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The Graviton

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Abstract

Gravitational waves have recently been detected. These space waves are predicted by General Relativity. As of today, there is no theoretical proof, or observational evidence, for the existence of quanta of these waves. These quanta are considered by some to be the “force-carrying” mediators between masses - the Gravitons.

In this paper we suggest a model of the, as yet hypothetical, Graviton. We also relate to the effort to quantize gravitation, and raise arguments in support of the existence of Gravitons.

Key Words: Gravitation, Graviton, Gravitational Wave, General Relativity

1 Introduction

1.1 The Graviton

The graviton is expected to be a massless spin-2 boson.

The nature of the expected graviton is discussed, in a very clear and compact way, in the introduction by Brian Hatfield (*Spin of the Graviton and Antigravity*) to the book: Feynman Lectures on Gravitation [1].

1.2 The Quantization of Space Curvature and the Graviton

Einstein's Field Equation of General Relativity deals with spacetime curving by Energy/Momentum, which is due to angular momentum, as we have shown [2]. By incorporating in this equation the additional curving by Charge/Current [2], we have extended the equation to become relevant not only to the **macroscopic** world, of mainly neutral bodies, but also to the **microscopic** world of elementary particles. This equation expresses the idea that space curvature is quantized, since both angular momentum and charge are quantized. This is what determines the nature of the graviton, as we show in Section 4.

Note that this paper is one in a series that establishes our new foundation of physics. The Appendix presents some surprising new results, both derived and calculated, which appear in these papers.

2 The Quantized Space Curvature

The quantization of spacetime curvature is due to quantized angular momentum and charge [2]. Thus, the creation of a pair of a particle and its anti-particle contributes twice to the curving by spin (and relevant energy). There is no contribution to curvature by a pair of bivalent elementary charges since the contributions of positive and negative curving cancel out. Note that in our theory - the GDM [3] gravitation [2] is space contraction (curving) [4].

Thus “quantizing gravitation” means that the amount of contraction jumps from one value to another by a quantum of contraction. The annihilation of a pair of a particle and its anti-particle subtracts twice the curving by spin (and relevant energy). This loss in curving (contraction), which is necessarily quantized, is a loss in space torsion and its relevant energy. This is more than a clue as to how the graviton is constructed. To construct a model of the graviton we must first relate to our models of the photon and its ground state photom [5], which are space wavepackets [5].

To summarize:

The curving of space is quantized. The minimal change in curving is a quantum of contraction or dilation. A graviton is created by a quantum reduction in curvature (contraction). Pair annihilation is an example (Sections 4 and 5). This graviton is a wavepacket of a transversal oscillating contraction and dilation of space, and as such it is massless. A gravitational wave is many gravitons in phase.

3 The Photon and Photom

3.1 The Photon

We have shown [5] that the photon is a confined oscillating dipole with its field. This dipole is an oscillation of a space contraction and dilation, which in the pair-production process are converted into the stable bivalent elementary charges of the positron and electron (as it is for other particles). **The photon in the GDM holds all the basic features that appear in all the other elementary particles.** Reading papers [6], [7] and [8] is a must; otherwise this statement will be considered an absurdity.

Note that the GDM model of the photon yields its size, among other things.

Note also that in the GDM a **transversal wave** is the oscillation of contraction, dilation, or both, perpendicular to the direction of motion. A **longitudinal wave** is the oscillation of

contraction, dilation, or both, in the direction of motion.

3.2 Photoms - the Ground State Photons

3.2.1 Photoms

QED, [9], attributes to a photon in its ground state one half of the energy, half of the momentum, and half of the spin. To distinguish a photon from a ground state photon, we name it a **Photom** (a photon at the bottom is a photom). In the GDM, however, there are two types of photoms.

The Positive Photom: This photom, Fig. (1), is an oscillating contraction of space (positive charge), close to the line of propagation. This oscillation is in a plane, or in a rotating plane, around the line of propagation.

The Negative Photom: This photom, Fig. (2), is an oscillating dilation of space (negative charge) close to the line of propagation. This oscillation is in a plane, or in a rotating plane, around the line of propagation.

