On the Essence of Electric Charge Part 2

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Part 2: How Charge Curves Space

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Abstract

The Standard Model of elementary particles, despite its successes, fails to derive and calculate the radii and masses of the elementary particles, and fails to explain what charge is. In this paper we present a new understanding of the essence of electric charge. We show that charge is not alien to space but simply a drastically curved zone of it. Based on this understanding, we construct a model, which enables us to derive and calculate the electron/positron, muon/anti-muon and the quarks/antiquarks radii and masses. The equations for these radii and masses are simple and contain only the constants G, c, $\hbar$ and α (the fine structure constant). We obtain results that comply well with experimental data of CODATA 2014.

Keywords: Electric charge, Curved space, Black holes, Electron mass, Quark mass

1 Introduction

1.1 The Current Paradigm

The current paradigm, despite the successes of the excellent theories that construct it, quantum mechanics included, is facing many obstacles. Many principles remain unproven, attributes of elementary particles cannot be derived and calculated, and mysteries are un-resolved. This situation results from the lack of a deeper theoretical layer.

1.2 The GDM

In order to cope with the long standing issues, and provide this missing underlying layer, we have constructed a new theory "The GeometroDynamic Model of Reality", the GDM, see Appendix A. This layer, the GDM, provides an answer as to what is charge, what is an elementary particle, and relates to additional fundamental subjects. Note that, at large, the GDM does not contradict the paradigm; it simply serves as a realistic and tangible New Foundation.

Since this paper has a specific purpose we do not elaborate on the GDM, but simply point out, whenever necessary, its relation to the present work. This work, however, exposes the reader to the ideas and reasoning of the GDM.

1.3 Part 1 of this Paper

In Part 1 of this paper [1], sub-titled "Charge as Deformed Space", we consider positive electric charge to be a contracted (deformed) zone of space and negative electric charge to be a dilated (deformed) zone of space. With this concept alone we derive theoretically, with no phenomenology, the Maxwell theory of electrostatics. Together with the Lorentz Transformation we derive Maxwell's theory in its entirety [2].

The geometry of deformed zones of space is Riemannian, as it is for bent manifolds [3]. Hence, we can attribute positive curvature to a contracted zone of space, i.e., to a positive charge, and negative curvature to a negative charge. This consideration enables us to apply General Relativity (GR) in our derivations.

1.4 The Bivalent Elementary Charges are Black and White Holes

The attribution of curvature to an elementary charge, and the fact that charge is quantized, led us to pursue the possibility that positive and negative elementary charges are hitherto unrecognized kinds of electrical black and white holes, respectively. This led us to derivate and calculate, using cgs units, the following radii and masses.

1.5 The Radii and Masses of Elementary Particles

The GDM result r_e for the electron charge radius, based on the radius r_p of the proton charge, see below, is:

$r_e = 1.4098 \cdot 10^{-13}$ cm

This r_e is also the positron charge radius, see Section 10.

Based on this r_e we derive and calculate the mass M of the electron:

$M = 0.91036 \cdot 10^{-27}$gr. A deviation of only 0.063% from the measured CODATA value: $M = 0.910938356(11) \cdot 10^{-27}$gr.

We also derive and calculate the mass of the Muon. Our calculated result deviates ~ 6% from the measured CODATA value.

Based on this M, and the GDM model of quarks, see Appendix B and [4] on current quark models, we derive and calculate the masses M_d and $M_{\tilde{u}}$ of the d and $\tilde{u}$ quarks:

$M_d = 4.5$ MeV/c^2 recent experimental value $M_d = 4.8 +/- 0.5$ MeV/c^2

$M_{\tilde{u}} = 2.25$ MeV/c^2 recent experimental value $M_{\tilde{u}} = 2.3 +/- 0.8$ MeV/c^2

The GDM radius r_p of the proton charge is:

r_p(calculated) = $0.8774 \cdot 10^{-13}$ cm, which is well within the experimental error range [5] r_p(measured) = $0.8768(69) \cdot 10^{-13}$ cm.

This is also the anti-proton charge radius that can be and should be measured, see Section 10.

So far no other theory has provided such results.

Note that the accuracy of our calculations is affected by the accuracy of the value for G.

2 The Schwarzschild Black Hole and the Quantized Elementary Charge

The Schwarzschild metric is the solution to the Einstein field equations of General Relativity (GR) outside a spherical mass.

In spherical coordinates (t, r, θ, φ), the line element for the Schwarzschild metric [6] is:

$$ds^2 = \left(1 - \frac{r_s}{r}\right) c^2 dt^2 - \left(1 - \frac{r_s}{r}\right)^{-1} dr^2 - r^2\, d\Omega^2 \qquad (1)$$

where c is the speed of light, t is the time coordinate (measured by a stationary clock at infinity), r is the radial coordinate and $d\Omega^2$ is a 2-sphere defined by: $d\Omega^2 = d\theta^2 + \sin^2\theta\, d\theta^2$. The Schwarzschild, gravitational black hole radius, r_s (see the metric) is given (cgs units) by:

$$r_s = \frac{2GM}{c^2} \qquad (2)$$

Equation (2) is also the result of equating the potential energy GMM'/r_s of a test mass M' , in the field of M, to its ultimate kinetic energy of escape from the black hole $1/2\ M'c^2$.

