# Gravitation – the Quantized Curving of Space by the Elementary Particle's Spin

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# On the Essence of Gravitation and Inertia Part 2

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## Part 2: The Curving of Space by an Elementary Particle

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### Abstract

A mass curves space positively. It also senses (is affected by) curvature, created by other masses, and moves accordingly. In this paper we show how the spin of an elementary particle causes space torsion. This torsion results in space contraction (curving). Knowing how spin and charge curve space we extend Einstein's field equation to become an equation of both energy/momentum and charge/current. This equation becomes a macroscopic/microscopic equation of the physical reality. Charge and angular momentum are quantized and thus we expect curvature of spacetime, on the microscopic level, to be also quantized.

Part 1 of this paper presents our model of an elementary particle that yields the axiomatic laws of Newton, the attribute of inertia and shows mass to be merely a practicality. It also shows how an elementary particle senses curvature and moves accordingly. This enables us to prove the equivalence of gravitational mass and inertial mass, whereas here we prove that gravitational mass is the inertial mass.

Key Words: Gravitation; General Relativity; Elementary Particle

# 1 Introduction

## 1.1 On Gravitation

Project “Gravity Probe B” [1] recently validated the GR predicted “Frame Dragging” [2], [3], phenomenon. This phenomenon is considered to be a result of an additional mechanism by which a rotation of a macroscopic mass contracts (curves) space around it and contributes to gravitation, as the Kerr Metric shows [4], [5]. We, however, show that the rotation (spin) of an elementary particle is the basic mechanism by which it gravitates - curves space - in addition to the curving by its charge [9].

Although there have been many attempts to explain gravitation or to present alternatives to General Relativity with its Newtonian weak field approximation, none are based on a model of an elementary particle. An example is “On the Origin of Gravity and the Laws of Newton” (2011), [6]. This theory considers gravity to emerge from the thermodynamic concept of entropy; hence it is “independent of the specific details of the underlying microscopic theory”. It also generates a self-contained, logical derivation of the equivalence principle based on the assumption of a holographic universe.

In contrast, our realistic and tangible theory – the “Geometrodynamic Model of Reality” (GDM) derives gravitation, based on a simple “underlying microscopic” model of an elementary particle. See below and Part 1 of this paper [7]. The GDM also shows how an elementary particle curves space by its charge, which itself is a highly curved zone of space [8], [9].

## 1.2 On Our Geometrodynamic Model (GDM) of Reality

The following introduction to the GDM enables a better understanding of our arguments and derivations.

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.

In order to provide this missing underlying layer (substratum), we have constructed, during the last twenty five years, a new theory the GDM. This layer, the GDM, provides an answer as to what is charge, what is an elementary particle, and relates to additional fundamental subjects.

The need for a “deeper theoretical layer” is expressed by Hartle [5] in his book “Gravity” p. 482: “The Einstein equation relating curvature to density of mass-energy is a fundamental equation of classical physics. **It cannot be derived**, for there is no more fundamental classical theory to derive it from.” The GDM is exactly this required theory.

**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** enables calculations of known phenomena and of predicted GDM new phenomena.

**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 [7], [8], [9]: $[v]=LT^{-1}$, $[a]= LT^{-2}$, $[H]=[G]=T^{-2}$, $[Q]=[M]=L^3$, $[E_E]=[E_G]=LT^{-2}$ , $[\varphi_E ]=[\varphi_G ]=L^2T^{-2}$, $[F]=L^4T^{-2}$, $[U]=L^5T^{-2}$.

Note that $c_L/c = \pi/2\cdot(1+ \pi\, \alpha)$, see (25) in [9], and we can exclude $c_L$ from the list of constants. A more systematic approach would take $c_L$ rather than $\alpha$ to be a constant of nature.

**"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 related to the spin of the elementary particle [7]. 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.

**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 (CMB) 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 Small Deformation Strain Tensor plays the same role as the Fundamental Metric Tensor [8, Appendix B] and hence the geometry of a deformed elastic space lattice is Riemannian. 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.

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 On Gravitation and the GDM

Some essential elements of GDM are presented in our previous published papers; "On the Essence of Electric Charge" Part 1, [8] and Part 2, [9] and Part 1 of this paper [7]. Reading these papers contributes to the understanding of this paper. It also contributes to confidence in our model, since we are able, for the first time, to derive theoretically and calculate accurately radii and masses of the electron, muon and the quarks.

