–International IFNA-ANS Journal,
No. 2 (28), Vol. 13, 2007, p. 123-140,
Kazan State University, Kazan, Russia.

Field Equations for Localized Photons and Relativistic Field Equations for Localized Moving Massive Particles

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(Revised 2017)

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Abstract :

Calculation of the energy of localized electromagnetic particles by means of the integration method that assumes that their energy fields mathematically radially decrease to infinity (∞) from a maximum intensity level located at an inner limit located at $\lambda\alpha/2\pi$ from their center, which allows defining discrete local electromagnetic fields coherent with permanently localized moving electromagnetic particles.

Also, in a paper published in the *International IFNA-ANS Journal* in 2003, Paul Marmet clarified by means of the Biot-Savart equation how the intensity of the magnetic field associated to part of the mass of an electron in motion increases as the square of its velocity.

This direct dependence between velocity of an electron and ambient magnetic and electric fields intensity is already established by the Lorentz force equation. However, Marmet's equation defines the intrinsic magnetic field of the electron in motion with which the ambient magnetic and electric fields of the Lorentz equation interact to define its velocity. We will study here the characteristics of this intrinsic magnetic field of the electron in motion as well as those of its associated electric field.

NOTE: The English and Russian versions of this article were formally published in December 2007 in the *International IFNA-ANS Journal*, No. 2 (28), Vol. 13, 2007, pp. 123-140, Kazan State University, Kazan, Russia.

Extended Abstract :

When localized electromagnetic particles are considered, the traditional way to sum up their total complement of energy, is to integrate this energy, as if it mathematically spherically radially decreased to a superior limit located at infinity, from a maximum intensity level located set to a specific distance from zero, since integrating to zero would integrate an infinite amount of energy.

By means of this established method and quantizing the unit charge in the Biot-Savart equation, Paul Marmet **[1]** established an equation allowing calculating the total relativistic mass corresponding to the magnetic field of a moving electron, from which the part of the invariant rest mass of the electron corresponding to its invariant magnetic field can be calculated. The lower limit of integration in the case of an electron turns out to be the constant that was named "the electron Classical Radius" (r_e = 2.817940285E-15 m).

Of course, we know that only an unfortunate mishap of history caused this constant to be given a name suggesting that this was the actual radius of the electron. It is in reality only the mandatory lower limit of rest mass energy integration in the case of the electron, and should have been named accordingly to avoid this confusion.

Postulating that the energy of the electron has local physical presence, this amounts to mathematically bundling this energy into a sphere of radius $r_e \div 18.42960512$ within which the energy would be incompressible and have isotropic density that could be used to calculate local electric and magnetic fields for the particle.

Of course, such a sphere cannot possibly be either what the particle really is, since we are only doing mathematical manipulation of its energy. Metaphorically speaking, this simply amounts to theoretically bundling up all of the leaves on a tree into the smallest uniformly isotropic sphere possible to more easily calculate the limit volume and density of the material that makes up all of the leaves. It allows, in fact, determining this particle's absolute limit density parameters, beyond which energy density cannot possibly be increased.

From working on other aspects of electromagnetic theory **[3]**, I had previously come across the fact that this classical radius of the electron was obtained by multiplying the amplitude of the electron Compton wavelength by the fine structure constant ($r_e=\lambda_c\alpha/2\pi$=2.817940285E-15 m) and that the Compton wavelength itself was the actual wavelength of the energy making up the rest mass of the electron ($\lambda_c=h/m_0c$=2.426310215E-12 m).

This led me to consider the possibility that the total complement of energy of any localized electromagnetic particle could possibly be obtained by integrating their energy in the same manner, that is by setting the upper limit of integration to infinity (∞), of course, and the lower limit to the product of the amplitude of the wavelength of the particle and the fine structure constant ($\lambda\alpha/2\pi$), which we will refer to in this paper as the "transverse electromagnetic amplitude" of a particle's wave-

length, for considerations that exceed the scope of the present paper. This possibilty turned out to be confirmed after verification.

The possibility also came to light that general equations for electric and magnetic fields specific to localized particles could also be established from the same considerations.

