22 x 10^{19}GeV/c^2?

METHOD

Analytical method

Visualizing a simple electron model addresses these issues and clarifies the nature of both electric charge and mass. As now well accepted electron - positron annihilation at low collision energies shows the particles are only localized electromagnetic (EM) energy. The desired electron concept must therefore show how electric charge and mass are emergent properties when EM energy is localized as a particle.

The Standard Model mostly concerns QED and includes the Strong Force $F_s = \hbar c/r^2$ at about 137 times the electrostatic force, $F_e = \alpha\hbar c/r^2$. The strong force only acts within particles and is 5.706×10^{44} stronger than the observer space gravitational attraction between electrons calculated via Newton's gravitational equation and the empirical value of his gravitational constant, G_N; the classical ratio is $Fs/F_g = \hbar c/G_N m_e^2$ where m_e is the electron rest mass at about 0.511 MeV/c^2. Physics has historically lacked a theoretical basis for this ratio, which is known as the "Large Number Problem".

Einstein's GTR is accepted as a cosmological scale theory and is well tested. But in addition to QED and GTR a third and smaller part of physics exists which has now been almost entirely replaced by GTR. However, Newton's classical gravitational relation, $F_g = Gm^2/R^2$ remains the only means to calculate the apparent gravitational attraction in observer space between two masses, each of m, R apart, and introduced the classical gravitational constant G_N. This presumed constant is not obtained via GTR and does not arise in QED, and a value is only determined empirically. Gravity must arise at the particle scale, so in essence G_N is the factor which scales gravity from the quantum particle scale to macroscopic observer space. A relatively simple expression for G_N has recently been derived obtaining a value within the empirical uncertainty.[1]

Since its introduction Newton's G has been considered a fundamental constant of unknown origin and is a key factor in two areas long bereft of progress. The first is the Large Number problem noted above, the second is an explanation of the huge difference ~ 10^{17}, between the masses of known particles and the notional Planck mass $M_p = (\hbar c/G)^{1/2}$ at 1.22 x 10^{19} GeV/c^2. This expression is obtained by essentially the same equation as for the Large Number problem but with both masses M_p, and assuming the strong force and the gravitational effect equal, i.e. $F_s/F_g = 1$.

Proposed model

The above questions are answered as follows:

A1. The electron energy configuration is essentially a single 0.511 MeV photon propagating rectilinearly around the z axis of a toroid with sinusoidal oscillation along the z axis so as to trace out a helical toroid as shown in Figure 1. The concept briefly summarized below and is fully described in the attached reference.[1]

The 0.511 MeV photon wavelength is wrapped α^{-1}, (~137) times around the z axis for each cycle along the z axis, increasing the localized 3D metric curvature and effective mass by α^{-1}, i.e. to 70 MeV. But the relativistic state relative to the observer expands the local space time and thereby the effective electron wavelength, reducing the 70 MeV back to 0.511 MeV in observer space.

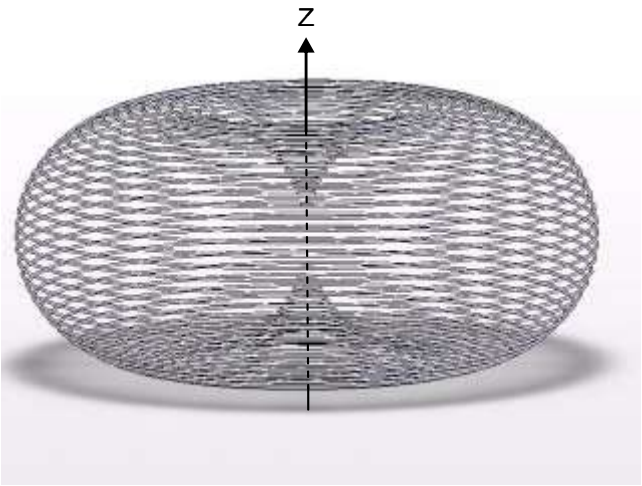

Figure 1: EM energy in the electron circulates about the z axis and its path traces the evolute of a helical toroid by sinusoidal oscillation along the z axis at a rate α less than the rotation rate.

Consider a toroid as in Figure 1 where the radii in all three dimensions are equal. For a relativistic volume increase of α^{-1} the surface area of a toroidal shell increases by $\alpha^{-2/3}$ and the radii increase by $\alpha^{-1/3}$. For EM energy in a quantum loop that is a "great circle" the circumferential path is increased by $\alpha^{1/3}$. Thus the wavelength of quantum energy propagating in a closed bound close to a toroidal event horizon is effectively increased and the energy decreased by $\alpha^{1/3}$ from $\alpha^{-1}m_ec^2$, ~70 MeV, to $\alpha^{-23}m_ec^2$, about 13.59 MeV if small cross coupling effects are included.[1]

The relativistic energy circulating in the two dimensional bound is orthogonal to all particle radials. For a toroidal geometry the energy path relative to another particle is orthogonal in two directions to the line connecting the particle centers. Consequently the circulating energy evidences a radial effect of E/c^2, in observer space with the effect between two particles proportional to E^2/c^4, i.e. m^2 where $m = E/c^2$.

The two effects, the relativistic state and the doubly orthogonal energy path, reduce the attractive effect of the circulating mass energy to $\alpha^{1/3}E/c^2$ ($= \alpha^{-2/3}m_ec^2$), relative to other particles. I.e. the macroscopic gravitational effect between two electrons due to relativistic energy in their curved metrics is proportional to $(\alpha^{-2/3}m_ec^2)^2$.