In the present paradigm gravitation and inertia are attributed to mass. We, however, contend that mass is not a fundamental attribute of elementary particles but is simply a practicality. We show that gravitation and inertia are intrinsic attributes of elementary particles - the result of their structure and energy. Hence there is no need in our theory for a special field, such as the Higgs Field, to create inertia, like.

## 2 Curvature and the Schwarzschild Radius

The right hand-side of Einstein's field equation (1) of GR (below) **should** express curvature exactly as the left-hand side does. This paper shows, for the first time, that this is indeed the case.

The need to express curvature by Riemannian geometry and obtain a covariant formulation of physical laws, by using tensors, led Einstein to the equation of General Relativity (GR):

$$R_{ij} - \frac{1}{2} R g_{ij} + \Lambda g_{ij} = \frac{8\pi G}{c^4} \cdot T_{ij} \tag{1}$$

$R_{ij}$ is the Ricci contracted Riemannian tensor and R is the Ricci scalar, $\frac{1}{2}R$ is the familiar Gaussian Curvature [10] and $\Lambda$ is the cosmological constant. The $\frac{1}{2}Rg_{ij}$ term is added to give a covariant divergence, which is identically zero, and $T^{00} = j^{(0)0} = \in$ is the energy density of space (see Appendix C). In this paper we ignore the Cosmological Constant term $\Lambda g_{ij}$.

It was Einstein's vision that "future physics" will show, as we do below, that the right-hand side of (1): $\frac{8\pi G}{c^4} \cdot T_{ij}$ is also curvature (and not simply by its dimensionality).

In equation (2), see [11] and [12], $R_c$ is the Gaussian radius of curvature, and $1/R_c^2$ is the Gaussian curvature at the radial distance r from the center of a black hole with Schwarzschild Radius $r_S$ (our notations are different from those in [11] and [12] ):

$$1/R_c^2 = r_S/r^3 \tag{2}$$

The right-hand side of the GR equation is $8\pi G/c^4 \cdot T_{ij}$. Relation (2) enables us, for the first time to show that $8\pi G/c^4 \cdot T_{ij}$ expresses curvature.

According to [13] p.290 "Ignoring curvature effects, the Schwarzschild radius of a body of uniform density m and radius r is $r_S = 2GM/c^2 \sim 8\pi G/3c^2 \cdot mr^3$ " , where m is the mass density. Hence:

$1/R_c^2 = r_S/r^3 = (1/3)\ 8\pi Gm/c^2 = (1/3)\ 8\pi G \epsilon /c^4$ where $\epsilon = T_{00}$ is the energy density. We thus conclude that $8\pi G/c^4 \cdot T_{ij}$ is indeed curvature (ignoring the factor 1/3, which is related to the suggested uniform density).

An elementary particle has an additional mechanism by which it contracts space around itself (creates positive curvature) besides its direct contraction or dilation of space which is related to its charge. This contraction is related to its energy content. This mechanism of contraction, as we explain in Section 4, is due to the torsion in space created by the spin of the elementary particle, and hence related to its inertial mass.

All this proves that **gravitational mass is inertial mass.**

Note that energy is purely electromagnetic and that elementary charges are kinds of black and white holes that curve space drastically [8], [9].

## 3 The Curving by Charge

In a recent paper [8] titled “On the Essence of Electric Charge” Part 1 we consider positive electric charge to be a contracted zone of space and negative electric charge to be a dilated zone of space. This yields the Maxwell theory of electromagnetism, with no phenomenology. We show that deformed spaces are represented by Riemannian geometry in the same way as are bent manifolds. Hence we can attribute positive curvature to a contracted zone of space, namely to a positive charge, and negative curvature to a negative charge. This attribution enables us, in Part 2 of [9], to show that the bivalent charges are kinds of electrical black and white holes, and derive and calculate their radii. We further derive and calculate the masses of the leptons and quarks. All this serves as the basis for our discussion on gravitation in this paper.

According to [7], [8] and [9] the energy of an elementary particle is purely electromagnetic. The absolute values of the bivalent charges are the same, and their absolute values of curving space are precisely equal. The curvature, contributed by pairs of these bivalent charges, to a neutral macroscopic body is therefore zero. But a macroscopic body gravitates and necessarily its curvature is positive. We thus conclude that each of the elementary particles, that construct the neutral body, possesses an additional, very small, positive curving that depends on its energy. We derive this additional curving in Section 4.

