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On the Fundamental Discrete LC Relation of Elementary EM Particles

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Abstract :

It can be shown, according to Louis deBroglie's theory regarding permanently localized photons, that they behave as discrete LC systems made up of half the photon's energy oscillating electromagnetically being propelled in space by the other half of its energy moving unidirectionally[1].

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1 deBroglie's hypothesis regarding permanently localized Photons

In the 1930's, Louis deBroglie, whose 1924 thesis inspired Schrödinger's wave equation and earned him a Nobel prize, formulated a hypothesis on how a permanently localized photon following a least action trajectory could satisfy at the same time Bose-Einstein's statistic and

[1] **NOTE**: To fully understand the structure of deBroglie localized photon it is recommended to first read a separate paper that describes the required underlying space geometry: **Description of the 3-Spaces Expanded Maxwellian Space Geometry ([5])**

Planck's Law, perfectly explain the photoelectric effect while obeying Maxwell's equations and totally conform to the properties of Dirac's theory of complementary corpuscles symmetry. His theory revealed that the only possibility answering all of these criteria was that it be constituted, not of one corpuscle, but of two corpuscles, or half-photons, that would be complementary like the electron is complementary to the positron ([1], p.277).

From his hypothesis: "*Such a complementary couple of particles is likely to annihilate at the contact of matter by relinquishing all of its energy, which perfectly accounts for the characteristics of the photoelectric effect.*"

Furthermore, "*The photon being made up of two elementary particles of spin $h/4\pi$, it must obey the Bose-Einstein statistic as the precision of Planck's law for the black body requires.*"

Finally, he concludes that "*…this model of the photon allows the definition of an electromagnetic field linked to the probability of annihilation of the photon, a field that obeys Maxwell's equations and has all of the characteristics of electromagnetic light waves.*"

1.1 Internal Electromagnetic Symmetry

These conclusions involve that photons have to be stable dynamic structures that can logically only alternate between a double-particles electric state with both particles separating in space (an electric dipole) and a single magnetic particle state that could be dipolar in only one manner, which can consist only in a spherical magnetic expansion phase as both electric state particles move towards each other, followed by a spherical magnetic regression phase as both electric state particles move away from each other, both magnetic phases being normal to the electric phase at all times. This involves that the magnetic aspect of the photon will be spherical at all times and can be dipolar only along the time dimension since both expansion and regression cannot possibly occur simultaneously.

Such a dynamic structure still preserves fundamental symmetry since the space-wise electric dipole is counterbalanced by a related time-wise orthogonal magnetic dipole, with both dipoles remaining orthogonal to the direction of motion of the photon in space in agreement with Maxwell's theory.

1.2 The possibility of fundamentally neutral Half-Photons

DeBroglie associated no signs to the two electric state particles of his localized photon hypothesis after having analyzed this possibility[2].

But paradoxically, it has been understood and extensively experimentally confirmed since the 1930's that any photon of energy 1.022+ MeV, which is electrically neutral, can be destabilized to convert into an electron-positron pair (charged in opposition) when grazing a heavy particle such as an atom nucleus.

Could the sign of charges then be an extrinsic property of charges, possibly a vectorial property that would be acquired at the moment of separation of the pair? This would leave the door wide open to the possibility that the half-photons could be associated to unsigned charges, that is, fundamentally neutral charges!

The unraveling of the origin of constants ε_0 and μ_0 proposed in ([2], **Chapter 11**) shows that the possibility of the existence of such neutral pairs of charges within photons is definitely worthy

[2] This was confirmed to me at the **Fondation Louis deBroglie** upon a specific question on my part regarding this point, through a copy of a Note to Dominique Morenas from Georges Lochak, director of the Foundation and lifelong colleague and friend of deBroglie.

of consideration, which would effectively reduce the "sign" of a charge to a property acquired at the moment of decoupling by the then fundamentally neutral charges of the decoupling photon.

2 The Sign of Charges

Indeed, the new equation for free energy derived from Marmet's work in ([3], equation (11))

$$E = hf = \frac{hc}{\lambda} = \frac{e^2}{2\varepsilon_0 \alpha \lambda} \tag{1}$$

does involve by structure two charges interacting. The very form e^2 reveal that both charges in a localized photon have to be identical, and can be neutral $|e|^2$ as hypothesized by deBroglie, which leads to the logical conclusion that the opposite signs of a decoupling pair (positron + and electron -) can effectively be considered as being acquired as the pair decouples, which is obviously contrary to current axiomatic beliefs[3], but is in perfect harmony with deBroglie's hypothesis.

The remaining issues regarding these assumed neutral fundamental charges are now "What are they?" and "How do they initially come into being?"

