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On Subquantum Electromagnetic and Gravitational Interactions

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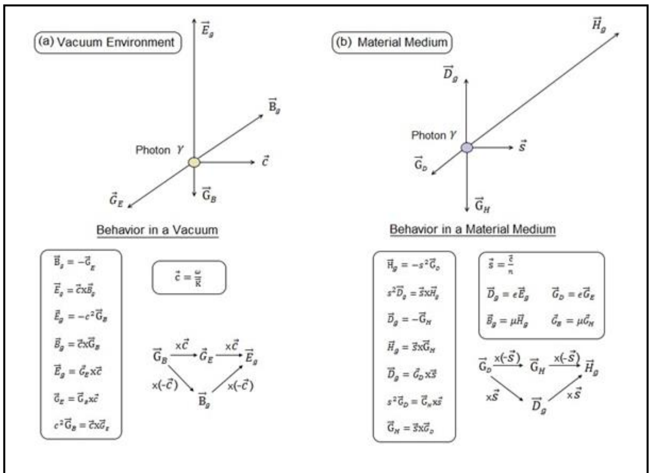
Abstract

To a greater or lesser extent, gravitational fields are always present in the environment of electromagnetic fields. Gravitational energy will decisively influence the value of electromagnetic energy present. Gravitons interact at subquantum level with photons, influencing the electromagnetic interaction. Moreover, gravitational interaction can produce photons by itself. The amount of gravitons that are necessary to have a photon of minimum energy and detectable frequency will be estimated. In addition, it is going to propose an electro-gravitodynamics compendium of vectorial character, descriptive of the fields that relate the graviton-photon interaction, both in a vacuum environment and in that of a material medium.



Subquantum Electro-Gravitodynamics: Vectorial representation and formalism

Keys: Subquantum, Graviton, Photon, Electro-gravitodynamics, Fields, Subparticles.

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1. Introduction

"All interactions between charged particles are described by photon exchange. The photon must be a virtual particle" [1]. That is, the electromagnetic interaction is mediated through the photon, zero rest mass particle without charge and spin one, with propagation speed that of light c in a vacuum [2].

The graviton is a particle with similar characteristics to those of the photon, zero rest mass and without electric charge, more complex having spin two, with propagation speed in a vacuum also of value c, which mediates gravitational interaction [3]. However, its null mass value is not consistent with experimentation [4].

$$m_g = \frac{\hbar}{c}\sqrt{\frac{2\Lambda}{3}} \quad (1)$$

Some authors, for example [5], using the approximation given by [6] according to (1), achieve the value $m_g = 1.909.10^{-69} Kg$, close to the one previously reached by [7] $m_g = 3.2.10^{-69} Kg$.

Based on the so-called NRP ("non rest particles"), in [8] appears the relationship and influence of the gravitational interaction, by the gravitons, on the photons carrying electromagnetic energy. Moreover, they propose that electromagnetic energy can be produced or changed from gravitational energy. That is to say, they consider the electromagnetic energy and the gravitational energy as two different interrelated manifestations, with origins in physical entities that coexist supported by each other. In this way, they try to describe how gravitons, always present to a greater or lesser extent in the electromagnetic environment, influence the characteristic energy of photons. On the other hand, in the same work, they explain how the exclusive interaction between gravitons, in an environment in absence of electromagnetic energy, can generate photons.

The authors in [8] establish a series of conditions that allow the photon-graviton relationship and determine the photon's subquantum structure:

1. The photon carries the electric $\vec{E}$ and magnetic $\vec{B}$ fields, always perpendicular and related to each other through the Maxwell's equations.
2. The photon is electrically neutral and, therefore, there must be sub-particles in its non-elementary structure that make up the field $\vec{E}$, which must neutralize each other.
3. Thus, there are two groups of positive and negative color charges in the internal photon structure used to define the field $\vec{E}$ of the photon itself and neutralize each other.
4. The displacement of the field $\vec{E}$ in the photon structure generates field $\vec{B}$ around.
5. Simultaneously, the internal photon fields of positive and negative charges produce, with their displacement, magnetic fields$\vec{B}$. Thus, there will be two associated groups of magnetic color.

The gravitons in their interaction with the photon become the subquantum particles, giving rise to the electric (G^-, G^+) and magnetic (G_m^-, G_m^+) color groups that the photon requires to carry $\vec{E}$ and $\vec{B}$ fields neutral. When we talk about the graviton-photon subquantum relationship, we must understand that both traditional particles are going to be treated as non-elementary, that is, subparticles intervene in the process of gravitonphoton interaction that make up each of the above.

Based on these premises, an estimation of the number of gravitons that are necessary to have a photon of minimum energy and detectable frequency will be made, based on a detailed study of the subquantum structure proposed by [1].

On the other hand, just as the classical electrodynamics of Maxwell's equations are a basic descriptive compendium of the photon behavior as an elementary particle associated with $\vec{E}$ and $\vec{B}$ fields, it is intended to define a subquantum electro-gravitodynamics based on the internal description of the photon and its relation to gravitons, expressed through gravitational and electromagnetic interactions, both in a vacuum and material environment.

