THE EMG THEORY OF THE PHOTON

by
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Abstract

Maxwell's equations represent a symbol of elegance and perfection. However in this work, we will demonstrate that they are incomplete and because of that, they violate the principle of conservation of energy. By adding two equations in accordance with classical mechanics, the unacceptable violation disappears and in consequence several unexpected and important situations come into view, opening new possibilities in theoretic and experimental physics. Among other things, new explanations are presented for some relativistic and quantum facts and the possible emergence of a graviton from destructive interference of two collinear photons is postulated.

Introduction

Most of the results and propositions presented in this work were already obtained by 1992, and published for the first time in Spanish by the Academy of Sciences of the Dominican Republic (1). Maxwell's equations not only represent the first unification of two important physical interactions (electricity and magnetism), but also constitute a true symbol of elegance, which have been almost untouchable since the moment they were presented to the scientific community. We just have to remember Max Planck's reaction when Einstein presented his explanation for the photoelectric effect. He practically apologized for the introduction of his quantum theory in view of its controversial consequences regarding Maxwell's theory of electromagnetism (2).

Today, if any person intents to point out an imperfection in Maxwell's equations, many scientific authorities will disregard such a pretension without even reading nor listening to the arguments relevant to it. However, this work exposes situations that we feel cannot be passed by. It would seem absurd to state that Maxwell's equations violate the principle of conservation of energy, but in view of the following analysis, it is surprising that no one has yet pointed it out.

This does not mean that there is any incorrectness in its mathematical structure, but that those equations are incomplete for the description of the phenomenon of electromagnetic dynamics. By adding two other equations, the apparent violation disappears. And consequently, with the application of some unsophisticated and simple classical physics equations, with logical reasoning, we arrive at very interesting results. With the purpose of simplicity and to take the advantage of having this approach accessible for discussion with colleagues with different backgrounds and perspectives, we have decided to keep a simple mathematical level throughout the work.

Two Instances in Which the Classical Electromagnetic Theory of Light Violates the Principle of Conservation of Energy

In this section we will introduce two examples where the violation of the principle of conservation of energy happens in Maxwell's electromagnetic theory, i.e.: a) It predicts an **oscillating energy** with predictable oscillation for the electromagnetic wave, and b) On destructive interference **the energy carried by the wave disappears**.

Oscillating Energy

For the present (classical) theory, the wave traveling at constant speed **C** has two orthogonal components perpendicular to the propagation path. These components (one electric and the other magnetic) oscillate in phase, as follows (we use the simple classical Real Solution form for the sake of simplicity in our discussion so that it may be understood by non specialists):

1) $E = E_o \sin(kx - \omega t)$

2) $B = B_o \sin(kx - \omega t)$

Where **E** and **B** stand for the intensity oft the electric and magnetic fields, respectively, while **x** and **t** are the position and time variables, respectively. **k** and ω represent the phase factor and the frequency of the wave, respectively.

The instantaneous energy per unit volume (Energy density) of the wave is the sum of the energy densities contained in the magnetic and the electric fields:

3) $\mathcal{E}_E = \frac{1}{2} \varepsilon_o E^2 \qquad \mathcal{E}_B = \frac{1}{2} B^2/\mu_o$

4) $\mathcal{E} = \mathcal{E}_E + \mathcal{E}_B = \frac{1}{2} (\varepsilon_o E_o^2 \_ \; B_o^2/\mu_o) \sin^2(kx - \omega t)$

5) $\mathcal{E} = \mathcal{E}_o \sin^2(kx - \omega t)$

Where, $\mathcal{E}$ is the energy density traveling with the wave in the electric and magnetic fields.

Equation **5)** describes an energy density that fluctuates in both the time and space coordinates. It does so in such a way that at certain moment there is no energy while at a **predictable** later moment the energy density is maximal, with a continuous variation from zero energy to a maximum. Because the moments and the positions are perfectly known, it is not possible to use the uncertainty principle to explain the energy fluctuations. Nor can it be explained in terms of variations of the energy density with constant total energy, because this presupposition implies that the volume of the photon (see section on the volume of the photon) varies with the oscillation from zero to infinity, nor by saying that the energy balance has to be taken in a volume that encompasses an integer number of whole cycles of the wave. Therefore the system behaves as if it had an **energy reservoir** (outside of this world?) from which it can extract and pour in energy. This assertion is incompatible with the principle of conservation of energy.

Destructive Interference

Let us now take two electromagnetic waves, collinear, but out of phase by 180°:

6) $E_1 = E_o \sin(kx - \omega t) \qquad E_2 = E_o \sin(kx - \omega t + \pi)$

7) $B_1 = B_o \sin(kx - \omega t) \qquad B_2 = B_o \sin(kx - \omega t + \pi)$

These two waves will produce an interference pattern defined by the sum wave:

8) $E = E_2 + E_2$ and $B = B_1 + B_2$

9) $E = E_o[\sin(kx - \omega t) + \sin(kx - \omega t + \pi)]$

10) $B = B_o[\sin(kx - \omega t) + \sin(kx - \omega t + \pi)]$

But, $\sin(kx - \omega t + \pi) = -\sin(kx - \omega t)$, then:

11) $E = E_o \times 0 = 0$

12) $B = B_o \times 0 = 0$

Thus,

$$\mathcal{E} = \mathcal{E}_1 + \mathcal{E}_2 = 0 \quad \textbf{13)}$$

But, $\varepsilon_1 \neq$ **0** and $\varepsilon_2 \neq$ **0,** in virtue of the fact that ε_1 and ε_2 are not constant, but oscillate, neither are they null. This leads us to the conclusion that the energy stored in each separate wave is destroyed in this form of interference, which again contradicts the principle of conservation of energy. The destruction of the wave has been experimentally observed, but this should not imply the destruction of the energy, because the conservation principle would be violated. Where does the energy go? None of the present day theories gives a satisfactory answer to this question, again it seems as if the energy is poured into a "reservoir" (outside this physical world). What kind of reservoir is this? In the following pages we analyze a possible answer to this question.

Another Induction Vector (Component X) is Required in Order to Keep the Energy Constant in the Induction Process

If the energy is to be conserved, there must exists another component **X** in the wave, oscillating out of phase with respect to the pair **(E,B)**, in such a way that when **(E,B)** is maximum (positive or negative), the value of **X** is zero, and vice versa, when **(E,B)** is zero, **X** is maximum. Furthermore, the energy must be continuously stored and distributed between these three components, "pouring" from one field to the other, but always constant: $\varepsilon_T = \varepsilon_E + \varepsilon_B + \varepsilon_X$. This new component must be co-induced with the electromagnetic field, and must have the capacity of storing energy, but with the peculiarity of being induced with an asymmetric oscillation (between zero and a positive maximum). This new member of the electromagnetic induction is necessary in order not to violate the principle of conservation of energy, and has not been conceived as an integral part of the photon up until now. This new member **(X)** must be one of the representative fields of the various interactions of matter. Since it travels with the electromagnetic wave, we can presume that it belongs to the long-range interactions. Because of these characteristics our best candidate is a gravitational field.

It is well known that the **(E,B)** pair in the wave oscillates perpendicular to the propagation axis, that is, this wave is a transversal one. This type of waves cannot transmit momentum in the direction of propagation, like the sea waves, but it is a well-known fact that the electromagnetic wave does transmit momentum in the direction of propagation, as is the case in the Compton effect and other phenomena (3), which indicates that this wave must contain a longitudinal component that is perpendicular to the **(E,B)** plane and oscillates in the direction of propagation. So this other **X** component oscillates longitudinally, and it must be responsible for the transmission of momentum in the propagation direction.

Let us investigate this possibility further.

Behavior of an Electromagnetic Wave as it passes through electrical, magnetic and gravitational fields

To investigate the possibility that an oscillating gravitational field is associated to the electromagnetic wave (EM), let us review the behavior of an EM wave as it goes through the following fields.