3 Creation of new pairs of neutral charges

For example, when a half-photon pair decouples, it is experimentally confirmed that the residual energy in excess of the 1.022 MeV required to form the rest masses of the separating pair and that causes the now massive electron and positron to fly away from each other, can only be two very normal photons as analyzed in a separate paper ([3]), but instead of flying away at the speed of light as would be expected, are slowed down by the presence of the massive particles that they now must carry separately and whose velocity and instantaneous relativistic mass increase they now determine.

How does the new pair of electrically neutral corpuscles of each new residual carrier-photon come into being then?

All indications lead to conclude that it would be the mere presence of energy in electrostatic space that would be perceived as corresponding to a charge when observed from normal space just like the mere presence of the very same energy in magnetostatic space is perceived as a magnetic field when observed from normal space.

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[3] It is a fact that all experimental research aimed at identifying charges in electromagnetic “waves” have failed to detect any in support of Maxwell's assumption of the existence of a displacement current and corresponding magnetic field as a foundation for his theory.

But Let’s consider that if electromagnetic “waves” turn out to be only a convenient mathematical representation of a macroscopic perception of a crowd effect due to the presence of countless localized photons that Planck and Einstein confirmed the physical existence of, it would indeed be these photons that would display the searched for charges and would be the local sites of displacement current versus magnetic induction activity.

There simply exists no instrument sensitive enough to detect the infinitesimal fields of individual photons, with the added difficulties that they are all moving at the speed of light and that any interception of a single photon simply incorporates it as an infinitesimal increase in kinetic energy to the material that the detector is made of.

This would explain very simply why all of a photon's energy can completely evacuate electrostatic space at the end of its transfer process into magnetostatic space, momentarily leaving absolutely nothing behind.

The assumed "neutral" charges of a permanently localized photon in electrostatic space would then not be fixed-dimensions "corpuscles", in the generally understood sense, but simply the energy itself that makes up the equal energy half-photons during the electrostatic phase of the cycle, whatever its total amount.

The "unit charges and opposite signs" acquired by both electron and positron upon decoupling would become fixed simply because the corresponding energy stops cycling between electrostatic and magnetic states to become fixed quantities in electrostatic space now applying unidirectional and stable "pressures" in opposite directions in normal space whose intensity depends on the decoupling radius of the pair in electrostatic space, as analyzed in ([2]).

4 Transverse travel vs longitudinal travel of a photon's energy

This structural analysis highlights one more astonishing fact about electromagnetic energy, which is that its transverse integrated amplitude being subject to the speed of light as a maximum limiting velocity of the constituting energy as the latter accelerates transversally in both electrostatic and magnetostatic spaces from velocity zero at each limit, can *de facto* only be different from the classical amplitude associated to constant longitudinal velocity at c of the photon.

Rather simple calculation show that this transverse amplitude corresponds very precisely to the integrated absolute amplitude of the particle's energy ($\lambda\alpha/2\pi$) (See [3]). Interestingly, the difference is exactly equal to the fine structure constant (α), whose origin and justification has mystified the community so much for the past hundred years.

So the fine structure constant (α) can now be defined as follows:

> <u>The fine structure constant</u> is the ratio of the transverse amplitude of transversally oscillating electromagnetic energy over the longitudinal amplitude of the same energy in the direction of its motion at the speed of light in space.

5 Displacement current as the source of photons' magnetic field

Now, considering the cyclic to and fro motion of the assumed neutral pair of charges involved in the deBroglie localize photon internal dynamic structure, it must be obvious that only displacement current could be at play here since no physically massive matter can be present to support in any way a conduction current.

It is well understood since Maxwell that displacement current can also act as a source of magnetic field and that a changing electric field (which would be the case with the cyclic symmetric dynamic motion of the pair of charges considered) in a region of space, will induce a magnetic field in neighboring regions, <u>even when no conduction current and no matter are present</u> (and in deBroglie's localized photon hypothesis, even if the charges are neutral).

Such an electro-magnetic relationship involving a displacement current, first proposed by Maxwell in 1865 was the foundation of his electromagnetic theory and provided the key to theoretical understanding of electromagnetic radiation ([4], p 625), which brings us to the behavior of LC circuits.

6 Macroscopic LC circuits

When an inductor coil is connected to a charged capacitor with no resistance inserted in the circuit, it is well verified experimentally that the capacitor will completely discharge into the inductor as the current in the inductor establishes a magnetic field in surrounding space.

When the potential difference between the capacitor terminals reaches zero, the magnetic field that just reached maximum about the inductor coil will now start decreasing thus inducing a current in the coil that will completely recharge the capacitor in the reverse direction until the magnetic field completely disappears and the capacitor is again fully recharged.