We now show that (1) and (2) are also relevant to the bivalent elementary charges. The self-energy U of a charge Q, accumulated in a sphere with radius r is $U = Q^2/2r$; divided by c^2 it is equivalent to a mass M. This mass $M = U/c^2$ is not fundamental; it is just a practicality, as shown here by our results and proven in [7] Part 1. Inertia, as we show, is related to energy and structure alone. Inserting this expression $M = Q^2/(2rc^2)$, with $r = r_s$ in (2) gives the r_s for a black hole whose "mass" is **purely electromagnetic**:

$$r_S = \frac{GQ^2}{r_S c^4} \tag{3}$$

For some particles the energy is not $U = Q^2/2r$ but $U = Q^2/\beta 2r$, where β is a numerical factor. Whenever β≠1 we bring specific arguments as to why it is so. Hence (3) turns into:

$$r_S = \frac{GQ^2}{\beta r_S c^4} \tag{4}$$

To explain the quantization of charge we suggest considering the elementary charge to be, not only a contraction or dilation of space (see Part 1), but a black or white (respectively) hole. Thus the radius of the elementary charge is related to the Schwarzschild radius. This consideration, as we show, yields the results mentioned in the Introduction.

Susskind [8], in July 2004, wrote: "One of the deepest lessons we have learned over the past decade is that there is no fundamental difference between elementary particles and black holes. As repeatedly emphasized by Gerard 't Hooft [9], black holes are the natural extension of the elementary particle spectrum. This is especially clear in string theory where black holes are simply highly-excited string states. Does that mean that we should count every particle as a black hole?"

Our answer to this question is affirmative.

Note that this idea was first expressed by A. Salam and J. Strathdee [10] and also by C.F.E. Holzhey, F. Wilczek [11] and A Sen [12].

We contend that the curving of space by elementary particles is due to two “mechanisms”. The elementary charge curves space by definition since it is dilation or contraction of space, see [1]. This curving, as we show, is orders of magnitude larger than the gravitational curving by the energy/momentum of the particle, which is related to its spin.

The equality of the absolute values of the bivalent charges is related to their creating photon in the pair production process [13].

Since (4) becomes $r_s^2 = \frac{GQ^2}{\beta c^4}$, its square root gives:

$r_s = \pm\sqrt{\frac{GQ^2}{\beta c^4}} = \pm\frac{Q\sqrt{G}}{c^2\sqrt{\beta}}$ This r_s is obtained for the self-energy of the elementary charge Q.

We **re-notate** it as r_{SQ} and the above equation becomes:

$$r_{SQ} = \pm\sqrt{\frac{GQ^2}{\beta c^4}} = \pm\frac{Q\sqrt{G}}{c^2\sqrt{\beta}} \tag{5}$$

In (5) r_{SQ} is positive for a positive charge and negative for a negative charge. A negative r_{SQ} means a negative radius of curvature. In this case we have a “white hole “instead of a black hole or a “repulsion”, as Kallosh and Linde [14] name it. This white hole reflects incoming particles like photons. In [14] the authors use String Theory whereas we use the GDM argument, that mass is purely electromagnetic, to arrive at a similar conclusion.

3 The Curving by the Elementary Charge and by its Energy

The curving K_M by a mass (energy), see [15] and [16], is given for $r \geq r_S$ by:

$$K_M = 1/R^2_c = r_S/r^3 \tag{6}$$

R_c is the Gaussian radius of curvature.

Using (2), the force F_M that two equal masses M apply on each other is:

$$F_M = \frac{GM^2}{r^2} = \frac{c^4}{4G}\frac{r_S^2}{r^2} \tag{7}$$

Thus, according to (6) and (7), **force is related to space curvature**.

For a purely electromagnetic mass, we substitute in (7) the r_{SQ} of (5) rather than r_s of (2). This step is legitimate since we relate only to the nature of M whereas the curvature remains the same. This substitution and taking $\beta = 1$ give:

$$F_M = \frac{GM^2}{r^2} = \frac{c^4}{4G}\frac{r_{SQ}^2}{r^2} \tag{8}$$

$$K_{QS} = 1/R^2{}_c = r_{SQ}/r^3 \tag{9}$$

We suggest expressing the curving K_Q by the net elementary charge (**not** the curving by its self-energy) in the same way as K_M is expressed in (6). This is possible since charge is merely the curvature (deformation) [1] of space:

$$K_Q(\text{charge}) = 1/R^2{}_c = r_Q/r^3 \tag{10}$$

This enables us, in the following sections, to derive and calculate the radii and masses of elementary particles. Since our results comply with experimental data, it is justified to extend the GR equation by incorporating K_Q(charge) and the charge/current tensor, [7] Part 2. This extended equation encompasses both gravitation and electromagnetism.

We consider r_Q to be the Schwarzschild radius of the net elementary charge, which **is not** the radius r_{SQ} due to its self-energy. We use the expression "net elementary charge", since we disregard the structure of the elementary, or composed, particle that incorporates this charge.