Note that we consider quarks to be, sub-tracks of topologically-twisted electrons or positrons and not elementary particles in their own right. This is how we understand confinement and the assignment of 1/3 $Q_e$ or 2/3 $Q_e$ to quarks. This enables us to derive and calculate the quarks' masses [9].

The equation:

$1/R_c^2 = r_s\rho/r^3$

is a corrected (2), that takes into account the space density ρ, see [8] and [9], as explained below.

The absolute charge values of the bivalent elementary charges are equal $|Q_+| = |Q_-|$. Hence for a spherical elementary charge with radius r and charge density q this implies, according to [2], the following: Since $r_+ < r_-$ (dilation versus contraction) and $|Q_+|=|Q_-| = |\int_0^{r_+} q_+ dr| = |\int_0^{r_-} q_- dr|$ , necessarily on the average $|q_+| < |q_-|$ .

We define, [8], Electric Charge in a given zone of space τ as:

$Q = \int_\tau q d\tau$ Electric Charge in the GDM has the dimensions of volume $[Q] = L^3$

Note that by omitting the factor 1/4π in equation (1) in [1] - the definition of charge density - we get for the spherical symmetric case $d\tau = 4\pi r^2 dr$ and hence:

$Q = \int_0^r q 4\pi r^2\, dr = 4\pi/3 \cdot r^3(1-\rho_0/\rho) = V - V'$. Thus $\rho > \rho_0$ gives $V > V'$ and $Q > 0$ whereas $\rho < \rho_0$ gives $V < V'$ and $Q < 0$. Thus Q becomes a pure volumetric change, which is positive for contraction and negative for dilation.

Note also that the equality $|Q_+| = |Q_-|$, of the absolute values of the bivalent elementary charges, means $(1- \rho_0/\rho_+) = -(1- \rho_0/\rho_-)$ and hence $2/\rho_0 = 1/\rho_+ + 1/\rho_-$ . It also means that:

$|Q_+| = |Q_-| = |V - V'|$. For example if $\rho_+ = 2\rho_0$ then $\rho_- = 2/3\cdot\rho_0$ and $|V - V'| = 1/2\cdot V$. This means that $V_+/V_- = 1/3$ and hence $r_+/r_- = (1/3)^{1/3} = 0.69$ whereas according to [9]:

$r_p / r_e = 0.64$ .

We show in [9], that the radius of the charge in the proton and positron is smaller than that of the charge in the electron and possibly that of the charge in the anti-proton, see Appendix C in [9]. Note that in this paper Q denotes the elementary charge only.

The exact equality $|Q_+| = |Q_-|$ is related to the essence of the photon and Pair Production, and is a theoretical result of our photon model, whereas here it is considered a phenomenological result.

According to [9]: $r_- = 3/2\ r_+$. Hence $|Q_+| = |Q_-|$ implies $q_- = 2/3\ q_+$ , as discussed at the beginning of this section. This means that the |curvature| created by $Q_+$ is the same as that created by $Q_-$ . As a result the |curvature| for both of the pure bivalent charges, according to (2), and denoting $r_{S(Charge)}$ as $r_Q$ , is:

$$1/R_c^2 = r_Q / r^3 = \sqrt{2}/2s^2 \cdot \sqrt{G}\ Q / r^3 \qquad (3)$$

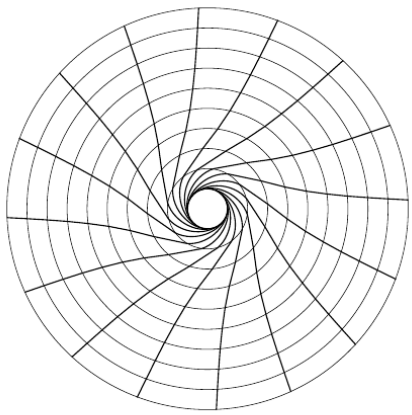
where s = 1 and [s] = $LT^{-1}$, see [9].

The bending of a light beam by charge, due to its induced space curvature, is discussed in Appendix B. In Appendix C we suggest an experiment designed to verify or falsify our theory.