Passage Through an Electric Field

In view of its nature, on passing through an external electric field the wave will be affected, but if this external field is homogeneous, the wave will not be in the average affected, because as it comes out of the external field it will still have its original direction, as if no field existed (this is true in the case that the length of the path across the field happens to be an integer multiple of the wavelength). This behavior is due to the symmetrical oscillation of the electric field of the wave. The effects of the passage through a stretch ½λ long are canceled by the next ½λ stretch in the path, thus producing a sinusoidal path with oscillation parallel to the external electric field; this path will average to the same path with no external electric field.

Passage Through a Magnetic Field

The behavior of the wave as it passes through an external magnetic field is identical to the passage through an electric field. Both the electric and the magnetic external fields simultaneously affect the path of the wave, each perpendicular to the order, both effects superimpose and due to the symmetry of the oscillation of the magnetic field the average effects is null.

Passage Through a Gravitational Field

On passing through a gravitational field many effects, related to the wave's path and the lines of force of the field are observed. If these two are not collinear the path is curved. In the other hand, a change in frequency, corresponding to a change in the amount of energy transported by the wave, is observed. The theory of relativity predicts both effects (4), but we will see below that the theory of relativity is not absolutely necessary to explain this observed natural phenomenon.

Let us see how the application of classical mechanics allows for the explanation of these phenomena. In classical mechanics any physical interaction can be interpreted with the force equations:

$$\textbf{14)} \qquad \mathbf{F} = \nabla\varepsilon \qquad \text{and} \qquad \mathbf{F} = d\mathbf{P}/dt$$

Where, ε and **P** are the energy and momentum of the particle, respectively.
For the photon:

$$\textbf{15)} \qquad \varepsilon = h\nu \qquad \text{and} \qquad \mathbf{P} = m\mathbf{C}$$

Where, ν is the frequency and **m** is the equivalent mass of the photon (**C** is the speed of light). If the photon interacts with a gravitational field, this interaction must express itself as a force. This implies a change in inertia, which will be manifested in a change of the path of the photon. It could be argued that the photon does not accelerate in vacuum, but a change in direction is acceleration even with a constant celerity (as in circular motion). Furthermore, as we will see below, the acceleration can be also only in the time domain:

$$\textbf{16)} \qquad \mathbf{F} = \nabla\varepsilon = \nabla(h\nu) = h\nabla\nu \qquad \Rightarrow \qquad \mathbf{F} = h\nabla\nu$$

This takes us to the conclusion that if a force acts upon a photon, it will induce in it a frequency gradient that is positive (violet shift) if the force and the displacement are in the same direction, and negative (red shift) if they are in opposite direction, which is precisely what is observed. The theory of relativity also arrives at the same conclusion (4). The nature of this interaction must allow the exact calculation of the values of these shifts. According to the theory o relativity, this change in frequency is due to the warping of space-time by the gravitational field of massive bodies (5), but, as we can see in equation 16), our interpretation is quite different, we believe that the force exerted upon the photon by the field induces a gain or a loss of energy, which will be reflected on its frequency. This frequency gradient is nothing but an acceleration of the photon in time, while its celerity remains constant. In other words, the photon does accelerate, but this acceleration is different from that of massive bodies.

According to the theory of relativity, the bending of the photon's trajectory as it passes close to a massive body is produced by the deformation of space due to the presence of the body (5). This explanation rends the photon passive with respect to this sort of interaction. Notice that in this context no interaction is considered between the photon and the gravitational field. However, the mechanism of interaction between the photon and the gravitational field must be explained with concepts in line with the electromagnetic theory, not divorced from it (or any other field theory of the wave). In this way, the coherent convergence of the different theories will be evident.

In the other hand, the force acting on the photon will be reflected in the variation of its momentum:

18) $$F = dP/dt = d(mc)/dt = mdc/dt + cdm/dt$$

But we know that **c** = constant, then:

19) $$dc/dt = 0 \quad \Rightarrow \quad F = cdm/dt$$

Being the spatial celerity of the photon **(c)** constant, its equivalent mass is affected by this force (as a mass acceleration, **dm/dt**). To understand this proposition we only need to express, by means of classical mechanics equations, concepts already introduced by modern physics. There is no mathematical restriction to do so. This way we arrive at two expressions for the dynamics of the photon, which are therefore equal:

20) $$h\nabla\nu = cdm/dt$$

Rearranging,

21) $$\nabla\nu = (c/h)dm/dt$$

This differential equation **21)** describes the dynamics of the photon's ν and **m** properties under the influence of a force. It can be integrated for the boundary conditions of **m = 0** for $\nu = 0$ (since $\nu = 0$, $\varepsilon = 0$ and the equivalent mass must also be zero). For the sake of simplification, let us solve **21)** for the **x** direction.

22) $$\nabla\nu = d\nu/dx \quad \Rightarrow \quad hd\nu/dx = cdm/dt$$

23) $$hd\nu = c(dm/dt)dx = c^2dm \qquad dx/dt = c$$

24) $$hd\nu = c^2dm \quad \Rightarrow \quad \int_0^\nu hd\nu = \int_0^m c^2dm$$

25) $$h\nu = mc^2$$

Replacing,

26) $$h\nu = \varepsilon$$

27) $$\varepsilon = mc^2$$

In conclusion, if a photon interacts through force its energy is related to its equivalent mass by the above stated equation **27).** This is also predicted by the theory of relativity for massive particles (Ref d).

Once it is established that the behavior of the photon in an external gravitational field can be interpreted using classical dynamics, it is pertinent to ask: What kind of mechanism makes this interaction possible? Naturally, we have to conclude that in order for a photon to interact with an external gravitational field it must have associated an intrinsic gravitational field. This photon's gravitational field is precisely the unknown field **X** required to avoid the violation of the principle of conservation of energy during the destruction of the wave. It is important to note that this gravitational field associated with a photon is not associated to an inertial central mass (the photon has none), in the same way that the electric field of the photon is not associated to any electric charge; but this gravitational field is part of a field entity: the photon.

In the following section we discuss the required induction law to account for this interaction and the characteristics of the electromagnetic wave under this **"new light"**.

An EMG Induction Law

If the photon has an associated intrinsic gravitational field, also oscillating, this field must be induced by the electromagnetic oscillation. Generalizing, all electromagnetic inductive processes are also gravitational. Our next task is to find this new law of electromagnetic-gravitational induction that describes the behavior of the photon. In this work we are proposing such a law, which fulfills all the requirements set by the analysis presented above. This new induction law expands the four Maxwell equations with two new equations, thus completing the picture for an **Electromagnetic-gravitational theory (EMG)**. The whole set of equations would be:

28) $$\mathrm{div}\mathbf{E} = \rho_o/\epsilon_o$$

29) $$\mathrm{div}\mathbf{B} = 0$$

30) $$\mathrm{div}\mathbf{g} = -4\pi G\rho_m$$

31) $$\mathrm{curl}\mathbf{B} = \mu_o(\mathbf{j} + \epsilon_o\partial\mathbf{E}/\partial t)$$

32) $$\mathrm{curl}\mathbf{E} = -\partial\mathbf{B}/\partial t$$

33) $$\mathbf{g} = \psi\,\mathrm{curl}\mathbf{B} \wedge \mathrm{curl}\mathbf{E}$$