We **assume** that:

$$r_Q = k\, r_{SQ} \tag{11}$$

Thus the force F_Q that two equal charges Q apply on each other is:

$$F_Q = \frac{Q^2}{r^2} = k^2\frac{c^4}{G}\frac{r_{SQ}^2}{r^2} \tag{12}$$

The ratio of the forces F_Q and F_M becomes:

$$F_Q / F_M = \frac{Q^2}{GM^2} = 4\,k^2 \qquad (13)$$

This ratio according to **experimental data** for the elementary charge Q_e and the electron mass M_e is:

$$F_Q / F_M = \frac{Q^2}{GM^2} = 4.162 \cdot 10^{42} = \text{the numerical value of } 5.094 \cdot c^4 \qquad (14)$$

The numerical value of c^4 can be written as c^4/s^4, where s = 1 and [s] = LT^{-1}. Thus, according to (13) and (14):

$$k^2 = 5.094/4 \cdot c^4/s^4 = 1.273 \cdot c^4/s^4 \sim c^4/s^4 \qquad (15)$$

This result means that r_Q (due to the intrinsic curvature of charge) is ~ c^2/s^2 larger than r_{SQ} (due to the electromagnetic self-energy of the charge).

Regarding these Schwarzschild radii, we raise a conjecture. It **includes** our previous assumption $r_Q = k\, r_{SQ}$, equation (11), and determines its k value:

CONJECTURE

$$\mathbf{r_Q \text{ (due to the intrinsic curvature of charge)} = r_{SQ} \text{ (due to the self-energy of charge)} \cdot c^2/s^2} \qquad (16)$$

This conjecture for the relevant curvatures (9) and (10) is:

$$\mathbf{K_Q = c^2/s^2\, K_{SQ}} \qquad (17)$$

In the denominator of (5) we replace c by s =1, [s] = LT^{-1}, and take $\beta = 1$. Thus our conjecture gives:

$$r_Q = \frac{Q\sqrt{G}}{s^2} \qquad (18)$$

This relation (18) enables us to derive and calculate radii and masses of the elementary particles.

4 On the Proton Charge Radius r_p

In this section we clarify the term "The proton charge radius r_p", which appears in the literature. In this and the following sections, **we relate to the letter** Q, **as the symbol of the elementary charge**. The two ũ valance quarks [4], see Appendix B, contribute to the positive charge of the proton Q. Each of them contributes only half of the electromagnetic energy, which means that β = 2. We thus assume that $r_p = r_Q$. Changing notation in (18), by using r_p instead of r_Q, substituting β = 2 in (5) and incorporating it into (18) gives:

$$r_p = (\sqrt{2}/2s^2)\cdot\sqrt{G}\,Q \qquad (19)$$

Note that "The proton charge radius" is the radius of the ũ quark, see Appendix B.

Note also, that in (19), Q is the elementary charge and not the ũ quark charge, which is considered 2/3·Q. Why it is Q in our case and not 2/3·Q, is explained in Appendix B**.**

5 A Derivation and Calculation of the Proton Charge Radius

By substituting the value for Q in (19), as it appears in $\alpha = Q^2/\hbar c$, we get:

$$r_p = (\sqrt{2}/2s^2)\cdot\sqrt{G\alpha\hbar c} \qquad (20)$$

Inserting the CODATA 2014 values $G = 6.67408(31)\cdot 10^{-8}\mathrm{cm}^3\mathrm{gr}^{-1}\mathrm{sec}^{-2}$ and

$Q = 4.80320425(10)\cdot 10^{-10}$ esu in (19) gives:

$$r_p\ (\text{calculated}) = 0.8774\cdot 10^{-13}\ \text{cm} \qquad (21)$$

This result is well within the experimental error range, Pohl et al [5]:

$$r_p\ (\text{measured}) = 0.8768(69)\cdot 10^{-13}\text{cm} \qquad (22)$$

This and the results presented in the next sections, confirm our conjecture.

The result (21) is also the anti-proton radius, see Section 10.

Our result (21) is somewhat larger than (22), the measured electronic hydrogen proton charge radius. And (22) is larger than that for the muonic hydrogen $0.84087(39)\cdot 10^{-13}$cm [17].

This discrepancy, between the measured results, is termed the "Proton radius puzzle" [17]. Note the possibility that it is the QED vacuum polarization that affects the measurements. Our result is for the bare proton whereas vacuum polarization in electronic hydrogen and muonic hydrogen affects the measurements to give smaller results. Note that the muon vacuum polarization is larger since the muon is about 200 times closer to the proton than the electron.

6 On Pair Production

Pair production is the creation of an elementary particle and its antiparticle, by the interaction of an energetic photon with matter. The electron and positron pair is an example.

In the GDM a photon is considered to be a transverse wavepacket [18], [13], whereas an elementary charge is considered a longitudinal circulating wavepacket (of contracted or dilated space) [1]. A similar concept, suggested by Sakharov [19], is titled: The Knot-Like Topological Structure of Elementary Charges. Pair production seems to be a **mode conversion** of the transverse wavepacket (the photon) into two longitudinal wavepackets rather than an extraction of an electron from Dirac's sea. This conversion takes place during the circulation of an, energetic enough, photon around a proton. This circulation is possible, since the proton is an electric black hole, which deforms (curves) space drastically.