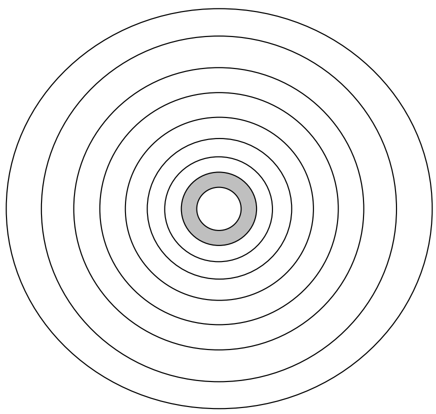
## 4 The Positive Curving of Space by the Spin of an Elementary Particle

In the GDM the electrons/positrons are circulating longitudinal wavepackets of dilation/ contraction. Thus, hinted by the validation of “Frame Dragging”, it is logical to explore the possibility that gravitation is the result of their angular momentum due to their circulation.

Our conjecture is that a longitudinal wavepacket applies pressure on the space lattice and bends its sides perpendicular to the wavepacket propagation direction. This bending is the "Frame Dragging" and it causes the contraction of space around the circulation track. As a result, both particles have an identical minute positive additional curvature that depends on their Angular Momentum. The sum of these two additional curvatures is the gravitational curvature of **neutral** matter. Fig. (1a) shows how an anti-clockwise rotating macroscopic mass (the inner circle) drags a radial frame; this is the kind of figure that usually appears in the literature. But this dragging causes space torsion around the mass and hence contraction, which is discussed in the literature on elasticity [14]. This contraction is presented in Fig.(1b); it shows that the concentric frame circles in Fig. (1a) should be corrected to show the contraction due to the torsion that takes place mainly in the gray zone around the mass. These figures also represent the dragging and contraction created by a longitudinal wavepacket of radius $r_e$ represented by the thickness of the gray annular ring of radius $R_e$ .



a



b

Fig.(1) Frame Dragging

Note that this type of space contraction, due to lattice bending, is not dependent on the direction of rotation of the wavepacket. Note also that the contraction is spherically symmetric only on the average.

This is also relevant to trios or duos of quarks, which are twisted electrons or positrons according to our theory of matter [9].

Our model of quarks [9] leads to the conclusion that in neutral matter the number of electrons equals the number of positrons. Thus the long standing issue of **“where is anti-matter?”** is resolved. The question that we have to ask now becomes “why almost all of the nucleuses in the universe are positive?” It seems that since positive charge curves space positively, atoms with a positive nucleus are much more stable, but this issue is out of the scope of this paper.

Rotation induces Frame Dragging [2], [3], [4], [5], which is a torsional contraction (positive curving). This phenomenon is expressed by the Kerr metric [5] equation (14.22) p.303. We, however, repeat the procedure used in [8] in which we rewrote the Schwarzschild radius,

$r_S = 2GM/c^2$, by considering mass to be purely electric charge self-energy (Surprisingly this procedure yielded the elementary particles radii and masses). Here we rewrite the Schwarzschild radius by expressing the mass of an elementary particle by its angular momentum $J=1/2\ \hbar$. Since $J= MRv$ we get for the elementary mass $M_e=1/2\ \hbar/R_ec$ , where $R_e$ is defined in [7]. This gives:

$$r_S = G\hbar/R_ec^3 \tag{4}$$

Using equation (2) we get for the curvature created by spin:

$$1/R_c^2 = r_S/r^3 \tag{5}$$

Note that M in this discussion is the inertial mass. Hence we are allowed to eliminate the concept of “gravitational mass”.

This result is compatible, as explained below, with the Kerr contribution to the square line element that appears in equation (14.22 p303) in [5]. This contribution is:

$$4GJ/c^3r^2 \operatorname{Sin}^2 \theta(r\, d\varphi)cdt \tag{6}$$

Note that we get (4) by taking J as $J = 1/2\cdot\hbar$ and the average of $\mathrm{Sin}^2\theta$ as 1/2.

Note also that "singularity" turns into merely a mathematical issue, since curvature is quantized.