In view of the fact that **g**, in this case, is an induced field, it is not necessarily associated to a mass, thus it is pertinent to investigate the behavior of the Gauss law for the gravitational field **($\mathrm{div}\mathbf{g} = -4\pi G\rho_m$)** in the EMG induction. This can be attained by taking the divergence of the induced field **g**:

$$\mathrm{div}\mathbf{g} = \mathrm{div}(\psi\,\mathrm{curl}\mathbf{B} \wedge \mathrm{curl}\mathbf{E}) = \psi\,\mathrm{div}(\mathrm{curl}\mathbf{B} \wedge \mathrm{curl}\mathbf{E})$$
$$\mathrm{div}\mathbf{g} = \psi\nabla\bullet[(\nabla\wedge\mathbf{B}) \wedge (\nabla\wedge\mathbf{E})] = \psi\nabla\wedge\mathbf{B} \bullet[\nabla\wedge(\nabla\wedge\mathbf{E})]$$
$$\mathrm{div}\mathbf{g} = \psi\nabla\wedge\mathbf{B} \bullet[\nabla\wedge(-\partial\mathbf{B}/\partial t)] = -\psi\nabla\wedge\mathbf{B} \bullet(\partial\nabla\wedge\mathbf{B}/\partial t)$$

34) $$\mathrm{div}\mathbf{g} = -\psi\nabla\wedge\mathbf{B} \bullet(\partial\nabla\wedge\mathbf{B}/\partial t)$$

Since $\nabla\wedge\mathbf{B}$ and $\partial\nabla\wedge\mathbf{B}/\partial t$ are collinear, **divg** is non-zero for $\nabla\wedge\mathbf{B} \neq \mathbf{0}$ and time dependent. This means that the induced field **g** encloses an induced equivalent mass; this mass is not inertial mass, but the energetically equivalent mass. If we know the amount of energy stored in the field, the mass can be calculated as follow:

35) $$m = \varepsilon/c^2 \qquad \rho_m = e/c^2$$

Where, **e** is the energy per unit volume.

If we now write Maxwell's equations for the vacuum (case of the photon), since in vacuum the charge density is zero, we have **divE = 0**, and the displacement current is **j = 0**. We then have **curlB =** $\mu_o \in_o \partial E/\partial t \neq 0$**,** and **divg =** $-4\pi G\rho_{mp} \neq 0$ (ρ_{mp} is the mass density of the photon).

This result was expected because in order for the photon to have an effective interaction with an external gravitational field, the topology of gravitational field of the photon has to be such that **divg** $\neq$ **0**, i.e. the effects of the field on one region should not cancel out with the effects on other regions. Thus we may write for the photon:

36) $$\mathrm{div}\mathbf{B} = 0$$
37) $$\mathrm{div}\mathbf{E} = 0$$
38) $$\mathrm{div}\mathbf{g} = -4\pi G\rho_{mp}$$
39) $$\mathrm{curl}\mathbf{E} = -\partial \mathbf{B}/\partial t \qquad \mathrm{curl}\mathbf{B} = \mu_o \in_o \partial \mathbf{E}/\partial t$$
40) $$\mathbf{g} = \psi^*(\partial \mathbf{B}/\partial t) \wedge (\partial \mathbf{E}/\partial t) \qquad \psi^* = \mu_o \in_o \psi$$

The Electromagnetic Wave Under a New Light: Electromagnetic–Gravitational (EMG) Wave

From the above mathematical relationships we can arrive to the following three differential equations, which describe the behavior of the EMG wave in vacuum:

41) $$\nabla^2 \mathbf{E} = \mu_o \in_o \partial^2 \mathbf{E}/\partial t^2$$
42) $$\nabla^2 \mathbf{B} = \mu_o \in_o \partial^2 \mathbf{B}/\partial t^2$$
43) $$\mathbf{g} = \psi^*(\partial \mathbf{B}/\partial t) \wedge (\partial \mathbf{E}/\partial t)$$

The two first equations are equivalent to the classic wave equation; the third one is solved by substitution once the solution of the first two is obtained. For the sake of simplification we will analyze only the particular case of one of the coordinate components of the fields. With a wave moving to the right we have:

44) $$E_y = jE_o \sin(kx - \omega t)$$
45) $$B_z = kB_o \sin(kx - \omega t)$$

Substituting, we obtain for **g**:

46) $$g_x = i\psi^* E_o B_o \omega^2 \cos^2(kx - \omega t)$$

Replacing $\mathbf{g_o} = \psi^* E_o B_o \omega^2$, we obtain:

47) $$g_x = ig_o \cos^2(kx - \omega t)$$

This means that the EMG wave has an associated gravitational field oscillating between zero and a positive maximum perpendicularly to the plane defined by **E** and **B**, and in the direction of the displacement of the wave. This oscillation of **g** is out of phase by 90° in such a way that when the **(E, B)** pair is zero, **g** is at maximum, and vice versa. As can be seen, this induction law coincides exactly with the **X** field necessary to complete the EM wave.

Moreover, in order for the **EMG** wave to be satisfactory it must obey the principle of conservation of energy. The energy of the wave is stored now in three different fields:

$$\varepsilon_E = \tfrac{1}{2}\in_o E^2 \qquad \varepsilon_B = \tfrac{1}{2} B^2/\mu_o \qquad \varepsilon_g = \tfrac{1}{2} g^2/G_o$$

$$(G_o = 4\pi G)$$

48) $$\varepsilon_E = \tfrac{1}{2}\in_o E_o^2 \sin^2(kx - \omega t)$$

49) $$\varepsilon_B = \tfrac{1}{2}(B^2/\mu_o)\sin^2(kx - \omega t)$$

50) $$\varepsilon_g = \tfrac{1}{2}(g_o^2/G_o)\cos^4(kx - \omega t)$$

The total energy per unit volume is:

51) $$\varepsilon_T = \varepsilon_E + \varepsilon_B + \varepsilon_g$$

52) $$\varepsilon_T = \tfrac{1}{2}(\in_o E_o^2 + B_o^2/\mu_o)\sin^2(kx - \omega t) + \tfrac{1}{2}(g_o^2/G_o)\cos^4(kx - \omega t)$$

For the sake of simplification let us define the constants **a** and **b**:

$$a = \tfrac{1}{2}(\in_o E_o^2 + B_o^2/\mu_o) \qquad b = \tfrac{1}{2} g_o^2/G_o$$

Then we have:

53) $$\varepsilon_T = a\sin^2(kx - t) + b\cos^4(kx - \omega t)$$

If the wave satisfies the principle of conservation of energy, we have:

54) $$d\varepsilon_T/dt = dx/dt\ \partial\varepsilon_t/\partial x + \partial\varepsilon_t/\partial t = c\partial\varepsilon_t/\partial x + \partial\varepsilon_t/\partial t = 0$$

We may evaluate these terms from the equation of total energy:

55) $$\partial\varepsilon_T/\partial x = 2ak\sin(kx - \omega t)\cos(kx - \omega t) - 4bk\sin(kx - \omega t)\cos^3(kx - \omega t)$$

56) $$\partial\varepsilon_T/\partial t = -2a\omega\sin(kx - \omega t)\cos(kx - \omega t) + 4b\omega\sin(kx - \omega t)\cos^3(kx - \omega t)$$

57) $$d\varepsilon_T/dt = 2a(ck - \omega)\sin(kx - \omega t)\cos(kx - \omega t) + 4b(\omega - ck)\sin(kx - \omega t)\cos^3(kx - \omega t)$$

Given $\mathbf{ck = \omega}$, the terms of the equation cancel each other, which makes $\mathbf{d\varepsilon_T/dt = 0}$. This means that the wave satisfies the principle of conservation of energy. Now, since the EMG wave moves at constant velocity, **x** and **t** are linearly dependent variables (see below topological analysis), therefore when $\mathbf{d\varepsilon_T/dt = 0}$, $\partial\varepsilon_T/\partial x$ and $\partial\varepsilon_T/\partial t$ must be simultaneously zero. On the other hand we can demonstrate the need of this condition by means of the principle of reduction to the *absurdum*:

58) $$d\varepsilon_T/dt = c\partial\varepsilon_T/\partial x + \partial\varepsilon_T/\partial t = 0 \quad \Rightarrow \quad c\partial\varepsilon_T/\partial x = -\partial\varepsilon_T/\partial t$$