7 The Elementary Negative Charge Radius r_e of the Electron

7.1 General

A photon circulating an electric black hole, like the proton charge, with energy above a certain threshold can be converted into a pair. The photon, by this circulation, gains [20] orbital angular momentum L_{ph}, which is divided between the electron and positron:

$L_{photon} = U/c \cdot r_{proton} = L_{electron} + L_{positron}$ and since:

$U = U_e + U_p = 2\,U_e$ the orbital angular momentum gained by the electron is:

$$L_e = U_e/c \cdot r_p \tag{23}$$

The numerical value for L_e is $2.3936 \cdot 10^{-30}$erg sec. Note that L_e is perpendicular to the k vector of the photon and, hence, to its spin. Thus the intrinsic angular momentum of the electron ½$\hbar$ plus the additional perpendicular L_e should create a larger magnetic dipole moment. This, unknown, classical result gives a correction to the magnetic dipole moment which is similar to the one-loop correction of the QED calculation. Dividing our result for L_e by the Dirac factor 2, and by $\hbar$**,** gives our correction which is: 0.001135, whereas that of Schwinger, the one-loop correction [21], is $a = \alpha/2\pi = 0.0011614$.

L_e for the electron, as a longitudinal wavepacket with wave velocity c_L, is:

$$L_e = U_e/c_L \cdot r_e \tag{24}$$

Equating (23) and (24) gives:

$$r_e = c_L /c \cdot r_p \tag{25}$$

The value of r_e gives, as (26) shows, the self-energy of the electron U_e and hence its equivalent mass M_e:

$$U_e = Q_e^2/(2r_e) \tag{26}$$

Using (25, 26) to derive and calculate U_e and M_e requires the derivation and calculation of c_L, which appears in (25). This is done in the next section.

7.2 Derivation and Calculation of the Longitudinal Wavepacket Velocity c_L

QED uses the concept of virtual photons and Feynman Diagrams, to perform accurate calculations. The idea is that particles exchange virtual photons and can also self-interact. This section shows how a classical approach to self-interaction can yield a result for c_L.

The buildup of a field around a suddenly created charge propagates, from the charge onwards, at velocity c. The sudden destruction of the charge causes the field around it to vanish at the same speed. Imagine, now, a circulating charge that moves with velocity $c_L > c$. In this case, if to move along half a circle takes less time than for the field to vanish along the diameter, the charge will be affected by its own field created when it passed the opposite point on the diameter. We refer to the charge, when on the opposite side of the diameter, as the “image” of the charge. Self-interaction is thus the interaction of a charge with its image, as we phrase it. Imagine the electron charge circulating with velocity c_L around a point. Self-interaction occurs if the time to circulate a half circle, $\pi\, r_e/c_L$, is shorter than, or equal to, the time for its propagating or retreating field to cross the diameter $2r_e/c$. Thus self- interaction takes place if at least:

$\pi\, r_e / c_L = 2\, r_e / c$. The requirement for self-interaction is thus:

$$c_L / c \geq \pi/2 \qquad (27)$$

The minimal value of this ratio is:

$$c_L / c = \pi/2 \qquad (28)$$

By constructing a more accurate model of the electron (Section 8.2), we arrive at (38), which is more accurate than the ratio (28).

7.3 The Stability of the Self-Circulation

The self-circulation is kept stable by the attractive Lorentz force $\mathbf{F} = Q/c\ \mathbf{v}\times\mathbf{B}$, towards the center of the circulation. The magnetic field **B**, which the charge senses, is created by the circulation of its image. This force balances the repulsive force $F = Q\cdot Q/(2r_e)^2$ between the charge and its image. The magnetic field created by the circulating charge, [2], is $\mathbf{B} = 1/c\ \mathbf{v}\times\mathbf{E}$. Hence:

$\mathbf{F}=(Q/c)\mathbf{v}\times\mathbf{B}=(Q/c)\mathbf{v}\times(1/c)\mathbf{v}\times\mathbf{E}$ but $v = c$ and this equation becomes $\mathbf{F} = Q\mathbf{E}$ or $F = Q\cdot Q/(2r_e)^2$

This centripetal force balances the repulsive force above. Note that this calculation is not dependent on whether we use c or c_L. Note also that **the circulation of the self-interacting charge with its own "image" is a current of two charges.** Hence the factor 2 in the anomalous gyroscopic moment, as Dirac showed. The additional Schwinger [21] correction factor $\alpha/2\pi$ is discussed in Section 8.2.

7.4 The Approximated Radius

Substituting the ratio (28) in (25) gives:

$$r_e = c_L/c \cdot r_p = \pi/2 \cdot r_p \tag{29}$$

Using (19) we get:

$$r_e = \frac{\pi\sqrt{2}}{4s^2}\cdot\sqrt{G}\cdot Q \tag{30}$$

Replacing Q in (30) by its value derived from the Fine Structure Constant $\alpha = Q^2/\hbar c$, gives:

$$r_e = \frac{\pi\sqrt{2}}{4s^2}\cdot\sqrt{G\alpha\hbar c} \tag{31}$$

The numerical value for r_e, based on CODATA 2014, is:

$$r_e = 1.378\cdot10^{-13}\ \text{cm}. \tag{32}$$

A more accurate result appears in Section 8.2.