## 5 The Ratio of Curvature-by-Charge to Curvature-by-Spin (Mass)

Dividing (3) by (5) gives the ratio of the curving by charge $K_Q$ to that by spin $K_S$. This ratio for a given distance r from the center of the elementary particle is the ratio:

$$K_Q / K_S = r_Q / r_S = (\sqrt{2}/2s^2)\sqrt{G}\, Q_e /(G\hbar/R_e c^3) \sim c^2 / s^2 \qquad (7)$$

The ratio of the electric force to the gravitational force between two electrons, at a distance r from each other is:

$$F_Q/F_G = Q_e^2 /GM_e^2 \sim 4c^4 / s^4 \qquad (8)$$

The comparison of equations (7) and (8) reveals the connection between the curving of space and the applied force:

$F_Q/F_G \sim (K_Q/K_S)^2$ which means that **Force is the multiplication of Curvatures.**

For masses $M_1$ and $M_2$ the multiplication of their curvatures is:

$K_{S1}K_{S2} = r_{S1}/r_{12}{}^3 \cdot r_{S2}/r_{12}{}^3 = [4G/(c^4 r_{12}{}^4)]\cdot G M_1M_2/r_{12}{}^2$ and thus **gravitational force** is:

$GM_1M_2/r_{12}{}^2 = [(c^4 r_{12}{}^4)/4G]\cdot K_{S1}K_{S2}$

For charges $Q_1$ and $Q_2$ the multiplication of their curvatures is:

$K_{Q1}K_{Q2} = r_{Q1}/r_{12}{}^3 \cdot r_{Q2}/r_{12}{}^3 = [(½)G/(s^4 r_{12}{}^4)]\cdot Q_1Q_2/ r_{12}{}^2$ and thus the **electric force** is:

$Q_1Q_2/ r_{12}{}^2 = [2(s^4 r_{12}{}^4)/G]\cdot K_{Q1}K_{Q2}$

## 6 The Curving by Both Charge and Angular Momentum

The total curvature, $K = 1/R_c^2$, created by an elementary particle is the sum of its curvature $K_Q$, due to charge and its curvature, $K_S$, due to angular momentum, $K = K_Q + K_S$, or according to (3) and (5) for the same r:

$$K = r_Q/r^3 + r_S/r^3 = \sqrt{G}\, Q/s^2r^3 + (2GM/c^2)/r^3 \qquad (9)$$

Thus, for two very close elementary particles, carrying the bivalent elementary charges, the charge contributions to curvature at a distance r cancel out, whereas the energy/angular momentum contributions add up.

Note that in annihilation of a pair the residual curvature does not cancel out. This is an open issue in the current paradigm that asks about the gravitational energy disappearance. We, however, wonder if this very small energy is not carried by two gravitons created in the annihilation.

Section 2 has shown that $(2GM/c^2)/\, r^3$ in equation (9) appears in the GR equation (1) as:

$\frac{8\pi G}{c^4} \cdot \in$ where $\epsilon = T_{00}$ and in general $8\pi G/c^4 \cdot T_{ij}$. Similarly $(\sqrt{2}/2)\sqrt{G}\, Q/\, s^2r^3$ in (9) becomes:

$(\sqrt{2}/2)\sqrt{G}\, Q/\, s^2r^3 = (2\sqrt{2}\pi/3)\, \sqrt{G}\, Q/\, s^2(4\pi/3)\, r^3 = (1/3)\, 2\sqrt{2}\pi\sqrt{G}/s^2 \cdot q$ where q is the charge density. Thus:

$$2\sqrt{2}\pi\sqrt{G}\, /s^2 \cdot q \qquad (10)$$

becomes analogous to $\frac{8\pi G}{c^4} \cdot \in$ and is used in Section 7 in the extension of the GR equation.

Note that we ignore the factor (1/3), as we did in Section 2.

Note also that in the GDM (10) is written as $4\pi\sqrt{HG}\, /s^2 \cdot q$ where $[H]=[G]=T^{-2}$, s=1 $[s]=LT^{-1}$ and [q]=1, see [8] and [9]. The dimensionality of (10) is thus that of curvature: $L^{-2}$.

## 7 The Extension of Einstein's Field Equation of GR to Incorporate the Curving by Charge / Current

This extension turns the GR equation from an equation that deals with spacetime curving by energy/momentum into a universal equation that also deals with the curving by charge/current. As a result, the equation becomes relevant not only to the **macroscopic** world but also to the **microscopic** world of elementary particles. Note that in this **microscopic** world the quantization of spacetime curvature also becomes relevant, since both angular momentum and charge are quantized.