These photoms are the split of the photon in [5]. The GDM considers them as the electron and positron of the Dirac Sea, and vacuum polarization is due to them. Thus, we dispel the need for a separate ground state (vacuum state) for the electromagnetic field and for the electron and positron field (Dirac Sea).

3.2.2 The Positive Photom

Fig. (1) shows our cylinder-like photom passing in front of us to the right, with a velocity c . At the moment $t = 0$, Fig. (1a), we see a cylinder of space with no strain; each square represents a group of space cells (this process is related to each and every space cell).

At $t = 1/4 \cdot T$, Fig. (1b), the space in the cylinder becomes contracted above, and close to, the line of propagation (the middle). The electrical field vector points opposite to the

displacement vector, shown in the figure. At $t = 1/2 \cdot T$, Fig. (1c), we face the same situation as in Fig. (1a). At $t = 3/4 \cdot T$, Fig. (1d), the displacement reverses its direction and the electrical field points down. At $t = T$, Fig. (1e), the cycle is completed.

Note that we do not know the exact shape of the photon or the photom. All we know, at this stage, is their geometric and dynamic features. This is the reason why we use the term cylinder-like.

3.2.3 The Negative Photom

Figure (2) shows our cylinder-like photom passing in front of us to the right, with a velocity c . At the moment $t = 0$, Fig. (2a), we see a cylinder of space with no strain; each square represents a group of space cells (this process is related to each and every space cell).

At $t = 1/4 \cdot T$, Fig. (2b), the space in the cylinder becomes dilated above, and close to, the line of propagation (the middle). The electrical field vector points opposite to the displacement vector, shown in the figure. At $t = 1/2 \cdot T$, Fig. (2c), we face the same situation as in, Fig. (2a). At $t = 3/4 \cdot T$, Fig. (2d), the displacement reverses its direction and the electrical field points up. At $t = T$, Fig. (2e), the cycle is completed.

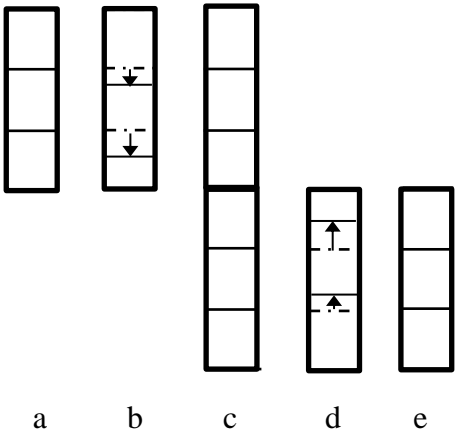


Fig. (1) The Positive Photom

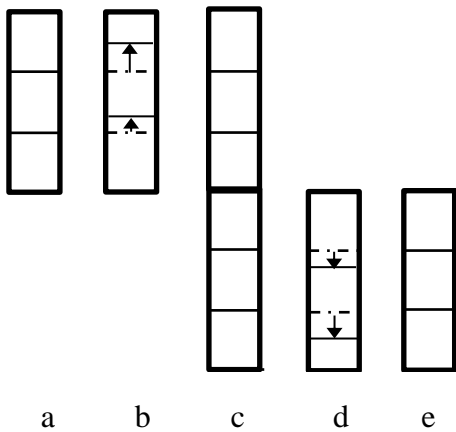


Fig. (2) The Negative Photom

4 The Quantized Gravitational wave – Gravitons

4.1 The Gravitational wave

Gravitational waves [10], predicted by GR [11], are space waves that have recently been detected.

Fig. (3) shows the effect of a linear polarized gravitational wave (Plus Polarization) on a ring of particles [12] at different quarters of the cycle time T . This wave moves towards us perpendicularly to the page and through it. It is a transversal wave of contracted and dilated space, with the axes of contraction and dilation perpendicular to each other and to the direction of propagation. As a transversal wave, it moves at light velocity c .