59) $$c = -(\partial\varepsilon_T/\partial t)/(\partial\varepsilon_T/\partial x) = -dx/dt$$

But $\mathbf{c = dx/dt}$, which is contradictory. This apparent contradiction can only be solved when $\partial\varepsilon_T/\partial t = 0$ and $\partial\varepsilon_T/\partial x = 0$. Therefore, these conditions must be satisfied for energy conservation, that is:

60) $$\partial\varepsilon_T/\partial t = \partial\varepsilon_T/\partial x = 0$$

61) $$-2a\omega\sin(kx - \omega t)\cos(kx - \omega t) + 4b\omega\sin(kx - \omega t)\cos^3(kx - \omega t) = 0$$

62) $$2ak\sin(kx - \omega t)\cos(kx - \omega t) - 4bk\sin(kx - \omega t)\cos^3(kx - \omega t) = 0$$

These last equations are equivalent since, when we divide the first equation by **-2ωsin(kx - ωt) cos(kx - ωt)** and the second one by **2ksin(kx - ωt)cos(kx - ωt)**, we obtain the same expression:

63) $$a - 2b\cos^2(kx - \omega t) = 0$$

Transposing terms:

64) $$a = 2b\cos^2(kx - \omega t)$$

But **a** and **b** are constant, therefore $\cos^2(kx - \omega t)$ is also constant, and its derivatives must be zero:

65) $$\partial[\cos^2(kx - \omega t)]/\partial t = \partial[\cos^2(kx - \omega t)]/\partial x = 0$$

Also:

66) $$-2k\sin(kx - \omega t)\cos(kx - \omega t) = 2\omega\sin(kx - \omega t)\cos(kx - \omega t) = 0$$

That is:

67) $$\sin(kx - \omega t)\cos(kx - \omega t) = 0$$

This condition is only satisfied when:

68) $$kx - \omega t = n\pi/2$$

This means that the argument $\phi = kx - \omega t$ can only take discrete values. This type of wave will be analyzed further in the section on topological analysis of the wave function **y = sin(kx - ωt)**, with discrete argument and constant velocity.

An interesting aspect of the **EMG** wave resulting from this statement is that the wave-associated fields can only take discrete values in every cycle, as follows (see conclusion):

$$(E_o,0,B_o) \Rightarrow (0,g_o,0) \Rightarrow (-E_o,0,-B_o) \Rightarrow (0,g_o,0) \Rightarrow (E_o,0,B_o)$$
$$\phi_1 \Rightarrow \phi_2 \Rightarrow \phi_3 \Rightarrow \phi_4 \Rightarrow \phi_1$$

From this we infer that the energy passes from the EM field to the gravitational field successively, thus the total energy is either completely electromagnetic or completely gravitational, which makes both equal in magnitude, but not simultaneously. This may be expressed as:

69) $$\varepsilon_{og} = \varepsilon_{oE} + \varepsilon_{oB}$$

From here we can deduce the relationship of the gravitational field with the electric and magnetic fields in the **EMG** wave:

70) $$G_o^2/G_o = \in_o E_o^2 + B_o^2/\mu_o$$

Using the relations:

$E_o = cB_o$ and $C = \dfrac{1}{\sqrt{\varepsilon_0\mu_0}}$

$$c^2B_o^2\in_o + B_o^2/\mu_o = g_o^2/G_o$$
$$B_o^2(c^2\in_o = 1/\mu_o) = g_o^2/G_o$$
$$B_o^2(\mu_o\in_o c^2 + 1)/\mu_o = g_o^2/G_o$$

But,

$$\mu_o\in_o c^2 = 1 \qquad \Rightarrow \qquad 2B_o^2/\mu_o = g_o^2/G_o$$

71) $$g_o = \sqrt{\frac{2G_o}{\mu_o}}B_o$$

Similarly:

$$\in_o E_o^2 + E_o^2/\mu_o c^2 = g_o^2/G_o$$
$$E_o^2(\in_o\mu_o c^2 + 1)/\mu_o c^2 = g_o^2/G_o$$
$$E_o^2(2/1/\in_o) = g_o^2/G_o$$

72) $$g_o = \sqrt{2\in_o G_o}E_o$$

In addition, the intensities of the fields $\mathbf{E_o}$, $\mathbf{B_o}$ and $\mathbf{g_o}$ can be calculated from the frequency of the wave:

$$\varepsilon_P = h\nu$$

Since ε_T is the photon's energy per unit volume:

$$\varepsilon_P = \varepsilon_T V_p \qquad V_P = \text{photo's volume}$$

From here:

$$h\nu = \tfrac{1}{2}(g_o^2/G_o)V_P$$

73) $$g_0 = \sqrt{\frac{2hG_0}{V_P}}\sqrt{\nu}$$

Similarly for the electric and magnetic fields:

$$E_0 = \frac{g_0}{\sqrt{2\varepsilon_0 G_0}} = \sqrt{\frac{2hG_0}{2\varepsilon_0 G_0 V_P}}\sqrt{\nu} = \sqrt{\frac{h}{\varepsilon_0 V_P}}\sqrt{\nu}$$

74) $$E_0 = \sqrt{\frac{h}{\varepsilon_0 V_P}}\sqrt{\nu}$$

$$B_0 = g_0\sqrt{\frac{\mu_0}{sG_0}} = \sqrt{\frac{2hG_0\mu_0}{2V_P G_0}}\sqrt{\nu} = \sqrt{\frac{h\mu_0}{V_P}}\sqrt{\nu}$$

75) $$B_0 = \sqrt{\frac{h\mu_0}{V_P}}\sqrt{\nu}$$

The photon's volume can be estimated using quantum and relativistic arguments.

The Volume of the Photon

Since the volume of the photon is one of the new concepts that emerge out of this theory, and in virtue of the fact that it appears in some of the equations here used, we have considered it prudent to advance a summary of the way in which it could be estimated using quantum and relativistic arguments. We will not make a detailed exposition here because this is part of another publication actually in preparation. It is important to remark here that there is an apparent inconsistency of the Compton effect with classical electromagnetism; only photons of very high frequencies collide with electrons. Why is that? Another important question to ask is "why are photons screened off by screens with cavities smaller than the wavelength of the photon?" A theory of the photon that proposes the size and shape of the photon, and how it relates to its wavelength and energy, would have no problem answering these questions. That is something that emerges naturally in this theory.

As we have seen above, in this theory the photon emerges as a set of four discrete, point-like and tensorial entities, which follow each other in sequence when the photon moves. Classically it is impossible to conceive the volume of a point-like entity, but when quantum and relativistic concepts are applied to this classical solution the following characteristics emerge:

- It can be easily demonstrated that the photon is delocalized with a rate $\mathbf{\Delta r/\Delta t} \geq \mathbf{c}$, where $\mathbf{\Delta r}$ and $\mathbf{\Delta t}$ are the uncertainty in position and time respectively. Thus making the photon appear as a "photonic cloud".
- $\mathbf{\Delta r}$ is a spherical symmetric vectorial field, with $|\mathbf{\Delta r_{max}}| = \mathbf{1/8\lambda}$ (see case "**Y Discrete, Relativistic (c = constant)"** in the section "**on the Topology of the Wave Function y = sin(2πx/λ ± 2πt/T)"** herewith bellow) . Thus the "photonic cloud is spherical.
- When it is classically said that the photon is at position $\mathbf{x_i}$, quantum mechanically this means that the photon has a higher probability of being at that position, but is delocalized between $\mathbf{x_{i-1}}$ and $\mathbf{x_{i+1}}$, thus the probability of finding it at those extreme positions is zero ($\mathbf{x_{i-1}}$, $\mathbf{x_i}$, $\mathbf{x_{i+1}}$ are successive positions along the photon path, see conclusion for more detail).
- Since the photon is delocalized between $\mathbf{x_{i-1}}$ and $\mathbf{x_{I+1}}$, then $|\mathbf{x_{i+1}} - \mathbf{x_{i-1}}| = \mathbf{2}|\mathbf{\Delta r_{max}}| = \mathbf{1/4\lambda}$.
- The volume occupied by the photon at each classical position will be equal to the volume of the space where it is delocalized around the classical position, since $\mathbf{\Delta r}$ is spherical, that volume will be the volume of a sphere with diameter $\mathbf{D} = \mathbf{2}|\mathbf{\Delta r_{max}}| = \mathbf{1/4\lambda}$, given by:

$$\mathbf{V_P = 4/3\ \pi(1/8\lambda)^3}$$

76) $$\mathbf{V_P = \pi\lambda^3/384}$$

Using the relations: $\mathbf{\varepsilon_P = h\nu}$ and $\mathbf{c = \nu\lambda}$