To construct the extended equation we adopt the idea expressed by (9) and add a new term to the GR equation, which is the multiplication of (10) by the tensor:

**charge density/current density**.

### 7.1 The 4 –Vector of Electric Current Density

**Electric Current**:

$J^{\mu} = (cQ, \mathbf{J})$, $\mathbf{J} = Q\mathbf{v}$ hence:

$$J^{\mu} = Q(c, \mathbf{v})$$

**Electric Current Density**:

$j^{\mu} = (cq, \mathbf{j})$, $\mathbf{j} = q\mathbf{v}$ hence:

$$j^{\mu} = q(c, \mathbf{v}) \quad q = \gamma q^{0}$$

$$j^{\mu} = \gamma q^{0}(c, \mathbf{v}) = q^{0} v^{\mu}$$

Q is not a relativistic quantity, whereas q is a relativistic quantity (note the volume).

### 7.2 The Tensor $Tq^{\mu\nu}$ of Charge Density / Current Density

The 4-current densities $j^{(0)\mu}$, $j^{(1)\mu}$, $j^{(2)\mu}$, $j^{(3)\mu}$ transform into each other under Lorentz Transformation (LT). Thus, they themselves form a 4-vector, $p^{\mu} = \left(p^{0}, p^{i}\right)$.

$T_q^{\mu\nu}$ is the tensor: (11)

$$T^{\mu\nu} = \begin{pmatrix} j^{(0)\mu} \\ j^{(i)\mu} \end{pmatrix} = \begin{pmatrix} j^{(0)0} & j^{(0)1} & j^{(0)2} & j^{(0)3} \\ j^{(1)0} & j^{(1)1} & j^{(1)2} & j^{(1)3} \\ j^{(2)0} & j^{(2)1} & j^{(2)2} & j^{(2)3} \\ j^{(3)0} & j^{(3)1} & j^{(3)2} & j^{(3)3} \end{pmatrix}$$

$T^{00} = j^{(0)0}$. $\qquad T^{0i} = j^{(0)i} = \text{the } i^{\text{th}} \text{ component of the current}.$

$$T^{01} = \gamma \frac{q^{0}k}{c} v_1 = \gamma q^{0} c v_1 = q c v_1$$

$$T^{10} = c\gamma q^{0} v_1 = q c v_1$$

### 7.3 The Extended Field Equation of General Relativity for Energy/Momentum and Charge/Current

Using (9), (10) and (11) the extended Einstein GR field equation becomes:

$$R^{\mu\nu}\text{-}1/2Rg^{\mu\nu} = 8\pi G/c^{4} \cdot T_m^{\mu\nu} + 4\pi\sqrt{G}\,/s^{2} \cdot T_q^{\mu\nu} \qquad (12)$$

And in the GDM, by inserting H, it takes the form:

$$R^{\mu\nu}\text{-}1/2Rg^{\mu\nu} = 8\pi G/c^{4} \cdot T_m^{\mu\nu} + 4\pi\sqrt{HG}\,/s^{2} \cdot T_q^{\mu\nu} \qquad (13)$$

## 8 Discussion

The gradient in light velocity, and the ability of elementary particles to sense this gradient and move accordingly, results in free fall. Each and every mass falls free in the gradient of light velocity created by the presence of all other masses. This is interpreted as gravitational attraction. But masses curve space positively and hence they are supposed to repel each other, like charges of the same sign. This repulsion is the result of a Ricci Flow [14] that "irons" the curving of space, in order to reduce its elastic stress.

This understanding of gravitation opens up a new way to address the issues of Dark Matter and Dark Energy. These subjects, however, are out of the scope of this paper.

## 9 Summary

We have shown how Charge and Angular Momentum curve space and have explored the nature of Inertia by constructing a simplistic model of an elementary particle. This model enables us to realize that mass is only a practicality and not a fundamental attribute of matter. This has shown how a mass senses curvature and moves accordingly. Sensing and moving accordingly is "free fall", which is known as "gravitational attraction" as we are used to refer to. On the other hand, we suggest considering the possibility that galaxies repulse each other and cause space expansion. We have also extended Einstein's field equation to become the equation of both energy/momentum and charge/current. This way the equation becomes an equation of the macroscopic/microscopic reality.

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## Appendix A The Energy Momentum Tensor

According to [15]:

**4-Vectors in Gravitomagnetism**

Position: $x^{\mu} = (ct, x, y, z) \qquad x_{\mu} = \eta_{\mu\nu} x^{\nu} = (-ct, x, y, z)$

Interval: $S^2 = x^{\mu} x_{\mu} = -c^2 t^2 + x^2 + y^2 + z^2 = c^2 \tau^2$

Proper time: $\tau$ (a Lorentz scalar)

Velocity: $v^{\mu} = \partial_{\tau} x^{\mu}$ but $t = \gamma\tau$ hence $v^{\mu} = \gamma \partial_{\tau} x^{\mu}$

$$v^{\mu} = \gamma(c, v_x, v_y, v_z) = \gamma(c, \mathbf{v})$$

$$\mathbf{v}^2 = v^{\mu} v_{\mu} = \gamma^2(-c^2 + v^2)$$

Quantities which transform a LT, like $x^{\mu}$, are 4-vectors.