2. On Photon's Subquantum Structure

Classical electrodynamics is summarized as follows [9]:

1. Supposed a certain accumulation q of electric charge with charge density ρ.
2. The charge q causes the existence of electric field $\vec{E}$ divergent from the sources, such that:

$$\vec{\nabla}.\vec{E} = \frac{\rho}{\epsilon_0}$$

or

$$\vec{\nabla}.\vec{D} = \rho \text{ , with } \vec{D} = \epsilon\vec{E} \quad (2)$$

Being ϵ the electric permittivity and $\vec{E}$ described in wave form as,

$$\vec{E} = \vec{E}(\vec{r}, t) = \vec{E}_0 e^{i(\vec{K}\vec{r} - \omega t)} \quad (3)$$

Where,

$$\vec{c} = \frac{\omega}{\vec{K}}$$

or

$$\vec{s} = \frac{\vec{c}}{n} \quad (4)$$

With $\vec{c}$ the propagation speed vector in a vacuum of the wave packet $\vec{K}$ with pulsation ω. $\vec{s}$ is the propagation speed vector in a material medium with n the refractive index in such medium.

If the electric field $\vec{E}$ varies with time and/or the charge q moves in the form of electric current $\vec{J}$, a Rotational circulation of the magnetic field $\vec{B}$ is generated, such that,

$$\vec{\nabla}\text{x}\vec{B} = \mu_0\vec{J} + \mu_0\epsilon_0\frac{\partial\vec{E}}{\partial t}$$

or

$$\vec{\nabla}\text{x}\vec{H} = \vec{J} + \frac{\partial\vec{D}}{\partial t} \quad \text{, with} \quad \vec{B} = \mu\vec{H} \qquad (5)$$

Where, μ_0 and ϵ_0 are the magnetic permeability and the electric permittivity, respectively, in a vacuum. μ is the magnetic permeability in a material medium. $\vec{B}$ can be described in wave form as,

$$\vec{B} = \vec{B}(\vec{r}, t) = \vec{B}_0 e^{i(\vec{K}\vec{r}-\omega t)} \qquad (6)$$

On the other hand, keeping in mind that,

$$c = |\vec{c}| = \frac{\omega}{|\vec{K}|} = \frac{1}{\sqrt{\mu_0\epsilon_0}} \quad \text{or} \quad s = |\vec{s}| = \frac{|\vec{c}|}{n} = \frac{1}{\sqrt{\mu\epsilon}} \qquad (7)$$

3. There are no sources of magnetic field $\vec{B}$, that is,

$$\vec{\nabla}.\vec{B} = 0 \qquad (8)$$

4. If the magnetic field $\vec{B}$ varies temporarily, a rotational circulation of electric field $\vec{E}$ appears,

$$\vec{\nabla}\text{x}\vec{E} = -\frac{\partial\vec{B}}{\partial t} \qquad (9)$$

In [1] the authors propose a structure for the photon at subquantum level based on the following description:

- Supposed a photon γ with energy composed by n_1 elements, such that,

1 $$n = n_{11} + n_{12} + n_{13} + n_{14} \qquad (10)$$

With n_{11} and n_{12} Representative of the charges color and with n_{13} and n_{14} the magnetic color and, therefore,

$$h\nu = \begin{bmatrix} n_{11} & n_{12} \\ n_{13} & n_{14} \end{bmatrix} \qquad (11)$$

- Considered a second photon γ' with energy h' composed of n_2 elements, such that,

$$n_2 = n_{21} + n_{22} + n_{23} + n_{24} \qquad (12)$$

With n_{21} and n_{22} representative of the charges color and with n_{23} and n_{24} the magnetic color and, then,

$$h\nu' = \begin{bmatrix} n_{21} & n_{22} \\ n_{23} & n_{24} \end{bmatrix} \qquad (13)$$

- Supposed an interaction between γ and γ^+ with energy exchange E embodied in the photon γ

$$\Delta E = h\nu - h\nu' = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \equiv CPH \text{, with } CPH \equiv \begin{bmatrix} kG & kG^- \\ G_m^+ & G_m^- \end{bmatrix} = [\gamma_0^+ \quad \gamma_0^-] \qquad (14)$$

Being γ_0^+ and γ_0^- virtual **semiphotons**, components of the photon γ_0, such that,

$$\gamma_0^+ \equiv SQE^+ = \begin{bmatrix} kG^+ \\ G_m^+ \end{bmatrix} \text{, with } SQE^+ \text{ positive subquantum energy of the photon } \gamma_0 \qquad (15)$$

$$\gamma_0^- \equiv SQE^- = \begin{bmatrix} kG^- \\ G_m^- \end{bmatrix} \text{, with } SQE \text{ negative subquantum energy of the photon } \gamma_0 \qquad (16)$$

Where,

$$A = kG^+ \text{ and } B = kG^- \qquad (17)$$

With A and B the positive and negative effect, respectively, of k gravitons with electric charge influence on the electric field $\vec{E}$.

$$C = G_m^+ \text{ and } D = G_m^- \qquad (18)$$

With C and D the positive and negative effect, respectively, of one graviton with magnetic color influence on the magnetic field $\vec{B}$.

The value of k in (17) is obtained taking into account that [10],

$$\vec{E} = \vec{c}\text{x}\vec{B} \quad \text{and} \quad |\vec{E}| = c|\vec{B}| \qquad (19)$$

Therefore, comparing (17) with (18) and considering (19), it is observed that k gravitons are necessary to influence the electric field $\vec{E}$ for each influence graviton in the magnetic field $\vec{B}$; since the field strength of $\vec{E}$ is c times the field strength of $\vec{B}$ (in a vacuum), it is concluded that,

$$k = c \qquad (20)$$

Being k a natural number. Thus, the minimum energy of the photon γ_0 can be described as,

$$E_{min\,\gamma_0} = (2k+2)E_g \qquad (21)$$

With E_g the graviton energy, such that,

$E_g < h\nu_0$ (22)

And ν_0 the minimum frequency of the detectable photon.