77) **a)** $V_P = \frac{\pi h^3 c^3}{384}(\frac{1}{\varepsilon_P^3})$ **b)** $V_P = \frac{\pi c^3}{384}(\frac{1}{\nu^3})$

Determination of the Field Intensities of the EMG Wave

The combination of equation **77b)** with equations **73)**, **74)** and **75)** allows us to estimate the intensities of the $\mathbf{E_o}$, $\mathbf{B_o}$ and $\mathbf{g_o}$ fields in the EMG wave. Thus, combining equations **73)** and **77b)** we obtain:

78)
$$g_o = \left(768\frac{hG_o}{\pi c^3}\right)^{1/2}\nu^2$$

Combining equations **74)** and **77b)**, we obtain:

79)
$$E_o = \left(384\frac{h}{\pi c^3 \varepsilon_0}\right)^{1/2}\nu^2$$

Combining equations **74)** and **77b)**, we obtain:

80)
$$B_o = \left(384\frac{h\mu_o}{\pi c^3}\right)^{1/2}\nu^2$$

This is a new feature introduced by this theory, which is absent from other known theories of the photon. Now we can determine the intensities of the electric, magnetic and gravitational field associated with a photon if we know its frequency.

To complete the analysis of this new concept of electromagnetic-gravitational wave, we need to make a topological analysis of the wave function **y = sin(kx - ωt)**, thorough enough as to reveal the wave characteristics that the **EMG theory** postulates.

Some Conclusions on the Topology of the Wave Function y = sin(2πx/λ ± 2πt/T) for Different Restricted Cases

We will see that this function has different properties depending on the imposed restrictions. Further on, an analysis of each case will be done of how the function **φ(x,y,t) = 0** behaves: 1) in the plane **(x,t)**, 2) in the space **(x,y,t)** and 3) how it is projected on the plane **(x,y)**. The physical interpretation of these properties will be given when possible.

Y Continuous, Non-Relativistic (c ≠ Constant)

In this case the argument **φ = 2πx/λ ± 2πt/T** may take any value in **R** (the real domain), without restrictions on **(x,t)**, that is, **x** and **t** are independent variables. In this way the wave is expressed: 1) in the plane **(x,t)** as the complete plane without any local particular characteristic. Physically speaking, the object described by the function is at each moment everywhere. 2) in the space **(x,y,t)** it is an ondulating surface starting at the origin. And 3) cutting the plane $(x,y)_{t=0}$ as a sine function, and cutting every successive plane $(x,y)_t$ with the same sine function, but shifted $2\pi t/T$ with respect to $(x,y)_{t=0}$. Physically speaking, this means that as time passes the object described by the function moves everywhere at the same time the same distance, i.e. the object moves in the whole universe at any velocity, which obviously is non existent.

Y Discrete, Non-Relativistic (C $\neq$ Constant)

For this case the argument $\phi = n\pi/2$ $(n = \pm 1, \pm 2, \ldots)$. There are two cases: a) For each value of **n**; **x** and **t** take all possible continuous values; and b) For each value of **n**; **x** and **t** take discrete values multiples of λ and **T** respectively.

In **case a)** the function is expressed: 1) in the plane **(x,t)** as a family of parallel straight lines with slope $\pm T/\lambda$ and interception on **t** every **T/4** equal to **nT/4**. This means that for each value of **n**, there is a trajectory of constant velocity for the object described by **y**. This has two different interpretations, one is that each value of **n** represents a different object, the **n** objects occupying different positions separated by a distance $\lambda/4$ at any time, and moving at the same speed with parallel or antiparallel trajectories. The other interpretation is still more bizarre, in this case **y** represents a single particle, but when **n** changes the particle leaps to another instant **T/4** later (or earlier) and to another position $\lambda/4$ further (or closer), but it keeps on moving at the same velocity in a new trajectory parallel to the one it had before. When does **n** change? at any God-given moment!. 2) In the space **(x, y, t), y** is expressed as a set of parallel strait lines distributed in the planes $(x, t)_{y=1}$, $(x, t)_{y=0}$ and $(x, t)_{y=-1}$, changing for each value of **n** from one plane to the next, when **n** changes to the next value. This can be interpreted, in the case of **n** objects, as follows: There are three types of objects with respect to the property **y**, this objects are located in the succession **y**, **0**, **-y**, **0**, **y…**, in their different trajectories. And in the case of only one object: The property **y** changes oscillating in the succession **y**, **0**, **-y**, **0**, **y…**, when **n** changes. If any of these two entities exists we would be facing a portent!.

Case b) is similar to case a), with discrete variables, i.e., we will have a succession of discrete points instead of a continuous straight line.

Y Continuous, Relativistic (c = constant)

We use here the term "relativistic" to indicate that the velocity of the wave is constant. For this case $|dx/dt| = c = \lambda/T$; under this condition $t = t_o \pm x/c$, then **x** and **t** are linearly dependent (we are not going to analyze the case of accelerated waves, since these are very special cases in which the waves move across continuous anisotropic media, and we are interested in solving the case for homogeneous media like vacuum).

Under these restrictions the function is expressed: 1) in the plane **(x, t),** as a strait line with slope $\pm c^{-1}$ (which for $t_o = 0$ passes through the origin); this represents the continuous path of an object with constant velocity $\pm c$. 2) In the space **(x, y, t),** the function is expressed as a transversal sine function that oscillates between **+y** and **–y** across the **(x,t)** plane, 3) with a projection on the plane $(x, y)_{t=0}$ as a sine function with period λ.

Mathematically **y** is a wave in **x** and **t**, or better said in $\phi = 2\pi x/\lambda \pm 2\pi t/T$, and it has all the mathematical properties of a wave, but that it does not mean that **y** is continuous across the whole space at every moment (as in the case of a stationary wave). This interpretation is only possible when **x** and **t** are independent variables, but in this case, to each value of **t** corresponds one and only one value of **x**, which means that the object described by **y** at instant t_o is located at the point x_o and not in any other place. This implies that ϕ describes a particle that moves with velocity $\pm c$ with properties **y** oscillating sinusoidally between **+y** and **–y** as the particle moves. This shows, by simple mathematics, that the wave behaves as a particle. **All waves moving at constant velocity**

are in essence particles, even when their ondulatory properties are continuous. *The wave-particle paradox does not exist*. From the classical point of view, particles are confined in physical space, where by definition they occupy a volume. But they may have properties like temperature, luminosity, electric field, etc., that could behave periodically in time. When one of these properties is plotted in a graph **y** vs **t**, it will appear as a wave. If the particle moves at constant velocity, the time ondulatory property will be also graphically ondulatory in space, because the position (motion) of the particle and time are linearly dependent. On the other hand, anything with a spatially periodical property needs not to be in motion to manifest this property. An example of this case would be any surface with regular roughness.