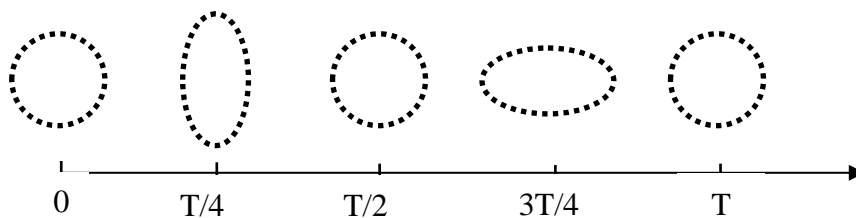


Fig. (3) The Gravitational Wave (Plus Polarization)

At $T = 0$ space is un-deformed (standard, normal). After $T/4$ space is dilated (stretched) vertically and contracted horizontally. At $T/2$ space is again un-deformed, and at $3T/4$ space is contracted vertically and dilated (stretched) horizontally.

The second linear polarization is tilted by $\pi/4$ rather than $\pi/2$ since the spin is $s = 2$, see [11] and [12]. This polarization is called – Cross Polarization (in Fig. (3), the ellipses are rotated clockwise by 45 degrees).

The Graviton model should, necessarily, be compatible with the gravitational wave.

4.2 The Graviton Model (Structure)

4.2.1 The Graviton - Symbolized by G

Inspired by Figures (1), (2) and (3), we **invent** the graviton.

Fig. (4) shows, for different quarters of the cycle time T , our cylindrical cross-like graviton moving towards us, with a velocity c , perpendicular to the page and through it.

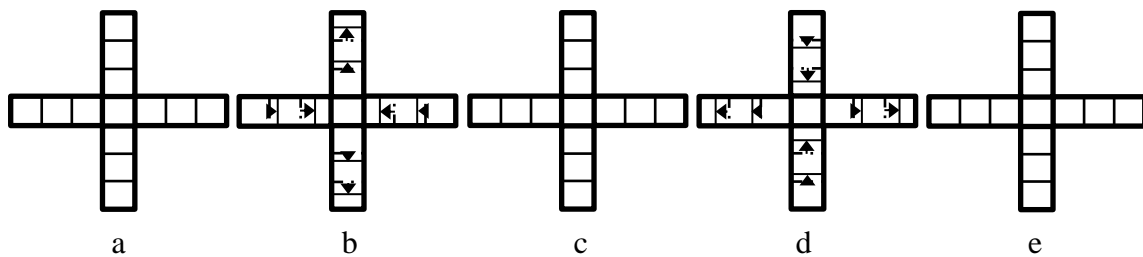


Fig. (4) The Graviton

At $T = 0$, see Fig. (4a), space is un-deformed (standard, normal). After $T/4$, see Fig. (4b), space is dilated (stretched) vertically (as if constructed by two opposing vertical negative photoms), and contracted horizontally (as if constructed by two opposing horizontal positive photoms). At $T/2$ space is un-deformed, and at $3T/4$ space is contracted vertically and dilated horizontally. This construction is good for gravitons with linear plus and cross polarizations or circular polarizations. In Section 5.2 we bring an argument as to why the graviton is a combined oscillation of space contraction and dilation.

4.2.2 The Graviton and the Photom

Fig. (4) shows that a graviton is constructed of two positive photoms and two negative photoms. We can, therefore, consider the ground state of gravitons to be that of photons. We expect the ground state of space to create space polarization. It affects, not only electric interactions, but also gravitational interactions, since **a neutral mass curves space positively like a positive charge** [7], [2]. Evidence for this possibility appears in Section 6.

5 The Spin Energy and Size of the Graviton G

5.1 The G Spin

The spin of each photom is $1/2 \hbar$. Since the graviton is constructed of 4 photoms its spin must be $s = 2$, hence:

$$L_G = 2 \hbar \quad (1)$$

Note that in pair annihilation, in order to conserve angular momentum, usually two photons and a graviton are created, see Section 5.2.

5.2 The G Energy

Let a pair with a combined mass M' be located on the surface of a mass M . The gravitational energy of the system M' and M due to the presence of M' is:

$$U_G = - GMM'/R \quad (2)$$

R being the radius of M (we neglect the self-gravitational energy of the pair).

The annihilation of the pair is a loss of gravitational energy - we relate to the absolute value of this energy. It is **a long-standing issue** as to where did this gravitational energy disappear.