According to (21), to produce a photon is necessary *k* times more energy to generate its electric field $\vec{E}$ than its magnetic field $\vec{B}$, from gravitons. In short, a photon of *n* elements has energy E defined as,

$E = n\ 2k + 2\ E_g = n\ CPH$ with $E_g = cte$ (23)

This is the description of the photon's subquantum structure, according to [1]. That is, a photon γ_0 of minimum energy $E_{min\,\gamma_0}$ would be generated from *2k* gravitons for the electric field $\vec{E}$ and only with the energy of two gravitons for the magnetic field $\vec{B}$. However, it does not seem, a priori, a very accurate description, taking into account that the graviton energy is very small, so that it is enough with only two gravitons to get magnetic field $\vec{B}$. It is more reasonable to think that to generate fields $\vec{E}$ and $\vec{B}$ in a photon of minimum energy we need $2i$ 2 and $2j$ gravitons with influence of electric charge and magnetic color, respectively, such that,

$\frac{i}{2j} = k = c$ (24)

Being *i* and *j* a pair of natural numbers, like *k*. Thus, for the generation of the electric field $\vec{E}$ we use $i(G^+, G^-)$ Gravitational particles and to generate the $\vec{B}$ field we need $j(G_m^+, G_m^-)$ gravitons, so that the relation $k = c$ in (24) is maintained. In this way, equation (21) should be replaced by,

$E_{min\,\gamma_0} = (2i + 2j)E_g$ (25)

And, in a generic photon, (23) must be rewritten as,

$E = n(2i + 2j)E_g = n[CPH]$ with $E_g = cte$ (26)

Being *CPH* replaced in (14) by,

$CPH \equiv \begin{bmatrix} iG^+ & iG^- \\ jG_m^+ & jG_m^- \end{bmatrix} = [\gamma_0^+ \quad \gamma_0^-]$, with $\gamma_0^+ \equiv SQE^+ = \begin{bmatrix} iG^+ \\ jG_m^+ \end{bmatrix}$ and $\gamma_0^- \equiv SQE^- = \begin{bmatrix} iG^- \\ jG_m^- \end{bmatrix}$ (27)

Taking into account (22),

$E_{min\,\gamma_0} = h\nu_0$ (28)

Applying (25) in (28),

$\frac{h\nu_0}{E} = 2i + 2j$ (29)

in (29),

$\frac{0}{E_g} = j(2c + 2) \approx 2cj$ (30)

Therefore, the number of gravitational particles *j* minimum to produce magnetic field $\vec{B}$ values, $j = \frac{h\nu_0}{2cE_g}$ (31)

You have to remember that,

$E_g = m_g c^2$ (32)

If we use the expression (32) in (31), the minimum values of *j* and *i* are definitively obtained to generate the fields $\vec{B}$ and $\vec{E}$, respectively,

$j = \frac{h\nu_0}{2c^3 m_g}$ (33)

$i = \frac{h\nu_0}{2c^2 m_g}$ (34)

Both for $\forall\nu_0$ detectable. If we now use in (33) and (34) the approximation given by [6] whereby $m_g = 1.909.10^{-69}Kg$, we obtain,

$j = 64.41.10^8\nu_0$ (35)

$i = 19.31.10^{17}\nu_0$ (36)

Note that the value of the minimum number of gravitons *j* required for the internal contribution of magnetic field $\vec{B}$ for each photon differs greatly from the only two gravitons proposed by the authors of the subquantum theory in [1].

3. On Graviton-Photon Relationship

Assuming a photon γ interacting with gravitons in a vacuum, that is, the photon moving in an environment of non-material gravitons. According to [1], "*two types of gravitons enter the internal structure of the photon* γ, *modifying the intensity of the carrier fields* $\vec{E}$ *and* $\vec{B}$, *without effect of charge change*".

The influence of the gravitons in the electric field $\vec{E}(\vec{r}, t)$ of the photon γ must be described as $\vec{G}_E(\vec{r}, t)$, giving rise to the field input $\vec{E}_g(\vec{r},t)$, that is to say,

$$\vec{G}_E = \vec{G}_E(\vec{r},t) \equiv i \quad \vec{G}^{+}(\vec{r},t), \vec{G}^{-}(\vec{r},t) \quad \to \vec{E}_g(\vec{r},t) \tag{37}$$

On the other hand, in a similar way, the influence of the gravitons in the magnetic field $\vec{B}(\vec{r},t)$ of the photon must be described as $\vec{G}_B(\vec{r},t)$, giving rise to the contribution of field $\vec{B}_g(\vec{r},t)$, that is,

$$\vec{G}_B = \vec{G}_B(\vec{r},t) \equiv j \quad \vec{G}_m^{+}(\vec{r},t), \vec{G}_m^{-}(\vec{r},t) \quad \to \vec{B}_g(\vec{r},t) \tag{38}$$

The total graviton flow $\vec{G}(\vec{r},t)$ in the considered environment can then be described altogether in terms of the contribution on the photon γ as,

$$\vec{G} = \vec{G}(\vec{r},t) \equiv \begin{matrix} \vec{G}_E \\ \vec{G}_B \end{matrix} = \begin{matrix} i\vec{G}^{+} & i\vec{G}^{-} \\ j\vec{G}_m^{+} & j\vec{G}_m^{-} \end{matrix} \tag{39}$$

Note: When speaking of gravitons flow here, we must understand it as a certain discrete amount of gravitons. The flow of gravitons is not considered normalized to a surface, as is usual when speaking of flow of a certain vector parameter.