8 The Electron Mass

8.1 An Approximation Taking $c_L/c = \pi/2$

Using (26) and (30) we obtain the equation for the mass of the electron:

$$M_e = \frac{s^2\sqrt{2}}{\pi} \cdot \frac{Q}{c^2\sqrt{G}} \tag{33}$$

Replacing Q in (33), by its value derived from $\alpha = Q^2/\hbar c$, (33) becomes:

$$M_e = \frac{s^2\sqrt{2}}{\pi} \cdot \sqrt{G^{-1}\alpha\hbar c^{-3}} \tag{34}$$

The numerical values for r_e, U_e and M_e are (for more accurate results see Section 8.2):

$$r_e = 1.378 \cdot 10^{-13}\ \text{cm}. \tag{32}$$

Substituting this result in $U_e = Q_e^2/(2r_e)$, which is (26), gives:

$$U_e = 0.837 \cdot 10^{-6}\ \text{erg} \tag{35}$$

Dividing by c^2 (and not c_L^2) gives:

$$M_e = 0.93119 \cdot 10^{-27}\ \text{gr} \tag{36}$$

This is a ~2% deviation from the experimental value (a more accurate result appears in Section 8.2).

8.2 An Accurate Derivation and Calculation

To retain the 1/2 $\hbar$ angular spin momentum, contributed by the photon in the pair production process, the elementary charge has to participate in yet another circulation. This circulation with a radius R_e, is at velocity c and gives: $1/2\ \hbar = U_e/c\ R_e$. This circulation, [7] Part 1, should be incorporated in our model to complete it. The complete model of circulations is described as follows:

The charge circulation with radius r_e and velocity c_L around the circumference of the spin circle with radius R_e, describes an epi-cycloid. The velocity of propagation of this charge along the circumference of this circle of radius R_e is, however, c and not c_L, since its rotation while traveling around the circumference slows down the propagation velocity. By reaching this lower velocity, the electron gains stability, see Section 9.2.

We therefore modify c_L/c in (28) to become $c_L/c = \pi (R_e + \pi r_e) / 2 \cdot R_e$ or:

$c_L/c = \pi/2 \cdot (1 + \pi r_e/R_e)$

Using (24) and $1/2\ \hbar = U_e/c\ R_e$ we get:

$$r_e/R_e = \alpha, \tag{37}$$

where α is the Fine Structure Constant, hence:

$$c_L/c = \pi/2 \cdot (1 + \pi \alpha) \tag{38}$$

$$c_L/c = r_e/r_p = 1.6068 \tag{39}$$

According to (25), (38) and (19) the corrected relation for r_e is:

$$r_e = \pi/2 \cdot (1 + \pi \alpha) \sqrt{2}/2s^2 \cdot \sqrt{G}\, Q \tag{40}$$

or:

$$r_e = \frac{\pi\sqrt{2}}{4s^2} \cdot (1 + \pi \alpha) \cdot \sqrt{G\alpha\hbar c} \tag{41}$$

Inserting the CODATA 2014 values in (41) gives:

$$r_e \text{ (calculated)} = 1.40985 \cdot 10^{-13} \text{ cm} \tag{42}$$

This is also the GDM radius of the Positron, not yet measured experimentally, see Section 10.

Substituting this improved relation (41) for r_e in (26), which is the equation $U_e = Q_e^2/(2r_e)$, gives:

$U_e = 0.81819 \cdot 10^{-6}$erg (43)

Dividing the two sides of (26) by c^2 and using (40), gives:

$$M_e = \frac{s^2\sqrt{2}}{\pi(1+\pi\alpha)} \cdot \frac{Q_e}{c^2\sqrt{G}} \tag{44}$$

Using $\alpha = Q^2/\hbar c$ to replace Q in (44) gives:

$$M_e = \frac{s^2\sqrt{2}}{\pi(1+\pi\alpha)} \cdot \sqrt{G^{-1}\alpha\hbar c^{-3}} \tag{45}$$

CODATA 2014 values for α, $\hbar$, G, and c inserted in (45) give the numerical value for M_e :

M_e (calculated) = $0.91036 \cdot 10^{-27}$gr. (46)

a deviation of ~ 0.063% from the experimental CODATA value:

M_e (measured) = $0.910938356(11) \cdot 10^{-27}$gr.

This result confirms our conjecture.

According to (39) $r_p / r_e = 0.622$.

Note that according to our model of quarks, the radius of the ũ quark, which is the "radius of the proton charge", is 2/3 of the electron radius (Appendix B).

Note that $3/2 \cdot r_p$ is the Photon Sphere radius of the proton black hole.

8.3 The Relation of M_e to M_{Planck}

$M_{Planck} = \sqrt{G^{-1}\hbar c} = 2.176470(51) \cdot 10^{-5}$grm

Hence:

$$M_e = \frac{s^2\sqrt{2}}{\pi(1+\pi\alpha)} \cdot \sqrt{G^{-1}\alpha\hbar c^{-3}} = \frac{s^2\sqrt{2\alpha}}{\pi(1+\pi\alpha)\,c^2} M_{Planck}$$

9 The Derivation and Calculations of the Muon and Tau Masses

9.1 The Muon

An energetic enough photon that enters the pair production process, by circulating the proton charge, might be converted into the heavy muon and anti-muon pair. This happens if the energy U_{photon} is high enough to retain the angular momentum of the particle/anti-particle $L = 1/2\ \hbar$, by circulation with radius r_e and velocity $c_{L,}$ around the proton charge alone and with no need for an additional larger circulation with radius $R_{e.}$ Hence:

$1/2\ \hbar = (U_\mu / c_L) \cdot r_e$ or:

$$U_\mu = 1/2\ \hbar\ c_L / r_e \qquad (47)$$

Using (39) for c_L and (42) for r_e we get:

U_μ (calculated) $= 0.5 \cdot 1.054571800(13)10^{-27} \cdot 1.6068 \cdot 2.99792458 \cdot 10^{10} / 1.40985 \cdot 10^{-13} =$

$180.15 \cdot 10^{-6}$erg $= 112.5$ MeV or:

$$M_\mu = 112.5\ \text{MeV}/c^2 \qquad (48)$$

According to CODATA 2014:

U_μ(experimental) = 105.6583745(24) MeV

$$M_\mu(\text{experimental}) = 105.6583745(24)\ \text{MeV}/c^2 \qquad (49)$$

Comparing (48) to (49), shows a deviation of ~ 6 % from the experimental CODATA value.

9.2 The Tau

According to the CODATA 2014:

$$U_\tau / U_\mu = 1776.84/105.66 = 16.82 \qquad (50)$$

$L = P \cdot R = (U_\tau / c') \cdot r$ and if L is retained then r/c' should be $(1/16.82)\ r_\mu / c_L$ or:

$r/c' = (1/16.82)1.378\cdot10^{-13} / 1.5348 \cdot3\cdot10^{10} = 1.779\cdot10^{-25}$ sec. This result occurs if $r < r_\mu$, which means that the elementary charge rotates around an inside point. But for rotation inside a black or white hole $c' < c_L$. Thus, r might be even smaller than $r_\mu/16.82$.

Note that the elementary charge of both the tau and the muon moves at the longitudinal velocity and there is no circulation that brings the overall average velocity down to that of the transversal velocity, c. In this case, the charge moves faster than the photons it radiates, which explains the short life-time of these particles. In the case of the electron, the complicated circulation of the charge brings down the average velocity to the light velocity, c. Hence, photons cannot be radiated (or radiated but re-absorbed). This explains the stability of the electron, see Section 7.3.

9.3 On the Quark's Masses of the Second and Third Generations

We wonder if the second generation of quarks has a similar construction to that of the first generation, but incorporates the muon/anti-muon rather than the electron/positron.

We also wonder if similarly the third generation incorporates the tau/anti-tau.

10 On the radii of the Anti-Proton and Positron

In Section 2.2 of [1] we define Electric Charge in a given zone of space τ as:

$Q = \int_\tau q d\tau$, where the electric charge density is $q = \frac{1}{4\pi}\frac{\rho - \rho_0}{\rho}$ and ρ is the space density,

$[q] = 1$ and $[Q] = L^3$. The factor $1/4\pi$ is introduced to ensure resemblance to the Gaussian system and for no other reason.

To simplify the discussion we omit the factor $1/4\pi$, in the above expression for q. For the spherical symmetric case, where $d\tau = 4\pi r^2 dr$, this gives the following result for Q:

$Q = \int_0^r q4\pi r^2\, dr = 4\pi/3 \cdot r^3(1-\rho_0/\rho) = V - V'$, where $V' = V\rho_0/\rho$. Thus $\rho > \rho_0$ gives $V > V'$ and $Q > 0$, whereas $\rho < \rho_0$ gives $V < V'$ and $Q < 0$.

In a given spherical zone of space with radius r, as we outsider observers measure, positive charge means more space cells in this zone than in an un-deformed space, whereas negative charge means less space cells in this zone than in an un-deformed space.

Note that the equality $|Q_+| = |Q_-|$, of the absolute values of the bivalent elementary charges, means $|Q_+| = |Q_-| = |V - V'|$. It also means that $(1-\rho_0/\rho_+) = -(1-\rho_0/\rho_-)$ and hence

$$2/\rho_0 = 1/\rho_+ + 1/\rho_- \qquad (51)$$

Note that both ρ_+ and ρ_- are functions of r and not just constants.

Since the mass of elementary particles equals that of their anti-particles and the energy is purely electromagnetic, we conclude that their radii are also equal.

This conclusion means that the radius of the Proton is also that for the Anti-Proton and that the radius of the Electron is also that for the Positron.

The radius of the Anti-Proton can be measured, using the same spectroscopic methods as are used to measure the Proton radius, see [5] [17].

11 Conclusions

Our idea that electric charge is a contracted or dilated zone of space led us to attribute curvature to electric charge. This is the basis of our derivation and calculation of the radii of the bivalent charges and their masses. Our result for the mass of the electron is $M_e = 0.91036 \cdot 10^{-27}$gr ; a deviation of only 0.06% from the experimental value. Neither the Standard Model nor String Theory has provided such results. All our results are based on the attribution of pure electromagnetic self-energy to the elementary particles. We show that inertia is also the result of pure electromagnetic self-energy and structure. We thus conclude that mass is not a fundamental attribute of matter but just a practicality.

Acknowledgements

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Appendix A On the GDM

“The GeometroDynamic Model of Reality”, or in short the GDM [22], is our realistic and tangible substratum for the theories that construct the current paradigm; it is a New Foundation.

The GDM Idea

The Elastic and Vibrating three-dimensional Space Lattice is all there is.

Elementary Particles are Transversal or Longitudinal Wavepackets of the vibrating space.