We suggest that this energy is carried by a graviton, which leaves the system at velocity c .

Note that, according to the GDM [6], [7], the elementary bivalent charges are contracted and dilated zones of space. Hence, it is natural to expect that their annihilation creates a ripple in space, which is a combined space oscillation of contraction and dilation.

This understanding enables us to calculate typical graviton energies. Our models of both the photon and the graviton lead us to conclude that the graviton energy U is related to its angular frequency ω by:

$$U = 2\hbar\omega \quad (3)$$

Note that in the electromagnetic field, a single mode can be excited, equally, n times and own energy $(n+1/2)\hbar\omega$. This, however, is not the case for the graviton. **In the “gravitational field”, each graviton owns its specific, individual, quantum of energy (3), according to the quantum reduction in curvature (contraction) [2] of its source. A graviton, although its energy comes as a quantum, unlike the photon it is not an excited mode of some kind. It seems that this is the “difficulty” in “quantizing” gravitation.**

5.3 The G Size

Our models of both the photon and the graviton lead us to conclude that the size of a graviton is like that of the photon [5]:

$$V_{\text{Graviton}} = 6.75 \cdot 10^{-7} \cdot \lambda^3 \text{cm}^3 \quad (4)$$

5.4 Typical Numerical results

For the Earth $M = 6 \cdot 10^{27}$ gr, $R = 6.4 \cdot 10^8$ cm and for a pair $M' = 2 \cdot 10^{-27}$ gr. According to Sections 5.2 and 5.3: $U = 1.25 \cdot 10^{-15}$ erg $\lambda = 0.15$ cm and $V_{\text{Graviton}} = 2.3 \cdot 10^{-2}$ cm³.

The graviton carries the energy of the quantum of the space curvature (contraction) that disappeared in the annihilation (we neglect the self-gravitational energy of the pair). We wonder how difficult it is to detect this kind of graviton.

6 Possible Evidence for Our Understanding of Gravitation

6.1 The Deviation from GR Prediction in the Flyby of Earth Satellites

J. D. Anderson presented in (2009) [13] the following spacecraft speedups in their flyby close to earth. The closer the spacecraft to earth the stronger is its speedup (“speedup” is the deviation from the GR-predicted speed).

Name of Spacecraft	Distance from Earth (km)	Spacecraft Speedup (mm/sec)
NEAR (1998)	539	13.5
GALILEO (1990)	960	3.9
ROSETTA (2005)	1956	1.8
MESSENGER (2005)	2347	0.0

6.2 Our Conjecture Regarding these Deviations

6.2.1 Space Polarization and Electromagnetic Interactions

As explained in [5] and Section 3.2 the photoms are the “virtual charges” of the Dirac Sea, or the ground state excitations of the vacuum [9]. As such they are responsible for the vacuum polarization [9]. This polarization, as QED shows, weakens the electric field of a charge at a distance (the $1/r^2$ field becomes distorted). At the charge it appears stronger as if the net charge is greater than the standard [9]. A scattering experiment, conducted in the TRISTAN accelerator in Japan in 1997, found that as the electrons get closer to each other, the field they sense is larger than expected. The explanation, given by Koltick (1997) [14], was that the vacuum polarization screens the charge of the electron. According to the GDM these Positive and Negative Photoms polarize space.

6.2.2 Space Polarization and Gravitational Interactions

A “polarized vacuum” or more correctly a polarized space, should affect gravitation in the same way as it affects charge. Thus, close to a mass, the field should appear stronger than at a distance - stronger than that predicted by GR. This explains the above spacecraft speedups phenomenon. It means that because of space polarization the measured Newtonian gravitational constant G is somewhat smaller than the G close to a mass.

6.3 Observed Deflection of Light by the Sun as a Function of Solar Distance

P. Merat, et al. (1975) [15] reported that the deflection of light by the sun deviates from the GR prediction. The closer is the beam of light to the surface of the sun, the greater is the deviation. It seems that the explanation in Section 6.2 is also applicable here.

6.4 Derivations and Calculations

Polarization of Space can be the reason for these deviations from GR, presented in the above sections. QED methods of calculation, of the polarization effect [9], can be used to verify or falsify our conjecture.