As in classical electrodynamics, it is considered that changes in the fields $\vec{B}$ and $\vec{E}$ produce rotational circulation of the fields $\vec{E}$ and $\vec{B}$ themselves, respectively, as indicated by (5) and (9), in [1] the authors propose that changes over time in the flow of gravitons $\vec{G}_E$ and $\vec{G}_B$ generate additional rotational circulation without change of charge inside the considered photon , of values $\vec{E}_g$ and $\vec{B}_g$, respectively. So,

$$\vec{\nabla} \mathrm{x} \vec{E}_g = \frac{\partial \vec{G}_E}{\partial t} \tag{40}$$

Equation (40) represents the interaction formal description of the gravitational field $\vec{G}_E$ with the photon γ considered in the form of field $\vec{E}_g$.

Observe the necessary sign change proposed in (40), with respect to the similar equation posed by [1] for the rotational of the field $\vec{E}_g$ that goes with a negative sign. The aim is to find compatibility between the classical electrodynamics equations that relate $\vec{E}_g$ and $\vec{B}_g$, with the equations that will be proposed as the interrelation of the fields $\vec{G}_E$ and $\vec{G}_B$.

In addition, the relation between the gravitons flow of type $\vec{G}_B$ and the field $\vec{B}_g$ generated by them on the photon γ must be,

$$\vec{\nabla} \mathrm{x} \vec{B}_g = -\frac{\partial \vec{G}_B}{\partial t} \tag{41}$$

The relationship between the fields $\vec{E}_g$ and $\vec{B}_g$ generated by the gravitational interaction can be described using (9), such that,

$$\vec{\nabla} \mathrm{x} \vec{E}_g = -\frac{\partial \vec{B}_g}{\partial t} \tag{42}$$

Comparing (40) with (42) it is concluded that,

$$\vec{G}_E = -\vec{B}_g \tag{43}$$

On the other hand, if (5) is used applied with respect to the fields $\vec{E}_g$ and $\vec{B}_g$ generated without additional electric current circulation [1], such that,

$$\vec{\nabla} \mathrm{x} \vec{B}_g = \mu_0 \epsilon_0 \frac{\partial \vec{E}_g}{\partial t} \tag{44}$$

Then, compared (41) with (44) the following is obtained,

$$\vec{G}_B = -\mu_0 \epsilon_0 \vec{E}_g \tag{45}$$

Using (7) for the vacuum in (45), we get the relation,

$$\vec{E}_g = -c^2 \vec{G}_B \tag{46}$$

Taking into account in (19) the relation between $\vec{E}$ and $\vec{B}$ on the photon γ, when incorporating the changes in the electric and magnetic fields $\vec{E}_g$ and $\vec{B}_g$ according to (42), one has to,

$$\vec{E}_g = \vec{c} \mathrm{x} \vec{B}_g \quad \text{with} \quad |\vec{E}_g| = c|\vec{B}_g| \tag{47}$$

Thus, applying (47) in (46), it turns out that,

$$\vec{c} \mathrm{x} \vec{B}_g = -c^2 \vec{G}_B \tag{48}$$

That is to say,

$$\vec{B}_g = \vec{c} \mathrm{x} \vec{G}_B \quad \text{with} \quad |\vec{B}_g| = c|\vec{G}_B| \tag{49}$$

And using the equality of (43) in (49) is obtained,

$\vec{G}_E = -(\vec{c}x\vec{G}_B)$ or $\vec{G}_E = \vec{G}_B x\vec{c}$ (50)

Applying (43) in (48), equation (50) can also be put as,

$\vec{c}x\vec{G}_E = c^2\vec{G}_B$ (51)

Also, incorporating (43) in (47), it can be stated that,

$\vec{E}_g = \vec{G}_E x\vec{c}$ (52)

Note that if we incorporate the relationship given in (46) in (40), we obtain the following differential equation that relates the gravitational fields $\vec{G}_E$ and $\vec{G}_B$,

$c^2\vec{\nabla}x\vec{G}_B = -\frac{\partial\vec{G}_E}{\partial t}$ or $\vec{\nabla}x\vec{G}_B = -\mu_0\epsilon_0\frac{\partial\vec{G}_E}{\partial t}$ (53)

Assuming that $\vec{G}_E$ and $\vec{G}_B$ are of the type $\vec{G}_E(\vec{r},t)$ and $\vec{G}_B(\vec{r},t)$, respectively, where both fields are described in the form of waves given by,

$\vec{G}_E \equiv \vec{G}_E(\vec{r},t) = \vec{G}_{E0}e^{i(\vec{K}\vec{r}-\omega t)}$ (54)

$\vec{G}_B \equiv \vec{G}_B(\vec{r},t) = \vec{G}_{B0}e^{i(\vec{K}\vec{r}-\omega t)}$ (55)

Where $\vec{G}_{E0}$ and $\vec{G}_{B0}$ are the maximum vector amplitudes of $\vec{G}_E$ and $\vec{G}_B$, respectively. It will be shown that (53) developed in terms of (54) and (55) equals (50). For this, we see that, $\vec{\nabla}x\vec{G}_B = i\vec{K}x\vec{G}_{B0}e^{i(\vec{K}\vec{r}-\omega t)}$ (56)

$\frac{\partial\vec{G}_E}{\partial t} = -i\omega x\vec{G}_{E0}e^{i(\vec{K}\vec{r}-\omega t)}$ (57)

If (56) is multiplied by c^2 and equals $-\frac{\partial\vec{G}_E}{\partial t}$ according to the value obtained in (57), simplifying,

$c^2 \ \vec{K}x\vec{G}_{B0} = -\omega\vec{G}_{E0}$ (58)

Applying (4) for the vacuum in (58),

$c^2\frac{w}{\vec{c}}x\vec{G}_{B0} = -\omega\vec{G}_{E0}$ (59)

And, simplifying (59), it turns out that,

$\vec{c}x\vec{G}_{B0} = -\vec{G}_{E0}$ (60)

And, therefore, (60) is equal to (50), as we wanted to demonstrate.