The capacitor will now start discharging again into the coil and the process would repeat indefinitely in theory if no energy was lost, a loss that always occurs in a lab experiment in reality due to eventual heating of the coil wire. It is well understood however that if no energy was lost through heat loss from the coil wire, the total energy of the system would remain constant and be conserved, which would keep the cycle going for ever.

7 The Photon as a LC Oscillator

Let us note that an oscillating LC circuit requires no conduction current keep operating, and that the displacement current inherent to the structure of a charged capacitor is sufficient to initiate and maintain the continuous process[4].

The classical equation representing the maximum energy stored in the capacitor of an LC circuit at the beginning of the cycle is

$$E_E = \frac{q^2}{2C} \tag{2}$$

and the one representing the maximum energy stored in the magnetic field of the coil when the capacitor has been emptied of its charge is

$$E_B = \frac{L\, i^2}{2} \tag{3}$$

Of course, if no energy was lost in such a system through heating of the coil wire, we could equate

$$E_E = E_B \tag{4}$$

8 Defining the Photon Integrated Capacitance (C)

Transposing now this LC behavior to deBroglie's localized photon, which has no wire that can resist and heat up and thus can completely conserve its energy, we can now determine its integrated capacitance (C) and inductance (L), in relation to its energy.

We previously determined that only half a photon's energy cyclically oscillates between electric and magnetic states (the other half moving unidirectionally to maintain the speed of light of the first half in space). So using the energy equation (1) previously mentioned derived from Marmet's work, that is:

[4] Let us note here that the difference between an alternating current and a displacement current is that the latter involves a self sustaining oscillation, in close circuit so to speak, while an alternating current needs to be permanently maintained externally.

$$E = \frac{e^2}{2\varepsilon_0 \lambda\alpha} \tag{5}$$

let us divide it by two to separate the half of a photon's energy that electromagnetically oscillates from the unidirectional half:

$$E_{EB} = \frac{E}{2} = \frac{q^2}{2C} = \frac{e^2}{4\varepsilon_0 \lambda\alpha} \tag{6}$$

Consequently, we can isolate

$$2C = 4\varepsilon_0 \lambda\alpha \tag{7}$$

and finally

$$C = 2\varepsilon_0 \lambda\alpha \quad \text{Farad} \tag{8}$$

which allows calculating the integrated capacitance of any localized photon from its wavelength and the permittivity constant of vacuum (ε_0).

Now since $\boldsymbol{\varepsilon_0}$ is in reality a measure of ***transverse capacitance*** *per meter in vacuum* (Farad per meter), if we multiply $\boldsymbol{\varepsilon_0}$ by a length in meter, we obtain de facto a capacitance in relation with that length. So, equation (8) should fully confirm the nature of $\boldsymbol{\varepsilon_0}$ as a unit of vacuum capacitance per meter since it effectively boils down to calculating the capacitance of a photon by multiplying $\boldsymbol{\varepsilon_0}$ by a transverse wavelength (in meters).

9 Defining the Photon Integrated Inductance (L)

We know besides that the angular frequency of an LC oscillator is obtained from the following equation

$$\omega = \sqrt{\frac{1}{LC}} \tag{9}$$

Since we can separately calculate the angular frequency of a photon's energy from $\omega=2\pi f$, or better yet, in context, from $\omega=2\pi c/\lambda$ (since we must use here the cycling frequency calculated from the absolute wavelength a localized photon's energy which is $f=c/\lambda$), we can write

$$\omega = \frac{2\pi c}{\lambda} = \sqrt{\frac{1}{LC}} \tag{10}$$

By squaring this last equation and replacing C by the value defined with equation (8), that is $\varepsilon_o 2\lambda\alpha$, we can isolate L and define the following equation for calculating the inductance of any photon from its wavelength and the permeability constant of vacuum (μ_0)

$$L = \frac{\lambda^2}{C\,4\pi^2 c^2} = \frac{\lambda}{\varepsilon_0\,2\alpha\,4\pi^2 c^2} \tag{11}$$

Knowing also that $\varepsilon_o c^2=1/\mu_o$ and substituting this value in equation (11) we can finally write:

$$L = \frac{\mu_0 \lambda}{8\pi^2 \alpha} \quad \text{Henry} \tag{12}$$

We note here in reference to the definition of the permeability constant as being *a unit of inductance per meter in vacuum*, that multiplying it by a wavelength (in meters), as our last equation reveals, we obtain a very straightforward inductance.