Y Discrete, Relativistic (c = constant)

In this case two restrictions are imposed upon the argument ϕ, the first one is $\mathbf{2\pi x/\lambda \pm 2\pi t/T = n\pi/2}$ and the second one $\mathbf{|\Delta x/ \Delta t|_{\Delta n=1} = \lambda/T = c}$ (We must remember that when **c** is positive, $\mathbf{2\pi x/\lambda - 2\pi t/T = n\pi/2}$, and vice versa, when **c** is negative, $\mathbf{2\pi x/\lambda - 2\pi t/T = n\pi/2}$). Again **x** and **t** are linearly dependent, but as can be seen below, both are discrete:

$$2\pi x/\lambda + 2\pi t/T = n\pi/2 \Rightarrow \quad x/\lambda + t/T = n/4$$

Taking two successive values of **n** ($\mathbf{n_i}$ **and** $\mathbf{n_{i+1}}$):

$$x_i/\lambda + t_i/T = n_i/4 \quad \Rightarrow \quad x_{i+1}/\lambda + t_{i+1}/T = n_{i+1}/4$$

Subtracting $\mathbf{n_i}$ from $\mathbf{n_{i+1}}$:

$$(x_{i+1} - x_i)/\lambda + (t_{i+1} - t_i)/T = (n_{i+1} - n_i)/4$$

$$\Delta x = x_{i+1} - x_i \qquad \Delta t = t_{i+1} - t_i \qquad \Delta n = n_{i+1} - n_i = 1$$

81) $$\Delta x/\lambda + \Delta t/T = 1/4$$

Dividing **81)** by Δ**t** and multiplying by λ:

$$\Delta x/\Delta t + \lambda/T = \lambda/4\Delta t$$
$$|\Delta x/ \Delta t|_{\Delta n=1} = \lambda/T = c$$

$$2c = \lambda/4\Delta t$$

$$\Delta t = \lambda/8c = 1/8\ \lambda/c = 1/8T \quad \Rightarrow \quad \Delta t = 1/8T$$

82) $$t = t_o + nT/8$$

Similarly, dividing **81)** by Δ**x** and multiplying by **T**:

$$T/\lambda + \Delta t/\Delta x = T/4\Delta x$$

$$1/c + 1/c = T/4\Delta x \quad \Rightarrow \quad 2/c = T/4\Delta x$$

$$\Delta x = cT/8 = \lambda/8 \quad \Rightarrow \quad \Delta x = \lambda/8$$

83) $$x = x_o + n\lambda/8$$

Another important aspect of $\mathbf{y = \sin(2\pi x/\lambda + 2\pi t/T)}$ is that, being **x** and **t** dependent variables, **y** can be expressed as a function of **x** only or as a function of **t** only, as follows:

$$x = x_o + ct \quad \Rightarrow \quad t = (x - x_o)/c$$

The argument ϕ would be:

$$\phi = 2\pi x/\lambda + 2\pi\,(x - x_o)/cT) = (2\pi/\lambda)[x + (x - x_o)] = (2\pi/\lambda)(2x - x_o)$$

84) $$\phi = (2\pi/\lambda)(2x - x_o)$$

This argument makes $y = \sin\phi$ a wave in x with wavelength $\lambda/2$, since:

85) $$\phi = (2\pi/\lambda)(2x - x_o) = 4\pi x/\lambda - 2\pi x_o/\lambda = 4\pi x/\lambda - \phi_o$$

Where, ϕ_o is the phase factor. Thus, each time the value of x is an integer multiple of $\lambda/2$, the wave will have a cycle, nevertheless, when the argument is expressed as a function of the space-time variable $\theta = x + ct$, then $\phi = (2\pi/\lambda)\theta$, in this variable the wave has a wavelength λ. That is, the spatial wavelength is $\lambda_x = \lambda/2$, while the period is $T_t = T/2$; however, when the wave is observed in space-time the wavelength is λ and the period is T. But all our measurements are made either in space or in time, thus we measure $\lambda/2$ and $T/2$.

The results shown in equations **82)** and **83)** show that the wave-particle exists (or occupies) only spatial positions separated by a distance $\lambda/8$ $(1/4\lambda_x)$, and that time advances in leaps of $T/8$ $(1/4\ T_t)$. With this, the function is expressed as: 1) a dotted line (discrete) in the plane $(x,t)_{y=0}$ with slope $1/c$. 2) In the space (x, y, t) as a discrete secession of points distributed in the planes $y = 1$, $y = 0$ y $y = -1$, along three parallel transverse lines, one on each plane, with the points changing to successive planes along the lines. 3) On the plane (x,y) the function is projected as a discrete secession of points that appear every $1/8\lambda$ and changing in height successively in y as follow: **+1**, **0**, **-1**, **0**, **+1…**

This may be interpreted (in harmony with quantum mechanics) as a discrete wave-particle. Discrete in y, because only discrete values of y are permitted; discrete in x, because only discrete positions are allowed; discrete in t, because the wave is expressed only at discrete moments in time. It is a wave in y, x and t, because the function is periodical in all these variables; and it is a particle because at each instant t there is one and only one position in space, x, assigned to the function.

This last case (y discrete, c = constant) is interesting because it allows the conception of the discrete motion of a particle, changing from one position to another without passing through intermediate positions, and with discrete intervals of time mediating between positions. Therefore it is possible to conceive a discrete flux of time and a discrete distribution of positional points in space, even though the time and space are specific for that particle.

Another important consequence is that different matrixes of discrete points in space correspond to waves with different frequencies (and therefore with different energies, since $\varepsilon = h\nu$), thereby they could never coincide at more than one point (since $x = x_o + n\lambda 8$, $\varepsilon = hc/\lambda$, $\lambda = hc/\varepsilon$). This makes it impossible for them to interact. Only waves of equal frequency (equal energy) or wavelength will interact. Moreover interactions can only occur with waves out of phase by integral multiples of $\lambda/8$ $(1/4\lambda_x)$, since all of them will have the same argument $\phi = n\pi/2$, in such a way that $\phi_i = n_i\pi/2$ is the argument for y_i. There are four different possible interactions:

a) $n_i - n_j = 1 \Rightarrow$	Out of phase by $\lambda/8$ **($1/4\lambda_x$)**	The waves superimpose without affecting each other, ineffective interference.
b) $n_i - n_j = 2 \Rightarrow$	Out of phase by $\lambda/4$ **($1/2\lambda_x$)**	The waves superimpose with opposing values of y or $y = 0$ in coincidence; in this way the wave is converted to a discrete succession of points separated by a distance $\lambda/8$ **($1/4\lambda_x$)** along the line $y = 0$. This is called destructive interference, because $y_i - y_j = 1$ cannot be differentiated from the background.
c) $n_i - n_j = 3 \Rightarrow$	Out of phase by **$3/8\lambda$ ($3/4\lambda_x$)**	Equal to case **a)**
d) $n_i - n_j = 4 \Rightarrow$	Out of phase by **$1/2\lambda$ (λ_x)**	The same as if $i = j$, the waves are superimposed with values of y in coincidence and in phase, thus producing a new wave with double intensity $y = y_i + y_j$, since $y_i = y_j$ then $y = 2y_i$.

Of these four cases only **b)** and **d)** are really important (the destructive and constructive interferences). It is worth noticing that discrete waves predict the resonance rules up until now accepted empirically. That is, two EM waves will interact only under the following conditions: 1) When they have equal frequency (energy) and are in phase and 2) when they have equal frequency (energy) and out of phase by half a wavelength. It also predicts that quantum mechanical interactions are ruled by spatial resonance, restricted by the energy of the interacting systems. This explains what is called quantum transparency.