On the other hand, if we apply (43) in (41), we obtain a second relation between $\vec{G}_E$ and $\vec{G}_B$,

$\vec{\nabla}x\vec{G}_E = \frac{\partial\vec{G}_B}{\partial t}$ (61)

In conclusion, (40) tells you that the gravitons in the form of $\vec{G}_E$ cause a rotational circulation of electric field $\vec{E}$ of value $\vec{E}_g$. This rotational on $\vec{E}_g$ represents a change in $\vec{E}$ that induces a rotational circulation in $\vec{B}$ of value $\vec{B}_g$ defined by (44). A change in $\vec{G}_E$(51) also causes the subquantum gravitons $\vec{G}_B$ to enter the structure of the photon □. This incorporation of $\vec{G}_B$ causes a rotational circulation of magnetic field $\vec{B}$ with value $\vec{B}_g$ (41). A change in $\vec{G}_B$(61) also causes the subquantum gravitons $\vec{G}_E$ to continue entering the structure of the photon □.

Also, if we apply (43) in (8) and (46) in (2), respectively, we get,

$\vec{\nabla}.\vec{G}_E = 0$ (62) $\vec{\nabla}.G_B = -\mu_0\rho$ → in a vacuum or, $\vec{\nabla}.G_B = -\mu\rho$ in a material medium (63) Note that $\vec{G}_E$, $\vec{G}_B$, $\vec{G}$ and their subelements ($\vec{G}^+$, $\vec{G}^-$, $\vec{G}_m^+$, $\vec{G}_m^-$) must be parameters described in terms of vector fields, when relating them to traditional fields $\vec{E}$ and $\vec{B}$. That is to say, they are going to be treated in all cases as vector magnitudes of gravitational fields. The characteristic module of each of these vectors (magnitude) represents a certain number of gravitons for $\vec{G}_E$, $\vec{G}_B$ and $\vec{G}$, while for the subelements $\vec{G}^+$, $\vec{G}^-$, $\vec{G}_m^+$, $\vec{G}_m^-$, each one is a single graviton.

4. On Graviton-Photon Relationship without Photons

The authors in [1] propose that even in the absence of photons in a vacuum, the proper interaction between gravitons, generating changes over time in the field $\vec{G}$ (39), can produce a rotational circulation of $\vec{G}_E$, sufficient for the acquisition of electric field of value $\vec{E}_g$ and, subsequent magnetic field by induction of $\vec{B}_g$ or through $\vec{G}_B$. That is, they formally propose,

$\vec{\nabla}x\vec{G}_E = -\frac{\partial\vec{G}}{\partial t} \Rightarrow Electromagnetic\ Energy$ (64)

And, definitively, that

$$Gravitational\ Energy \Leftrightarrow ElectroMagnetic\ Energy \quad (65)$$

In this sense, electromagnetic energy and gravitational energy are two manifestations of the same physical entity.

However, according to the results of the previous section, it seems more reasonable to state that,

$$\vec{\nabla} \text{x} \vec{G}\,' = -\frac{\partial \vec{G}}{\partial t} \quad \text{with} \quad \vec{G} = \begin{bmatrix} \vec{G}_E \\ \vec{G}_B \end{bmatrix} \quad \text{and} \quad \vec{G}' = \begin{bmatrix} c^2\vec{G}_B \\ -\vec{G}_E \end{bmatrix} \quad (66)$$

That is, any change in the fields $\vec{G}_E$ or $\vec{G}_B$ induces rotational circulation of $\vec{G}_B$ or $\vec{G}_E$, respectively. With such rotational circulations, it is sufficient to generate electric $\vec{E}_g$ and magnetic $\vec{B}_g$ fields, overall representation of the photon. Therefore, it is true that the exclusive interaction between gravitons in an environment without photons can lead to the manifestation of photons, based on the composition of the electric $\vec{E}_g$ and magnetic $\vec{B}_g$ fields, but not in the way proposed by [1] according to (64), but rather as in (66).

On the other hand, considering (37) and (38) applied on (50), we obtain,

$$-i[\vec{G}^+, \vec{G}^-] = \vec{c}\text{x}j[\vec{G}_m^+, \vec{G}_m^-] \quad (67)$$

That is to say,

$$-i\vec{G}^+ = \vec{c}\text{x}j\vec{G}_m^+ \quad (68)$$

$$-i\vec{G}^- = \vec{c}\text{x}j\vec{G}_m^- \quad (69)$$

Applying (24) in (68) and (69), we have to,

$$\left|-i\vec{G}^+\right| = \left|\frac{i}{j}j\vec{G}_m^+\right| \quad (70)$$

$$\left|-i\vec{G}^-\right| = \left|\frac{i}{j}j\vec{G}_m^-\right| \quad (71)$$

Simplifying (70) and (71) result in,

$$\left|\vec{G}^+\right| = \left|\vec{G}_m^+\right| \quad (72)$$

$$\left|\vec{G}^-\right| = \left|\vec{G}_m^-\right| \quad (73)$$

And therefore,

$$\left|\vec{G}^+\right| + \left|\vec{G}^-\right| = \left|\vec{G}_m^+\right| + \left|\vec{G}_m^-\right| \quad (74)$$

That is,

$$\frac{|\vec{G}_E|}{i} = \frac{|\vec{G}_B|}{j} \quad (75)$$

The results obtained in (72), (73), (74) and (75) indicate the elementarity of the vector magnitudes $\vec{G}^+$, $\vec{G}^-$, $\vec{G}_m^+$, $\vec{G}_m^-$. That is to say, in the four cases above, it is about the manifestation of the gravitational field produced by a single graviton in four different ways.