The value $(\alpha^{-2/3}m_ec^2)^2$ can be evaluated in the context in which G was first measured. Initial measurements made in1797 used the $cm.gm.s^{-1}$ system of units wherein light velocity is $c = 2.998\ x\ 10^{10} cms.sec^{-1}$. Using the numerical value $\underline{c} = 2.998\ x\ 10^{10}$ and $\alpha^{-2/3} = 26.5801$ we obtain,

$$(\alpha^{-2/3}\underline{c}^2)^2 = 5.707\ x\ 10^{44} \qquad (1)$$

This is essentially the same value as the above Large Number. A full derivation of G from basic principles shows how assuming gravity force in observer space inadvertently and erroneously assigned G_N incorrect units.[1] The real gravitational interaction occurs between relativistic energies circulating within particles. The energies are each independently c^2 removed from observer space, and thus c^4 from each other, and reduce the circumferential strong force by the above factor to the apparent gravitational attraction in observer space. The factor (1) is the long sought scaling factor which connects GTR and QED.

Identifying the source of the Large Number $\sim 10^{44}$ removes the problem of the large difference between the strong force and gravity. This same concept shows the radial strain projects directly into observer space reduced only by the relativistic rotation of the electron, i.e. by α. For this reason the localized potential formed by localizing ħc is reduced to αħc, leading to $e^2 = \alpha\hbar c$ and showing the electrostatic force is α less than the strong force. Thus within the electron rotating frame gravity, the strong force and the electrostatic force are equal even though they appear different to the observer by reason of relativistic rotation in a dimensionally orthogonal path.

A2. EM energy propagating in a quantum loop is equivalent to an infinite energy path length which via the uncertainty principle allows a highly defined wavelength and thereby a precisely defined circulation energy and gravitational effect, i.e. quantified as the particle mass.

A3. The energy of a photon circulating within the electron is given by $E = \hbar c/\lambda$ with a two component circulation of spin-1 implying each is spin-$^1/_2$.

With $\alpha^{-23}m_ec^2 \sim 13.59$ MeV from above, and including energy along the z axis, the electron total mass energy is (1+ α) 13.59 MeV = 13.69 MeV. Spin-½ quanta are more fundamental than spin -1 quanta and the energy of each electron spin-$^1/_2$ component is half of 13.69 MeV at m_qc^2 = 6.845 MeV.

It is noted α^{-1}6.845 MeV = 938 MeV, close to the proton empirical rest mass at 938.272 MeV. This strongly suggests the same base quantum energy of 6.845 MeV is common to both electron and proton and is the energy at which the gravitational effect is quantized. Visualizing particles as EM energy localized and relativistic in helical toroidal propagation paths substantially bridges the huge gulf between QED and GTR by explaining the different strengths of gravity and the strong and electric forces, and shows the uncertainty principle does not an impede merging QED and GTR into a unified quantum theory.

A4. The issue of the Planck mass being vastly larger than known particle masses is essentially resolved in addressing the Large Number problem and shows Newton's G inadvertently contains a $\underline{c}^4$ term with the numerical value of c in cgs units included in the constant. With the Planck "mass" given by $M_p = (\hbar c/G_N)^{1/2}$ substituting $\hbar c/(\alpha^{-2/3}m_e\underline{c}^2)^2$ for G_N gives $M_p = \alpha^{-2/3}m_e\underline{c}^2 = 1.22\ x\ 10^{19}$ GeV, showing the heretofore notional Planck "mass" is dimensionally in error and is simply the energy circulating within the electron.

RESULTS

Further analysis of the derivation of Newton's G as in Oakley's article has deep consequences.[1] Gravity is shown to arise at the particle scale in a consistent manner with GRT and the long sought scaling factor connecting GRT and QED derives from essentially strong forces at the particle scale manifesting much weaker effects in macroscopic observer space. This enables the basic precepts of GRT and QED to be combined, unified, in a relatively simple concept of the electron.

DISCUSSION

Combining the basic precepts of both GRT and QED essentially achieves the "Holy Grail" of physics but has huge consequences at both the cosmological and particle scales. Although nothing changes for QED and GRT is simply applied to the particle scale, it is evident the large difference between the notional Planck scale and the stable particles is due to misunderstanding the nature of Newton's G and thereby assuming gravity acts in observer space. Gravity is not force in observer space but an apparent mass attraction therein due to energy interaction via relativistic metric strains each dimensionally c^2 remote from the observer. It follows, in the electron rotating frame, gravity, the strong force and the electrostatic force are all equal, satisfying the notion of equal forces at the Planck scale as now adjusted. At a yet deeper physical level several issues remain

unresolved pertaining to the specific particle values exhibited by the electron.

- Evidently the spin-$^1/_2$ quantum energy m_qc^2 = 6.845 MeV applies to the electron and proton and also the muon and pion. With $\alpha^{-1/3}m_qc^2$ = 35.99 MeV their respective mass energies are about $3\alpha^{-1/3}m_qc^2$ and $4\alpha^{-1/3}m_qc^2$. The remaining question is why is this energy level special?
- The fine structure constant α ~137.036 is evidently the relativistic factor for both the electron and proton. The question is why does this specific factor arise when EM energy is localized?

There are also consequences at the cosmological scale, one of which results in understanding the nature of the MOND constant and the reason star rotation curves flatten in outlying regions of galaxies.[2]

CONCLUSION

The historical assumption of gravity as force in observer space was unavoidable during Newton's time and has unfortunately lead to his gravitational constant G being taken as natural and fundamental, which it is not. The notion of "force equality" at the Planck scale led to the scale being assigned far too small a value, and which has thereby been a major factor in impeding unification of GTR and QED.

Further, the GTR was developed and tested at the macroscopic scale and the erroneous and enduring belief that G was a natural and fundamental constant prevented realization the theory must be applicable at the particle scale, and a scaling factor is necessary to apply it to the macroscopic domain, not vice versa.

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