By associating the quantization of the unit charge, the integration of the energy associated to the very precisely known electron dipole moment (the Bohr magneton) and the magnetic field of the ground state of the hydrogen atom to the Biot-Savart law, an equation was then developed to calculate the magnetic field of any photon with the wavelength of the photon's energy as the only variable (λ), all other parameters being known constants (π, μ_0, e, c, and α), which, when considering any specific energy value also reduces the wavelength to an instantaneous constant, thus resulting in a very simple intermediate electromagnetic equation set requiring no integrals nor derivatives.

From the known density equality of magnetic and electric energy per unit volume in any electromagnetic field, an equation was then derived from this discrete magnetic field equation to calculate the electric field of any photon with the wavelength of the photon's energy as again the only variable (λ), all other parameters being known constants (π, e, ε_o and α).

At this point, there remained to be addressed the possibility of relativistic discrete fields equations for moving scatterable massive particles, for which the carrying energy must be considered on top of the energy making up the rest mass of such particles.

The natural starting point for such an exploration is the Lorentz equation, which allows calculating the relativistic velocity of a charged massive particle in straight line motion by means of both **E** and **B** fields.

By making use of the magnetic field equation previously obtained for photons, it is possible to calculate the magnetic field of the electron at rest from its wavelength (the electron Compton wavelength), and to separately calculate the magnetic field of its carrying energy, which also constributes the relativistic mass increment related to this electron's relativistic velocity.

From Marmet's demonstration **[1]**, it is clear that the composite magnetic field of an electron in motion can be obtained from the simple sum of the magnetic field of the electron at rest plus the magnetic field of its carrying energy.

From relativistic equation ($E=\gamma mc^2$), an equation for relativistic velocity can then be obtained, making use of only the wavelength of the carrying energy and the Compton wavelength of the energy making up the rest mass of the electron.

Having then resolved the **B** element of equation ($\mathbf{E}=v\mathbf{B}$) from only fundamental constants (π, μ_o, e, c, and α) and two wavelengths (λ and λ_c), and the **v** element from the same two wavelengths (λ and λ_c), a discrete electric **E** field equation can easily be resolved making use of these same elements, which allows calculating the relativistic velocity in straight line of any material particle in motion from only electromagnetic considerations.

These equations support the idea that photons, as well as moving massive particles self-propel at the observed velocity from the mutual interaction of their own internal orthogonal electric and magnetic fields.

Moreover, in accordance with the only equation that allows describing straight line motion of a charged particle when **E** and **B** fields of equal densities, drawn from the Lorentz equation are applied to it, that is (**E**=v**B**), the new composite fields equations for massive moving particles directly explain why they self-propel in straight line, in accordance with Newton's first law; and by similarity, as a limit case with no massive particle involved, that is (**E**=c**B**) for photons, drawn from Maxwell's fourth equation, why they provides the same explanation for default straight line motion of photons, when no external force is acting on them to deflect their trajectories.

Establishing the value of individual electromagnetic fields of electrons, up quarks and down quarks (which are the only scatterable elementary particles known to exist inside atoms) and of their carrying energy, may finally allow determining with precision the contribution of each of them to the resulting electromagnetic equilibrium inside atoms.

Finally, the fact that these equations support the idea that electromagnetic particles may be self-propelling directly hints at the possibility that they may exist without the need for any underlying "ether" or medium of any sort.

Energy Calculation by spherical integration

When the electron velocity is small with respect to the speed of light, the following equation is obtained by Marmet ([1], Equation (23)), which allows clearly determining the part of its rest mass related to its magnetic field.

$$\frac{\mu_0 e^2}{8\pi r_e}\frac{v^2}{c^2} = \frac{m_e}{2}\frac{v^2}{c^2} \tag{1}$$

where $\mathbf{r_e}$ is the classical electron radius (2.817940285E-15 m), and **e** is the unit charge of the electron (1.602176462E-19 C).

His starting point was the Biot-Savart equation, into which he quantized the charge in the definition of electrical current, and also replaced dt with dx/v, based on the notion that at any given instant, the velocity of current is constant, giving the following equation for current:

$$I = \frac{dQ}{dt} = \frac{d(Ne)}{dt} = \frac{d(Ne)v}{dx} \tag{2}$$

where N represents the number of electrons in one Ampere.