5. On Graviton-Photon Relationship in a Material Medium

The above subquantum electro-gravitodynamics, descriptive of the graviton-photon relationship, is for non-material environments, that is, in a vacuum, where the propagation speed of the fields is $\vec{c}$. The concepts of electrodynamics in a material medium will be transferred to those of subquantum electro-gravitodynamics in order to achieve an extension in material medium, where propagation speed of fields is $\vec{s}$, as it is defined in (4).

So, to begin with, the gravitational fields $\vec{G}_D$ and $\vec{G}_H$ are defined as,

$$\vec{G}_D = \epsilon\vec{G}_E \quad (76)$$

$$\vec{G}_H = \frac{\vec{G}_B}{\mu} \quad (77)$$

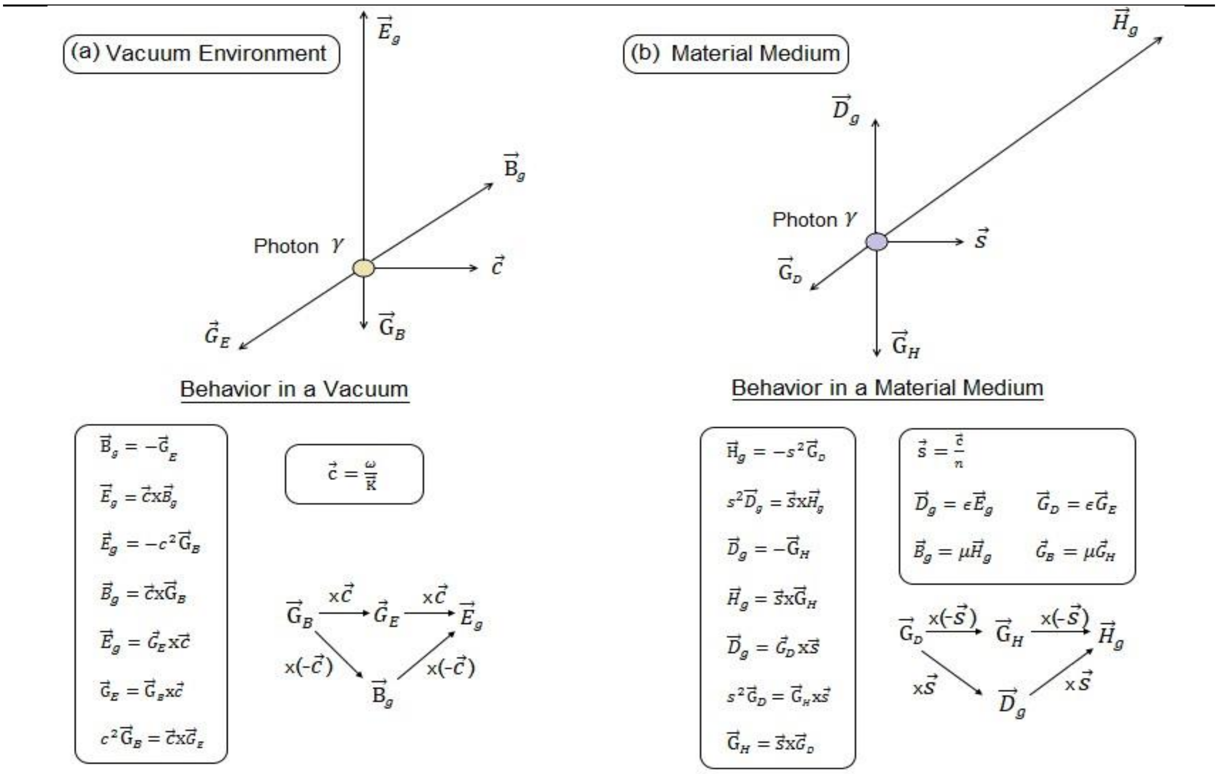

Figure 1 | Subquantum Electro-Gravitodynamics: Vectorial representation and formalism of electric, magnetic and gravitational fields interrelation, (a) in a vacuum and (b) in a material medium

Using (43) for a material medium, it can be put as,

$$-\frac{\vec{B}_g}{\mu}\mu = \frac{1}{\epsilon}\epsilon\vec{G}_E \tag{78}$$

And, using $\vec{H}_g$ and $\vec{G}_D$ according to the definitions given in (5) and (76), respectively, on (78) and applying (7), we obtain,

$$\vec{H}_g = -s^2\vec{G}_D \tag{79}$$

Using (46) for a material medium, we obtain,

$$\mu\epsilon\vec{E}_g = -\vec{G}_B \quad \Rightarrow \quad \epsilon\vec{E}_g = -\frac{\vec{G}_B}{\mu} \tag{80}$$