Conclusion

During the development of this work, many surprising things have come up that force us to review fundamental concepts. First, we have shown systematically that the present electromagnetic theory of light violates the principle of conservation of energy. This classical theory has today great importance, since it is applied to a variety of modern technologies, in which any insufficiency of the theory will be reflected with unpredictable results. Therefore, it is of prime importance to recognize any existing defects and find solutions to circumvent them. The above-mentioned violation of the principle of conservation of energy is not due to incorrectness in the mathematical structure of the theory, but to the fact that the latter is incomplete. In addition, we have seen that, in the course of solving the problem posed by the violation of the principle of conservation of energy, new ways to explain facts and phenomena common to quantum-relativistic physics spontaneously emerge, while new theoretical and phenomenological possibilities that up until now escaped our knowledge are opened. In the coming paragraphs we summarize the most outstanding ones:

1. As a result of the topological analysis of the wave function of the sine/cosine type, it has been established that any wave traveling at constant speed is in essence also a particle. Thus, the apparent paradox of the wave/particle duality is mathematically clarified. There is no contradiction between the ondulatory and corpuscular properties when the wave moves at constant speed.

2. The solution to the problem of conservation of energy in the electromagnetic induction here presented lead us to the introduction of two complementary equations to the Maxwell's equations. These two new equations represent the participation of the gravitational field in the induction:

   a) The Gauss law for gravitation:

   $$\mathbf{div g = -4\pi G\rho_m}$$

   b) The EMG induction law:

   $$\mathbf{g = \psi curl B \wedge curl E}$$

Furthermore, we have shown that for this induction law **divg ≠ 0**, even for the EMG wave. Which is the same as saying that the space where **g** is induced encloses an **equivalent mass** (energetically speaking, because there is no inertial mass in the photon**)**, because the lines of force of **g** do not cancel each other out when they are integrated over the surface surrounding the induction space. In addition, this fact is consistent with the properties that the proposed third field **X** requires for the conservation of energy in the wave, and with the way the wave behaves when passing through an external gravitational field. This is so because **divg ≠ 0** is an indication of the asymmetry of the vibration of **g** in the wave, while **divB = divE = 0** indicate the symmetry of the vibration of these two fields.

Another consequence of the addition of these two equations is the prediction of the induction of a gravitational field without gaussian symmetry **(divg ≠ 0)** in any region of space where an electromagnetic induction is produced. This is a very important prediction due to the direct technological implication in the study and control of the plasma stability. According to this theory, it is possible that gravitational centers, capable of perturbing the dynamics of the massive particles of the plasma in ways not predicted by Maxwell's equations, are being formed within the volume of the contained plasma, inducing its collapse.

3. We have also seen that it is possible to explain, without the need of the theory of relativity, the behavior of the photon when it passes through an external gravitational field. The deflection of

the photon's path can be explained from the interaction of the photon's gravitational field with the external field. This is the only theory that allows the calculation of the intensities of the photon-associated fields from its frequency or energy (See equations **78)**, **79)** y **80)**). Furthermore, according to this theory, the direction of the gravitational field at the location of the photon in a particular moment determines the trajectory of the photon at that particular point. The gravitational field at a point occupied by a photon is the sum of the photon's intrinsic g-field at the moment previous to arrival at this particular point plus the g-field associated with that particular point of space at the moment of arrival of the photon.

According to this, if the photon moves across a g-field gradient, the intensity of its intrinsic g-field will change during its trajectory; which is equivalent to say that its frequency will vary accordingly. That is, the photon will suffer a frequency shift. The same prediction is expected using classical mechanics arguments (See equation **16)**). But equation **78)** now allows us to calculate the exact frequency gradient expected in the photon passing across a known gravitational field if we know the trajectory and frequency of the photon at the moment it enters the g-field.

We can also calculate exactly the new trajectory of the photon (the photon's path) upon entering the external g-field, just by adding the photon's g-vector to that of the external g-field at each point occupied by the photon.

These results apparently coincide with the predictions of the relativity theory. But, according to relativity, the photons path does not depend on the photons frequency, but only on the external g-field; while this theory predicts that the photon's path and frequency depend on both, the photon's frequency and the external g-field. Thus, photons of different frequencies will be diverted with different intensities by the same external g-field, leading to different paths for photons with different frequencies.

According to this prediction, when a light beam coming from a distant star passes close to the sun's surface, those photons closer to the **uv** region of the visible spectrum will be deflected farther than those closer to the **IR** region of the visible spectrum. Thus inducing what is called in optics "chromatic aberration": a blurring of the image, and the formation of a chromatic rainbow-like halo around it. This can never be predicted by the theory of relativity, because, according to it, photons (regardless of their frequency) follow the trajectory set by the sideral lines of the gravitational field produced by massive bodies (5)

4. The application of this induction law and of the condition of conservation of energy $(d\varepsilon_t/dt = \partial\varepsilon_t/\partial t = \partial\varepsilon_t/\partial x = 0)$ produced an EMG wave with the following characteristics:

a) The wave is associated with three orthonormal vector field components, i.e. the electric, magnetic and gravitational fields, with this latter oscillating in the direction of propagation of the wave.

b) The gravitational field of the wave vibrates out of phase by 90° with respect to the electric and magnetic fields, which are in phase. Furthermore, the gravitational field oscillates asymmetrically between zero and a positive maximum, and at a frequency twice as fast as the other two fields; i.e. when **E** and **B** oscillate in $\sin\phi$, **g** oscillates in $\cos^2\phi$.

c) The wave argument $\phi = kx - \omega t$ is quantized $(\phi = n\pi/2)$. And, since the wave moves at constant speed, it has all the characteristics described in the section on the topology of the wave function $y = \sin(kx - \omega t)$ for a discrete wave with constant speed. Its most outstanding properties are:

I. The wave is also a particle.

II. The wave-particle propagates in a discrete way, occupying discrete positions along the path.

III. It complies with the interference rule only on resonance (waves with equal energy or frequency) and out of phase by zero or 180° only.

IV. The components of the wave **(E, g, B)** can only take discrete values given by the values of **n** in $\phi = n\pi/2$. Thus, the sequence of **E** is $E_o \Rightarrow 0 \Rightarrow -E_o \Rightarrow 0 \Rightarrow E_o \Rightarrow \ldots$, that of **B** is $B_o \Rightarrow 0 \Rightarrow -B_o \Rightarrow 0 \Rightarrow B_o \Rightarrow \ldots$, and that of **g** is $0 \Rightarrow g_o \Rightarrow 0 \Rightarrow g_o \Rightarrow 0 \Rightarrow \ldots$ Of these four properties the following consequences are derived:

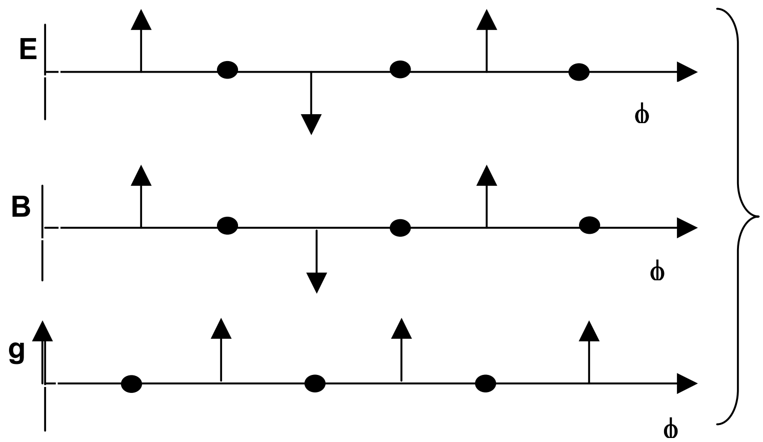
d) The wave is defined in space-time, because in the quantized argument $kx - \omega t = n\pi/2$, **x** and **t** are linearly dependent variables. In this space-time, the path of the wave is not defined by a continuous line, but by a discrete secession of points, separated by a distance dependent on the energy of the photon (positions are given by: $x = x_o + n\lambda/8 \Rightarrow x = x_o + nhc/8\varepsilon_\rho$), where the increments of **x** are given by $n\lambda/8 = nhc/8\varepsilon_\rho$. This means that the more energetic the photon, the smaller the **x** increments and consequently the closer to be continuous the motion of the wave-particle will be. The time increments have the same characteristics as those of **x**, and are given by $t = t_o + n/8T = t_o + nh/8\varepsilon_\rho$. We will use the term "**quantized space-time**" for a space-time with the characteristics just mentioned.