By substituting that value of **I** in the scalar version of the Biot-Savart equation as follows:

$$dB = \frac{\mu_0 I}{4\pi r^2}\sin(\theta)\,dx\,, \quad \text{he obtained} \quad dB = \frac{\mu_0 v}{4\pi r^2}\sin(\theta)\,d(Ne) \tag{3}$$

Without going into the detail of his derivation, which is clearly laid out in his paper [1], let us only mention that the final stage of his reasoning consists in spherically integrating the electron's magnetic energy, whose density is mathematically assumed to be decreasing radially from a maximum intensity level set at a minimum distance from r=0 corresponding to $\mathbf{r_e}$ to a minimal intensity located at infinity (∞).

$$M = \left\{\frac{\mu_0 e^2 v^2}{2(4\pi)^2 c^2 r^4}\right\} 2\pi \int_0^{\pi} \sin(\theta) d\theta \int_{r_e}^{\infty} r^{-2}\, dr \tag{4}$$

In such an integration to infinity, the electron classical radius r_e is the mandatory lower limit of integration due to the simple fact that integrating any closer to r=0 would accumulate more energy than experimental data warrants. This specific constraint turns out to be the only reason for the existence of this co-called "classical radius" of the electron. After integration, we finally obtain Marmet's equation no (23), as already mentioned:

$$M = \frac{\mu_0 e^2 v^2}{8\pi r_e c^2} = \frac{m_e}{2}\frac{v^2}{c^2} \tag{5}$$

that very precisely corresponds to the total mass that can be associated to the magnetic field of an electron moving at velocity v, from which he demonstrated that the invariant magnetic field of the electron at rest corresponds to a mass of:

$$M = \frac{\mu_0 e^2}{8\pi r_e} = \frac{m_0}{2}, \tag{6}$$

which is exactly half the rest mass of an electron.

Since this magnetic component represents precisely half of the rest mass of the electron, multiplying it by 2 will of course restitute the electron's total mass, and further multiplying it by c^2 will restitute its total invariant rest mass energy.

$$\frac{\mu_0 e^2}{8\pi r_e} = \frac{m_e}{2} \quad \text{from which} \quad E = m_e c^2 = \frac{\mu_0 e^2 c^2}{4\pi r_e} \tag{7}$$

A quick verification will reveal here that multiplying the amplitude of the Compton wavelength, which happens to be the wavelength of the energy making up the mass of an electron (λ_C = c h/E), by the fine structure constant (α), restitutes directly this classical electron radius.

$$r_e = \frac{\lambda_C \alpha}{2\pi} = 2.817940285\ E-15\,m \tag{8}$$

[1] Note: The reader should be aware that due to some transcription error, in view of the fact that only one charge is being considered and that at any instantaneous velocity being considered, the **B** field has the exact intensity related to that velocity, as he clearly explains, his equation 7 should read:

$$B_i = \frac{\mu_0 e^- v}{4\pi r^2}$$

Since setting the lower limit of integration to the transverse electromagnetic amplitude of the electron Compton wavelength ($\lambda_c\alpha/2\pi$) in Marmet's equation amounts to spherically integrating the magnetic energy of the particle by treating it mathematically as if it decreased radially from a maximum intensity level set at that lower limit ($\lambda_c\alpha/2\pi$) to an upper limit located at infinity (∞), the method seemed consequently applicable by definition to any localized electromagnetic particle.

This hinted at the possibility of defining a new general equation, equivalent to E = h*f*, derived from Marmet's equation and this new relation between λ and α:

$$E = \frac{\mu_0 e^2 c^2}{4\pi r_e} = \frac{\mu_0 e^2 c^2 2\pi}{4\pi \alpha\lambda} = \frac{\mu_0 e^2 c^2}{2\alpha\lambda} \qquad E = \frac{\mu_0 e^2 c^2}{2\alpha\lambda} \tag{9}$$

and alternately, since $\mu_0 = 1/\varepsilon_0 c^2$

$$E = \frac{\mu_0 e^2 c^2}{2\alpha\lambda} = \frac{e^2 c^2}{\varepsilon_0 c^2 2\alpha\lambda} = \frac{e^2}{2\varepsilon_0 \alpha\lambda} \qquad E = \frac{e^2}{2\varepsilon_0 \alpha\lambda} \tag{10}$$