And, therefore, applying (2) and (77) in (80),

$$\vec{D}_g = -\vec{G}_H \tag{81}$$

Using (47) in a material medium, we have to,

$$\frac{1}{\epsilon}\epsilon\vec{E}_g = \vec{s}\text{x}\frac{\vec{B}_g}{\mu}\mu \tag{82}$$

Applying (2), (5) and (7) in (82), is achieved,

$$s^2\vec{D}_g = \vec{s}\text{x}\vec{H}_g \tag{83}$$

Using (49) in a material medium, we will obtain that,

$$\frac{\vec{B}_g}{\mu} = \vec{s}\text{x}\frac{\vec{G}_B}{\mu} \tag{84}$$

Thus, by applying (5) and (77) in (84), we obtain,

$$\vec{H}_g = \vec{s}\text{x}\vec{G}_H \tag{85}$$

Using (50) for a material medium, we obtain,

$$\frac{1}{\epsilon}\epsilon\vec{G}_E = \mu\frac{\vec{G}_B}{\mu}\text{x}\vec{s} \tag{86}$$

And, using (76) and (77) in (86),

$$s^2\vec{G}_D = \vec{G}_H\text{x}\vec{s} \tag{87}$$

Using (51) for a material medium, we have to,

$$\frac{\vec{G}_B}{\mu} = \vec{s}\text{x}\epsilon\vec{G}_E \tag{88}$$

And, using (76) and (77) in (88), it is achieved,

$$\vec{G}_H = \vec{s}\mathrm{x}\vec{G}_D \quad (89)$$

Using (52) for a material medium,

$$\epsilon\vec{E}_g = \epsilon\vec{G}_E\mathrm{x}\vec{s} \quad (90)$$

Therefore, applying (2) and (76) in (90),

$$\vec{D}_g = \vec{G}_D\mathrm{x}\vec{s} \quad (91)$$

6. Subquantum Electro-Gravitodinamics

Figure 1 graphically proposes a vector description of the fields that accompany the photon in a vacuum environment or in a material medium, with the presence of gravitons. In addition, the vectorial equations that represent the behavior of the photon and their fields in each environment, vacuum and material medium, are indicated too as scheme of the subquantum electro-gravitodynamics developed.

Table 1 presents a formal summary of subquantum electro-gravitodynamics defined by the possible interrelations between electric, magnetic and gravitational fields in a vacuum environment.

Table 2 presents a second formal summary of subquantum electro-gravitodynamics defined by the possible interrelations between electric, magnetic and gravitational fields in a material media.

In both Tables 1 and 2, in each equation, the influence field has been considered as input and the influenced field as output. The equations are expressed in differential and vector format.

Table 1 | Subquantum electro-gravitodynamics formalism in a vacuum

↓Output / Input→	$\vec{E}_g$	$\vec{B}_g$	$\vec{G}_E$	$\vec{G}_B$
$\vec{E}_g$	$\vec{\nabla}.\vec{E}_g = \frac{\rho}{\epsilon_0}$	$\vec{\nabla}\mathrm{x}\vec{E}_g = -\frac{\partial\vec{B}_g}{\partial t}$ $\vec{E}_g = \vec{c}\mathrm{x}\vec{B}_g$	$\vec{\nabla}\mathrm{x}\vec{E}_g = \frac{\partial\vec{G}_E}{\partial t}$ $\vec{E}_g = \vec{G}_E\mathrm{x}\vec{c}$	$\vec{E}_g = -c^2\vec{G}_B$
$\vec{B}_g$	$\vec{\nabla}\mathrm{x}\vec{B}_g = \mu_0\epsilon_0\frac{\partial\vec{E}_g}{\partial t}$ $B_g = \frac{\mathrm{E}_g\mathrm{x}c}{c^2}$	$\vec{\nabla}.\vec{B}_g = 0$	$\vec{B}_g = -\vec{G}_E$	$\vec{\nabla}\mathrm{x}\vec{B}_g = -\frac{\partial\vec{G}_B}{\partial t}$ $\vec{B}_g = \vec{c}\mathrm{x}\vec{G}_B$
$\vec{G}_E$	$\vec{\nabla}\mathrm{x}\vec{G}_E = -\mu_0\epsilon_0\frac{\partial\vec{E}_g}{\partial t}$ $\mathrm{G}_E = \frac{c\mathrm{x}\mathrm{E}_g}{c^2}$	$\vec{G}_E = -\vec{B}_g$	$\vec{\nabla}.\vec{G}_E = 0$	$\vec{\nabla}\mathrm{x}\vec{G}_E = \frac{\partial\vec{G}_B}{\partial t}$ $\vec{G}_E = \vec{G}_B\mathrm{x}\vec{c}$
$\vec{G}_B$	$\vec{G}_B = -\mu_0\epsilon_0\vec{E}_g$	$\vec{\nabla}\mathrm{x}\vec{G}_B = \mu_0\epsilon_0\frac{\partial\vec{B}_g}{\partial t}$ $\mathrm{G}_B = \frac{\mathrm{B}_g\mathrm{x}c}{c^2}$	$\vec{\nabla}\mathrm{x}\vec{G}_B = -\mu_0\epsilon_0\frac{\partial\vec{G}_E}{\partial t}$ $\mathrm{G}_B = \frac{c\mathrm{x}\mathrm{G}_E}{c^2}$	$\vec{\nabla}.\vec{G}_B = -\mu_0\rho$