e) To each point of the quantized space-time through which the wave passes would correspond a four-vector tensor (one vector for each field associated to the wave, and one vector corresponding to the momentum of the wave-particle). Furthermore, the fields **E**, **B** and **g** are defined only for those points. Thus, their nature is different from that of the non wave-associated classical fields (i.e. inverse of the squared of the distance, etc.). These fields (the ones associated with a wave-particle) are purely punctual and can only affect other points as long as the interaction of those points with other physical entities is mediated by the points directly associated to the mentioned wave associated fields. For example, if a point in space is permanently perturbed by the gravitational component of an EMG ray and that point is in the path that mediates the interaction between two massive bodies, the gravitational interaction between the bodies will be affected.

f) To any EMG wave correspond four different tensors, which repeat in tandem every whole cycle. These tensors can be represented as follows (the momentum vector is omitted because it is constant when there is no interaction):

$$\phi_1 = \phi(0,g_o,0)_o$$
$$\phi_2 = \phi(B_o,0,E_o)_{\pi/2}$$
$$\phi_3 = \phi(0,g_o,0)_\pi$$
$$\phi_4 = \phi(-B_o,0,-E_o)_{3\pi/2}$$

It is easy to inspect that each tensor is transformed into the next in the sequence when it passes from one point to the next in its path in space-time (when **n** changes of value). That is, the wave exists in four tensorial entities translocating in a quantized space-time in a determined sequence. When time changes a quantum $(hc/8\varepsilon_\rho)$, the entity is transformed into the next in the sequence and at the same time it is translocated to another point in space-time. This can be depicted as follows:



Vector components (fields)
Where:

ϕ = position the space-time
$\phi = kx - \omega t = n\pi/2$

$\phi_1 \Rightarrow \phi_2 \Rightarrow \phi_3 \Rightarrow \phi_4 \Rightarrow \phi_1 \Rightarrow \phi_2 \Rightarrow \phi_2$ **(Tensors)**

g) We have seen that this wave follows the interference by energetic resonance rule (only in phase or out of phase by 180°). But an interesting aspect is the destructive interference (out of phase by 180°). In this case two cases are of interest: 1) When both waves are collinear **($P_1 = P_2$)** and 2) when these are antilinear **($P_1 = -P_2$)**. This situation allows us to study how is the energy conserved in this interference, and to predict effects that can be experimentally tested. For the first case we have:

Tensor 1	$E_1 = E_o\sin\phi$ $B_1 = B_o\sin\phi$ $g_1 = g_o\cos^2\phi$	$E_2 = E_o\sin(\phi + \pi) = -E_o\sin\phi$ $B_2 = B_o\sin(\phi + \pi) = -B_o\sin\phi$ $g_2 = g_o\cos^2(\phi + \pi) = g_o\cos^2\phi$	**Tensor 2**

Since the waves are collinear, the argument ϕ is the same for both of them. The result of the interference is:

$$E = E_1 + E_2 = E_o\sin(\phi) - E_o\sin\phi = 0, \qquad E = 0$$
$$B = B_1 + B_2 = B_o\sin(\phi) - B_o\sin\phi = 0, \qquad B = 0$$
$$g = g_1 + g_2 = g_o\cos^2\phi + g_o\cos^2\phi = 2g_o\cos^2\phi, \qquad g = 2g_o\cos^2\phi$$

Which means that the resulting wave particle has only a gravitational component, oscillating in the direction of the displacement of the wave. This oscillation is only apparent because, since **$\phi = n\pi/2$**, **g** only takes values of zero (odd values of **n**) or **$2g_o$** (even values of **n**). The structures of **tensors 1** and **2** must be such that, after the interference, **n** could only take even values, so that the energy is conserved. Thus we have a new wave-particle that moves by quantum leaps given by:

$$x = x_o + nhc/8\varepsilon_\rho$$
$$t = t_o + nh/8\varepsilon_\rho$$

Where, **$n = 0, \pm 2, \pm 4$ …**

With a constant gravitational component:

$$g = 2g_o\cos^2\phi = g = 2g_o$$

In other words, this new particle, generated through interference, does not have oscillation of its component field, has a momentum $\mathbf{P = P_1 + P_2 = 2P_1}$, but nevertheless the fact that it moves by quantum leaps **(Δx = 2hc/8ε_ρ, Δt = 2h/8ε_ρ, Δn = 2)** confers it periodicity in space and time, so it has all the ondulatory properties.

The emergence of a particle with such characteristics induces us to predict which particle might it be. Let us see:

Energy of the interfering photons:

$$\varepsilon_P = \tfrac{1}{2} V_P g_o^2/G_o$$

Energy of the new particle:

$$\varepsilon_g = \tfrac{1}{2} V_g(2g_o)^2/G_o$$

$$\varepsilon_g = 2V_g g_o^2/G_o$$

But, $\varepsilon_g = 2\varepsilon_P$, then:

$$V_P g_o^2/G_o = 2V_g g_o^2/G_o \qquad \Rightarrow \qquad V_P = 2V_g$$

Which means that the new particle occupies half the space that each photon occupied separately before interference.

The new particle has a momentum $\mathbf{P = P_1 + P_2 = 2P_1}$, twice that of the photon. But the momentum of spin should also be conserved, if each photon has a spin of **h/2π**, the new particle must have a spin of **2(h/2π)**. In other words:

- The new particle has only a gravitational component.
- The new particle has a volume twice smaller than that of the originating photons.
- The new particle has a momentum $\mathbf{P = P_1 + P_2 = 2P_1}$.
- The new particle has a spin = **2(h/2π)**.
- It can be postulated that the **new particle is a graviton**.

In the second case we have the same condition as in the first one, but since in this case the photons are antilinear, we have:

$$P = P_1 + P_2 = P_1 - P_1 = 0 \qquad \Rightarrow \qquad P = 0$$

if **P = 0**, then $\mathbf{v \neq c \Rightarrow v = 0}$, in consequence Δ**x = 0**, that is **n** = constant. This indicates the existence of a particle without mass nor momentum, which reminds us of the characteristic of a virtual particle; although the Heisenberg uncertainly principle limits the existence of this type of particle to the condition Δ**E.**Δ**t** $\geq$ **h2π** (Δ**E** is the energy of the virtual particle, and the particle can only exist for a time **t** $\leq$ Δ**t**). But, as we have just seen, the energy of the particle is given by $\varepsilon_g = 2V_g g_o^2/G_o$, thus the term virtual particle cannot be used here with all propriety. The apparent contradiction between the existence of that energy and the lack of mass and momentum would have a classical answer in the existence of a static gravitational field in that region of space. This gravitational field would affect the gravitational interactions passing through the region where it is at. That, of course, leaves open the way to search for a quantum mechanical solution. These last two situations can be created artificially with a laser interferometer.

5. A very interesting prediction that comes out of the properties of the EMG wave is: The continuously produced destructive interference in interstellar space, due to the pervasive bath of EMG waves to which it is submitted, should produce a matrix of high gravitational density nodes similar to an interference pattern. This matrix must be denser towards the regions with higher star density (towards galaxies centers). It is possible that part of the matter of the universe is trapped in this form of "obscure" (does not emit electromagnetic radiation), dense and transparent (as long as it does not reach the characteristics of a black hole) matter. Furthermore, these nodes could with time become so dense as to degenerate into "strange" black holes or galaxies centers.

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