7 On Singularity and Creation

Our extended General Relativity equation expresses the fact that it is spin and charge that curve space. Hence curvature of space is quantized. On the face of it, space with no matter cannot be curved. In this case, there is no physical meaning to singularity. If space is just loaded with photoms, and photons do not exist yet, one can wonder how the first particle was created. Note, however, that a zone of space can be dilated - curved negatively - by a concentration of negative photoms, oscillating in phase, or be contracted - curved positively- by a concentration of positive photoms, oscillating in phase. This understanding has implications for the nature of creation, but this subject is out of the scope of this paper.

8 Summary

In this paper we have further developed our unified model of reality - the GDM- by suggesting a model of the graviton.

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Appendix Some Results of Our Physics – New Foundation

THE EXTENDED GR EQUATION [2]

Exploring the essence of electric charge, we found that by defining charge as nothing but curved space we are able to derive the entire Maxwellian Electromagnetic theory, without any phenomenology. This result enables us to extend Einstein's equation of General Relativity (GR) to become an equation that incorporates not only the energy/momentum tensor ($T_m^{\mu\nu}$), but also the charge/current tensor ($T_q^{\mu\nu}$). This equation becomes a macroscopic/microscopic equation of the entire physical reality. Charge and angular momentum are quantized and thus we predict that the curvature of spacetime is also quantized.

$$R^{\mu\nu} - 1/2 R g^{\mu\nu} = 8\pi G/c^4 \cdot T_m^{\mu\nu} + 4\pi G^{1/2}/s^2 \cdot T_q^{\mu\nu}$$

where $S = 1$ and $[S] = \text{cm/sec}$

In the past, efforts were made to incorporate the energy/momentum tensor of the electromagnetic field in the GR equation. The common denominator of all these efforts to unify gravitation and electromagnetism was the idea that only energy/momentum curves spacetime. In contrast, we show that the right-hand-side of the GR equation expresses curving by angular momentum and charge. Curving by angular momentum is related to frame dragging, whereas charge is simply curved space. Charge and angular momentum are

quantized and thus we predict that curvature of spacetime is also quantized. Thus the creation or annihilation of pairs is supposed to result a double quantum change in curvature. This understanding led us to our model of the Graviton as a particle with spin 2, given energy, and defined size.

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 unresolved. This situation results from the lack of a deeper theoretical layer.

THE GDM

In order to cope with the long-standing issues, and provide this missing underlying layer, we have constructed a new theory – foundation - “The Geometrodynamical Model of Reality”, the GDM. This layer, the GDM, provides answers as to what are: charge, an elementary particle, inertia, gravitation, and relates to additional fundamental subjects. The GDM does not, at large, contradict the paradigm; it simply serves as a realistic and tangible New Foundation.

Attributes of Elementary Particles [7] Derived and Calculated

Electron/Positron Mass

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

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

Electron/Positron Radius

$$r_e(\text{calculated}) = 1.409858 \cdot 10^{-13} \text{ cm}$$

Muon/Anti-Muon Mass

$$M_\mu(\text{calculated}) = 112.5 \text{ Mev}/c^2$$

$$M_{\mu}(\text{experimental}) = 105.8 \text{ MeV}/c^2$$

Quarks/Anti- quarks Masses

$$M_d = 9M_e = 4.5 \text{ MeV}/c^2$$

$$M_d = 4.8 \pm 0.5 \text{ MeV}/c^2 \text{ experimental value}$$

$$M_{\bar{u}} = 4.5M_e = 2.25 \text{ MeV}/c^2$$

$$M_{\bar{u}} = 2.3 \pm 0.8 \text{ MeV}/c^2 \text{ experimental value}$$

Proton/Anti-Proton Charge Radius

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

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

The GDM method OF UNIFICATION

The GDM **approach** to the issue of unification is as follows: **Instead** of adding spatial dimensions, which we consider a formal, even artificial, way of unification, we have explored the possibility that **all phenomena** have a common denominator. This common denominator turns out to be the **geometroynamics of space**. Thus Riemannian geometry, applied to deformed spaces rather than to bent manifolds [6], becomes our mathematical tool to explore the reality.