10 Photon Maximum Displacement Current (*i*)

Knowing now how to calculate L for a localized photon and that the electromagnetically oscillating energy involved (equation (6)) amounts to half of the photon's energy (E_{EB}), we can determine the maximum current (*i*) involved from the equation giving the maximum energy momentarily stored in the magnetic field. So, from

$$E_B = \frac{L\,i^2}{2} \tag{13}$$

we derive

$$i = \sqrt{\frac{2E_{EB}}{L}} = \frac{2\pi\, ec}{\lambda} \quad \text{Ampere} \tag{14}$$

11 The Photon General LC Equation

One final consideration before establishing a general dynamic equation for localized photons is that the sum of both E_E and E_B is permanently constant and since both values concern the very same amount of energy transferring form one form to the other. The sum of both can thus never exceed the maximum energy of either E_E or E_B. Consequently, we can write

$$E_{EB} = E_E + E_B = \left[2\left(\frac{e^2}{4C}\right)_Y \cos^2(\omega t) + \left(\frac{L\,i^2}{2}\right)_X \sin^2(\omega t)\right] \tag{15}$$

where t is the time for one cycle to be completed and corresponds to $1/f$, or when defined as a function of λ as required here, $t=\lambda/c$, and where the electric aspect of course splits into two equal quantities moving in opposite directions.

Since this energy corresponds to only half of the energy of a photon, we must finally add the other half which is the permanently unidirectional kinetic energy that propels the oscillating half at the speed of light

$$E = \left(\frac{hc}{2\lambda}\right)_Z + \left[2\left(\frac{e^2}{4C}\right)_Y \cos^2(\omega t) + \left(\frac{L\,i^2}{2}\right)_X \sin^2(\omega t)\right] \tag{16}$$

We have here the most detailed and general equation, all terms of which being function of the single variable λ, that can possibly be established for the energy of a localized photon, and where indices Z, Y and X respectively represent the three mutually orthogonal spaces into which the associated energy is in motion in the 3-spaces model ([2]).

All that is required now to observe how the energy oscillates between electric and magnetic states is to cyclically vary t from 0 to λ/c.

This equation allows clearly understanding why the Poynting vector is totally stable when deBroglie's hypothesis is taken into account, at a value equal to the averaged out value of this vector in classical Maxwell. This stability is due to the fact that at any given moment, the sum of capacitance energy and inductance energy is always exactly equal to half a photon's energy, which means that the electromagnetic oscillation behaves very precisely like a simple harmonic oscillator.

12 The Electrostatic Recall Constant

Why not now do some verifying with a real wavelength to clarify the last remaining hanging threads? We will use the electron Compton wavelength (λ_C=2.426310215E-12 J) since it exactly coincides with the absolute wavelength of a photon of same energy as is captive in an electron rest mass, and that all related data are well known and verified.

Let us first determine the ***electrostatic recall constant*** (k) for the LC transverse oscillation for the Compton wavelength related energy (which is of course $E_C/2$= 4.09355207E-14 Joules). From Hooke's law, E= $-kA^2/2$, where A is the related amplitude $\lambda_C\alpha/2\pi$, and E is the energy related to the oscillation E= $E_C/2$. Consequently:

$$K = \frac{2E}{A^2} = \frac{4\pi^2 E_C}{\lambda_C{}^2 \alpha^2} = 1.031019177E16 \ \text{N/m} \quad (17)$$

Now, since F = -k x (x being a distance in meter), the recall force at maximum transverse extent will be

$$F = kA = k\lambda_C\alpha/2\pi = 29.05350473 \text{ Newton} \quad (18)$$

Now how can we verify that this figure is correct?

Since F is proportional to kA, if we multiply the equation by α, we get the corresponding force for the longitudinal Compton wavelength

$$F\,\alpha = k\lambda_C\alpha^2/2\pi = 0.212013666 \text{ Newton} \quad (19)$$

We know also that the energy induced at the Bohr rest orbital is equal to the electron rest mass energy multiplied by α^2. Since force is proportional to energy, we can further find the force associated with a photon of same energy as the Bohr rest orbital energy by further multiplying by α^2

$$F\,\alpha\,\alpha^2 = k\lambda_C\alpha^4/2\pi = 1.12900148E\text{-}5 \text{ Newton} \quad (20)$$

Now, this is the force for a photon of same energy as is induced at the Bohr rest orbital, but that photon is obviously moving at c. We know also that force is proportional to velocity. And we further know that the velocity at the Bohr rest orbital is equal to c multiplied by α. Consequently, a final multiplication by α should give us the well known force associated with the Bohr rest state

$$F\,\alpha\,\alpha^2\,\alpha = k\lambda_C\alpha^5/2\pi = 8.238721808E\text{-}8 \text{ Newton} \quad (21)$$

Which is the well known force associated to the Bohr rest orbital.

Doesn't this confirm that the Force / Energy / K / C / L / *i* / ω parameters of the double-particles photon LC equation of deBroglie's hypothesis are mathematically self consistent?

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