The Units of the GDM

In the GDM all units are expressed by the unit of length L (**cm**) and the unit of time T (**sec)** only. A conversion from the **cgs system** of units to the GDM system and vice versa is possible.

The Constants of Nature According to the GDM

$c_T = c$ Velocity of transversal Space vibrations (EM waves) $[c_T]=LT^{-1}$

[c_L Velocity of longitudinal Space vibrations ($c_L > c_T$)] $[c_L]=LT^{-1}$

$\hbar$ Planck Constant $[\hbar]=L^5T^{-1}$

G Gravitational Constant $[G]= T^{-2}$

α Fine Structure Constant $[\alpha]=1$

Note that in the GDM (see also [1]): $[v]=LT^{-1}$, $[a]= LT^{-2}$, $[H]=[G]=T^{-2}$, $[Q]=[M]=L^3$, $[E_E]=[E_G]=LT^{-2}$, $[\varphi_E]=[\varphi_G]=L^2T^{-2}$, $[F]=L^4T^{-2}$, $[U]=L^5T^{-2}$.

Note that $c_L/c = \pi/2\cdot(1+ \pi\,\alpha)$, see (38), and we can exclude c_L from the list.

Note that in this paper our G is the Newtonian G.

"Rest" and Motion in the GDM

Every disturbance in space must move at the velocity of its elastic waves, c_L or c_T. As a consequence there is no state of rest. "Rest" is defined, therefore, as a situation in which a disturbance, although moving at velocity c_L or c_T, is on a closed track. This orbital movement, Dirac's Zitterbewegung, is the spin of elementary particles. A "translational" motion at a constant velocity v, relative to space, is the moving of a wavepacket, of **constant length**, on a spiral. An accelerated motion is that on a spiral, with an ongoing contraction of its radius.

Note that a longitudinal wavepacket is necessarily a moving dilation, contraction or an oscillation between the two. A transversal disturbance in space moves at the speed of light

$c = c_T$, whereas a longitudinal disturbance moves at a higher speed c_L

Note that the GDM considers mass to be just a practicality.

Space in the GDM is a Special Frame

Space is a special frame, and velocity and acceleration relative to it are measured by the Cosmic Microwave Background Doppler shift. The Special Theory of Relativity in the Lorentzian interpretation is encompassed within this idea.

The GDM is based on the theories of Elasticity and Riemannian Geometry

The geometry of a deformed elastic space lattice is Riemannian, as it is for bent manifolds. We thus conclude that General Relativity (GR) is not only a theory of bent manifolds of a continuous space, but also a theory of deformed elastic three-dimensional space lattices and four-dimensional space-time lattices.

Appendix B On Quarks and the Proton

The proton is made of quarks. We clarify the term "The proton charge radius r_p", and derive and calculate the quarks masses.

B1 On Quarks

Quarks are not elementary particles in their own right. We suggest that quarks are sub-tracks of a topologically-twisted electron or positron [19], [23], which is also a simple way to understand confinement. Fig. (1) shows a trio of d quarks, which are sub-tracks of a twisted electron at "rest", see [7] Part 1. In a translational motion the trio becomes a trio of spirals. We assign charge to each sub-track according to the time the electron (positron) spends on this sub-track. We, of course, assume that the tangential velocity is c.

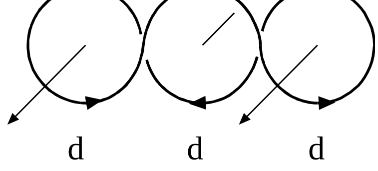


Fig. (1) A Trio of Quarks S = 1/2

The electron spends one third of its full revolution time in each of the sub-tracks. We therefore assign it a charge of 1/3 Q_e. From the conservation of angular momentum, it is clear that each sub-track has the same spin as has the electron, but because of the directions, in which these vectors point, see Fig. (1), the resultant spin is S = ½. How the track is being twisted, or what causes the motion from one sub-track to the other, is still not clear to us. We refer to a sub-track of an electron as the quark, d, and to a sub-track of a positron as the anti-quark, $\tilde{d}$. We can illustrate the creation of ddd and $\tilde{d}\tilde{d}\tilde{d}$ in a similar way to the creation of the pair e^-, e^+. It is thus clear that quarks in our model are not independent fundamental particles, and therefore are not found as such. Fig. (2) shows another possibility with S = 3/2:

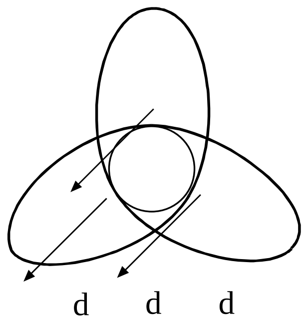


Fig. (2) A Trio of Quarks S = 3/2

If one twist opens, we get the structures shown in Fig. (3) and Fig. (4), these structures represent **mesons**.