Momentum: $P^{\mu} \equiv M v^{\mu} = \gamma(Mc, P_x, P_y, P_z)$

$$P^0 = \gamma Mc = Mc\left(1 - \frac{v^2}{c^2}\right)^{-\frac{1}{2}} = Mc\left(1 + \frac{1}{2}\frac{v^2}{c^2} + .....\right) = \left(Mc^2 + \frac{1}{2} Mv^2 + ........\right)$$

Rest energy: $cP^0 = Mc^2 = U$

Relativistic energy: $\gamma c P^0 = \gamma M c^2 = \gamma U$

$$P^{\mu} = \left(\frac{U}{c}, \mathbf{P}\right)$$

$$\mathbf{P}^2 = P^{\mu}P_{\mu} = M^2 v^{\mu} v_{\mu} = M^2\left(-c^2\right)$$

Hence: $U^2 = \left(Mc^2\right)^2 + \left(c\mathbf{P}\right)^2$ Covariant force: $F^{\mu} = d_{\tau}P^{\mu} = M d_{\tau} v^{\mu}$ or:

$$F^{\mu} = \gamma d_t P^{\mu} = \gamma d_t \left(\frac{U}{c}, \mathbf{P}\right) = \gamma\left(\frac{\dot{U}}{c}, \mathbf{F}\right)$$

Rate of energy change – power:

$$W = F^{\mu} v_{\mu} = M d_{\tau} v^{\mu} \cdot v_{\mu} = \frac{1}{2} M d_{\tau} v^{\mu} v_{\mu} = 0$$

since $\mathbf{v}^2$ is a constant.

$$F^{\mu} v_{\mu} = \gamma^2\left(-\dot{U} + \mathbf{F} \cdot \mathbf{v}\right) = 0$$

hence: $F^{\mu} = \gamma\left(\frac{\mathbf{F} \cdot \mathbf{v}}{c}, \mathbf{F}\right)$

Mass current: $J^{\mu} = \left(cM, \mathbf{J}\right)$, $\mathbf{J} = M\mathbf{v}$

hence: $J^{\mu} = M\left(c, \mathbf{v}\right)$ Mass current density: $j^{\mu} = \left(cm, \mathbf{j}\right)$, $\mathbf{j} = m\mathbf{v}$

hence: $j^{\mu} = m\left(c, \mathbf{v}\right)$ $m = \gamma m^0$ $j^{\mu} = \gamma m^0\left(c, \mathbf{v}\right) = m^0 v^{\mu}$

Energy current–momentum: $P^0 = \frac{\mathbf{U}}{c}$

$J^{(0)\mu} = \left(U, \frac{\mathbf{U}}{c}\right)$ Energy current - momentum density: $j^{(0)\mu} = \left(\in, \frac{\boldsymbol{\in}}{c}\right)$

The 4-current density for the i th momentum component ($p^i$):

$$j^{(i)\mu} = \left(cp^i, p^i\right)$$

Note that in this section M and m stand for inertial mass and mass density. With a proper modification they also stand for gravitational mass and mass density.

**The Energy Momentum Tensor**

$T^{\mu\nu}$ in (1) is: $T^{\mu\nu} = \begin{pmatrix} j^{(0)\mu} \\ j^{(i)\mu} \end{pmatrix} = \begin{pmatrix} j^{(0)0} & j^{(0)1} & j^{(0)2} & j^{(0)3} \\ j^{(1)0} & j^{(1)1} & j^{(1)2} & j^{(1)3} \\ j^{(2)0} & j^{(2)1} & j^{(2)2} & j^{(2)3} \\ j^{(3)0} & j^{(3)1} & j^{(3)2} & j^{(3)3} \end{pmatrix}$ The 4-current density

$j^{(0)\mu}$, $j^{(1)\mu}$, $j^{(2)\mu}$, $j^{(3)\mu}$ transform into each other under Lorentz Transformation. Thus, they themselves form a 4-vector, $p^{\mu} = \left(p^0, p^i\right)$.