Table 2 | Subquantum electro-gravitodynamics formalism in a material medium

↓Output / Input→	$\vec{D}_g$	$\vec{H}_g$	$\vec{G}_D$	$\vec{G}_H$
$\vec{D}_g$	$\vec{\nabla}.\vec{D}_g = \rho$	$\vec{\nabla}\mathrm{x}\vec{D}_g = -\mu\epsilon\frac{\partial\vec{H}_g}{\partial t}$ $D_g = \frac{s\mathrm{x}H_g}{s^2}$	$\vec{\nabla}\mathrm{x}\vec{D}_g = \frac{\partial\vec{G}_D}{\partial t}$ $\vec{D}_g = \vec{G}_D\mathrm{x}\vec{s}$	$\vec{D}_g = -\vec{G}_H$
$\vec{H}_g$	$\vec{\nabla}\mathrm{x}\vec{H}_g = \frac{\partial\vec{D}_g}{\partial t}$ $\vec{H}_g = \vec{D}_g\mathrm{x}\vec{s}$	$\vec{\nabla}.\vec{H}_g = 0$	$\vec{H}_g = -\vec{G}_D s^2$	$\vec{\nabla}\mathrm{x}\vec{H}_g = -\frac{\partial\vec{G}_H}{\partial t}$ $\vec{H}_g = \vec{s}\mathrm{x}\vec{G}_H$
$\vec{G}_D$	$\vec{\nabla}\mathrm{x}\vec{G}_D = -\mu\epsilon\frac{\partial\vec{D}_g}{\partial t}$ $\mathrm{G}_D = \frac{s\mathrm{x}\mathrm{D}_g}{s^2}$	$\vec{G}_D = -\frac{\vec{H}_g}{s^2}$	$\vec{\nabla}.\vec{G}_D = 0$	$\vec{\nabla}\mathrm{x}\vec{G}_D = \mu\epsilon\frac{\partial\vec{G}_H}{\partial t}$ $G_D = \frac{G_H\mathrm{x}s}{s^2}$
$\vec{G}_H$	$\vec{G}_H = -\vec{D}_g$	$\vec{\nabla}\mathrm{x}\vec{G}_H = \mu\epsilon\frac{\partial\vec{H}_g}{\partial t}$ $\mathrm{G}_H = \frac{\mathrm{H}_g\mathrm{x}s}{s^2}$	$\vec{\nabla}\mathrm{x}\vec{G}_H = -\frac{\partial\vec{G}_D}{\partial t}$ $\vec{G}_H = \vec{s}\mathrm{x}\vec{G}_D$	$\vec{\nabla}.\vec{G}_H = -\rho$

VII. Conclusions

Traditionally, the study of electromagnetic fields has been carried out without taking into account the inevitable presence of gravitational fields. Graviton and photon are the mediating particles of the gravitational and electromagnetic interaction, respectively, in principle independent of each other. However, comparing both particles, it is observed that they have the same physical behavior in terms of:
They can be classified as NRP (Non Rest Particles), that is, they only exist by traveling at the speed of light. They have infinite capacity for influence (range) with respect to the interaction in which they mediate, whose intensities are proportional to $\frac{1}{r^2}$.

On the other hand, it is known that electromagnetic radiation moves to blue (blueshifted) or red (redshifted) when it falls or leaves, respectively, a gravitational field [11], which is indicative of the influence of gravitational interaction on the electromagnetic fields. Therefore, taking into account the compatibility of characteristics between graviton and photon, in addition to the relationship of influence between their interactions, it seems reasonable to think that gravitons as gravitational field carriers, can influence the internal structure of the photon, varying the electric $\vec{E}$ and magnetic $\vec{B}$ fields that it carries. Since the photon is electrically neutral, so that the fields $\vec{E}$ and $\vec{B}$ are affected by the surrounding gravitons, they must carry subquantum influence of electric charge, on the one hand, and influence of magnetic color, on the other, but that leave the photon after its intervention also in neutral state.

Considering the graviton as a particle with mass $m_g=1.909.10^{-69}Kg$, it is estimated that $64.41.10^8 \nu_0$ and $19.31.10^{17} \nu_0$ gravitons are necessary to generate the magnetic fields $\vec{B}$ and electric fields $\vec{E}$, respectively, to obtain a photon of minimum energy at the frequency ν_0.

A flow of gravitons $\vec{G}$, understood as a certain discrete quantity of gravitons, when entering the internal structure of a photon, influences the fields $\vec{E}$ and $\vec{B}$ of it, in the form of gravitational fields $\vec{G}_E$ and $\vec{G}_B$ in a vacuum, respectively. The field $\vec{G}_E$ provides electrical influence from the gravitons of type $\vec{G}^+$and $\vec{G}^-$, while the field $\vec{G}_B$ incorporates changes of magnetic color from the gravitons $\vec{G}_m^+$ and $\vec{G}_m^-$.

Just as Maxwell's equations describe the relationship between fields $\vec{E}$ and $\vec{B}$ in classical electrodynamics, the consideration of the fields $\vec{G}_E$ and $\vec{G}_B$ in a vacuum as an influence in the fields $\vec{E}$ and $\vec{B}$ allows us to propose new equations that relate gravitational fields with electromagnetic fields. In addition, it is possible to describe formal relationships between the gravitational fields $\vec{G}_E$ and $\vec{G}_B$ in a vacuum. In short, with this approach, we obtain a set of descriptive equations of the graviton-photon interrelations, named here as "electro-gravitodynamics", applicable both in a vacuum and, with the appropriate considerations, in any material medium too.

The electro-gravitodynamics study performed in terms of fields, incorporates not only the interrelation and influence between gravitational fields and electric and magnetic fields, but also, the proper relationship between gravitational fields, thus justifying the possibility of generating photons from the interaction exclusive among gravitons.

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