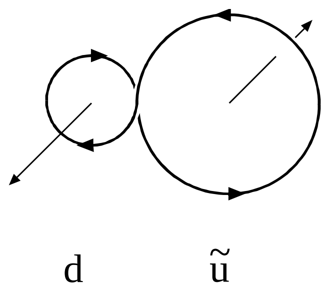


Fig. (3) A Duo of Quarks S = 0

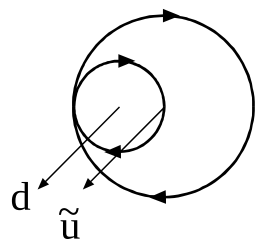


Fig. (4) A Duo of Quarks S = 1

An electron spends two thirds of its time in the sub-track with the double radius, therefore, we assign it a charge 2/3 Q and refer to it as the quark ũ. For a positron, we refer to it as the quark u.

Note that in our figures a solid line indicates an electron, and a dashed line a positron.

B2 Derivation and Calculation of the Quarks Masses

We show how our model of quarks yields the quarks masses (on the other merits of our model we elaborate in [23]).

We know the electron mass M_e. From this mass, based on our quark model, we derive the masses $M_{\tilde{u}}$ and M_d of the first generation quarks which are also the masses M_u and $M_{\tilde{d}}$ of their anti-particles. The electron angular momentum $L = M_e R_e^2 \omega$ must be conserved. Hence it is the same L for each of the sub-tracks of the d quark, see Fig. (1). For the ũ quark it is 2L, since the L of its companion d quark points in the opposite direction, see Fig. (3). For the quarks, ω is the same, but R and M are different and conversely related. In a twisted track, which is a set of three quarks, ddd, the radius of each sub-track is $R = \frac{1}{3} R_e$.

Since $2\pi R_e$, the length of the electron wavepacket, is conserved: $2\pi R_e = 2\pi \frac{1}{3} R_e \times 3$.

From the known relation $L = MR^2\omega$ we obtain:

$$M_d = \frac{L}{\omega R^2} = \frac{L}{\omega} \frac{1}{\left(\frac{1}{3} R_e\right)^2} = 9 \frac{L}{\omega R_e^2} = 9 M_e \qquad \textbf{(B1)}$$

For a twisted track of a pair of quarks, like $d\tilde{u}$, we get for $\tilde{u}$ a sub-track with $R = \frac{2}{3} R_e$, spin 2L and a mass:

$$M_{\tilde{u}} = 2 \frac{9}{4} M_e = 4.5\, M_e \qquad \text{(B2)}$$

From (B1) and (B2) and M_e = 0.51 MeV/c^2 we obtain the following results:

M_d = 4.5 MeV/c^2 (B3)

A recent experimental value [24] is: M_d = 4.8 +/− 0.5 MeV/c^2.

$M_{\tilde{u}}$ = 2. 25 MeV/c^2 (B4)

A recent experimental value [24] is: $M_{\tilde{u}}$ = 2.3 +/− 0.8 MeV/c^2.

B3 A Symbolic Model of the Valence Quarks of the Neutron and Proton

The three valence quarks of the neutron ddu, see Fig. (8), are an electron and positron in the form of quarks which are a pair of d quarks and one u quark. The middle d quark of the triple ddd and the $\tilde{d}$ of the couple $u\tilde{d}$ attract each other to create a stable structure. This structure rotates in the middle of a "cage' constructed by the other quarks that compose the neutron.

Q = 0

S = 1/2

dud

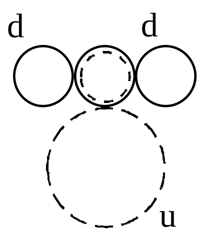


Fig. (8) The Neutron Valance Quarks

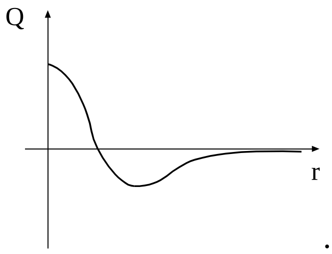


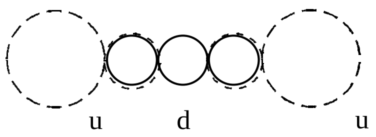
Fig. (9) N Charge Distribution

Fig. (9) shows the spatial charge distribution, known from scattering experiments.

This picture is compatible with the fact that, despite having no charge, the neutron has

a magnetic moment opposite to its spin direction

The three valence quarks uud of the proton P, Fig. (10), are an electron and two positrons in the form of quarks which are a pair of u quarks and one d quark. The $\tilde{d}$ and u of the two couples u$\tilde{d}$ attract each other to create a stable structure. This structure rotates in the middle of a “cage’ constructed by the other quarks that compose the proton.



Q = 1

S = 1/2

udu

Fig. (10) The Proton Valance Quarks

The charge distribution, shown in Fig (11), is compatible with the proposed structure.

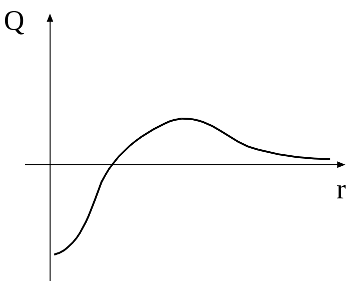


Fig. (11) P Charge Distribution

We see that the net charge of the proton is the elementary positive charge of the positron. But the radius of its sub-track is only 2/3 of that of the un-twisted positron. This ratio, 2/3, is the ratio of the relevant tracks (designated by R's), but since $r/R = \alpha$, see (37), 2/3 is also the ratio of r_p/r_e. This result complies with our theoretically calculated ratio $r_p/r_e = 0.622$, which is the inverse of (39).