$T^{00} = j^{(0)0} = \in$ energy density $T^{0i} = j^{(0)i} =$ the $i^{th}$ component of the $\frac{\in}{c}$ current

$T^{01} = \gamma \frac{\in^0}{c} v_1$ or $\gamma \frac{m^0 c^2}{c} v_1 = \gamma m^0 c v_1 = m c v_1$ $T^{10} = c\gamma m^0 v_1 = m c v_1$

We see that the momentum density $T^{i0}$ is equal to the energy density current $T^{0i}$

$T^{ii}$ = momentum current = $\frac{\text{momentum}}{\Delta S \cdot \Delta t} = \frac{\text{force}}{\Delta S} = \text{pressure}$

The off-diagonal terms are shear forces. $T^{ij} = T^{ji}$ is a symmetric tensor.

$\partial_{\mu} T^{\mu\nu} = 0$ for an isolated system is the conservation of energy – momentum

## Appendix B The Bending of a Light Beam by an Electric Charge

The bending of a light beam by mass M is given by the known equation [13]:

$$\alpha_M = 2GM/bc^2 \qquad \text{(B1)}$$

where $\alpha_M$ is the bending angle in radians and b is the impact parameter (the distance of the passing beam from the center of the mass). Note that 1 miliradian ($10^{-3}$ radian) equals

206” arc second. We now derive a similar equation to (B1) that expresses the bending angle $\alpha_Q$, caused by the presence of charge Q rather than a mass M.

Equation (7), which is the ratio of the curvatures $K_Q / K_S = r_Q / r_S \sim c^2/ s^2$ for the electron/positron, enables us to modify (B1) and convert it to become an equation for $\alpha_Q$. Since the curving, and hence the bending, by the elementary charge $Q_e$ is $c^2/ s^2$ times larger than that by the lowest elementary rest mass $M_e$ of the electron/positron we can set a lower limit to $\alpha_Q$. This limit is achieved by replacing M in (B1) by $Q\cdot c^2/ s^2$, which gives:

$$\alpha_Q = 2GQ/bs^2 \tag{B3}$$

For a grazing light beam to a sphere of radius b = 10cm the bending by

$\alpha_Q$=1miliradian $=1\cdot10^{-3}$ is achieved by charging the sphere by $Q = \alpha_Q\, bs^2/ 2G = 7.5\cdot10^4$esu. The potential of the surface is then:

$\varphi = Q/b = 7.5\cdot10^3$esu or $v = 300\cdot7.5\cdot10^3 = 2.25\cdot10^6$ volt.

See also Appendix C.

**Appendix C A Practical Experiment to Test Our Theory**

We suggest creating an “accumulated flowing charge” at the focal zone of an electron beam. It is a simple task to take a slow beam of several milliamps current and create a focal zone of, say, several microns. Thus we create at the focal zone a charge of similar esu to the charge in our example above and observe a similar bending angle. The details are as follows:

1 ampere = (1 coulomb / 1 cm$^2$ )·(1/1sec ) = (1 coulomb / 1 cm$^3$ )·(1 cm/1 sec)

$I = Q/(At) = (Q/V) \cdot v$ I - current, A - cross section area, Q - charge, V - volume, v - speed.

$Q = I\,(V/v)$

The current: $I = 0.1$ amps $= 10^{-1} \cdot 3\cdot10^9 = 3\cdot10^8$esu cm$^{-2}$sec$^{-1}$.

The “radius” of the focal zone volume is $r \sim 3\cdot10^{-1}$cm.

The velocity of the electrons is $v = 10^4$cm $sec^{-1}$.

The "accumulated flowing charge" at the focal zone is thus: $Q \sim I\,(r/1cm)\,/v \sim 1\cdot10^4$esu

A laser beam, with a radius $r \sim 3\cdot10^{-1}$cm, crosses the electron beam perpendicularly, but close to and above the focal zone.

Using (B3) we get the exact (and not the lower limit, since we are dealing with electrons) bending angle $\alpha_Q$. From the center of the focal zone to the center of the laser beam: $b = 2r$.

$\alpha_Q = 2GQ/bs^2 = 2\cdot6.67\cdot10^{-8}\cdot10^4/(2\cdot3\cdot10^{-1}) \sim 2\cdot10^{-3} = 2$ miliradians.

This experiment is doable. The result can verify or falsify our theory.