Consequently, we can conclude:

$$E = h\mathrm{f} = \frac{\mu_0 e^2 c^2}{2\alpha\lambda} = \frac{e^2}{2\varepsilon_0 \alpha\lambda} \tag{11}$$

To confirm the validity of this equation, let us now reconcile it with Maxwell's forth equation (Ampere's law generalized) by deriving from equation (9) the same equation for calculating the speed of light from both permittivity and permeability constants of vacuum.

$$hf = \frac{\mu_0 e^2 c^2}{2\lambda\alpha} \quad \text{can be written} \quad h\lambda f = \frac{\mu_0 e^2 c^2}{2\alpha} \tag{12}$$

But since λf = c, we can reduce to

$$h = \frac{\mu_0 e^2 c}{2\alpha} \ \text{which then can become} \ \alpha = \frac{\mu_0 e^2 c}{2h} \tag{13}$$

Now, the standard definition of α, defined from the electrostatic permittivity of vacuum constant (**[2]**, p 1.2), is:

$$\alpha = \frac{e^2}{2\varepsilon_0 hc}, \text{ so we can now equate } \frac{\mu_0 e^2 c}{2h} = \frac{e^2}{2\varepsilon_0 hc} \tag{14}$$

Simplifying, we obtain

$$c^2 = \frac{1}{\varepsilon_0 \mu_0} \quad \text{and finally} \quad c = \frac{1}{\sqrt{\varepsilon_0 \mu_0}} \tag{15}$$

which confirms the soundness of equation (9) and consequently also of equation (10).

One last point of interest regarding the standard equation defining α is that it can easily be converted to the electrostatic counterpart of equation (9), that is equation (10), that we just introduced to calculate the energy of a photon from its magnetic component. All that is required is to multiply it term for term by equation $\lambda f = c$:

$$\lambda f \alpha = \frac{e^2 c}{2\varepsilon_0 hc} \quad \text{When isolating h}f\text{ and simplifying, we effectively obtain} \quad E = hf = \frac{e^2}{2\varepsilon_0 \alpha \lambda} \qquad (16)$$

which exactly reproduces equation (10).

Definition of a local magnetic field for isolated photons

Besides, the dependence between the electron velocity and the ambient magnetic field is clearly established with Lorentz's magnetic force equation, that we will apply here to the amount of energy induced in the electron in the least action ground state of the Bohr atom, to then identify the magnetic and electric fields of the electron rest mass and those of its carrying energy.

We will use the Bohr atom as a familiar reference on account of the fact that it provides the well known and documented mean energy level induced for the hydrogen ground state orbital. This energy level corresponds to a quite effective low-relativistic velocity for free moving electrons possessing the same reference energy:

$$F = qv\mathbf{B} \qquad (17)$$

Where q is the charge of the particle considered, v is its theoretical velocity and **B** is the magnetic field intensity in Tesla. Being a vector product between a *charged particle in motion* (qv), seen as a current, and a locally active magnetic field, this relation, derived from the Biot-Savart law, wonderfully illustrates the triple orthogonality associated to electromagnetic energy.

When this equation is applied to the isolated Bohr atom, where electromagnetic equilibrium logically could possibly allow a translation motion of the electron, and knowing that the electrostatic force, associated to the electron charge, is directed towards the nucleus as it applies to the electron in motion (ev), which is itself moving perpendicularly to that force, we can much more easily visualize that the magnetic force (**B**), associated to that current (the electron theoretically in motion on the Bohr ground orbit), that is, the spin associated to the electron, can only act perpendicularly to the plane of the orbit, and also of course perpendicularly to the direction of the electrostatic force.

Knowing the force at the Bohr radius (8.238721759E-8 N), the charge of the electron, as well as the theoretical classical velocity of the electron on the ground state orbit of the Bohr model (2,187,691.252 m/s), it is easy to calculate the magnetic field intensity involved:

$$\mathbf{B}_o = \frac{F_o}{ev} = 235{,}051.7336\, T \qquad (18)$$

Knowing besides that $F=mv^2/r$, one can also write:

$$ev\mathbf{B}_o = \frac{m_o v^2}{r_o} \quad \text{and finally} \quad \frac{e}{m_o} = \frac{v}{\mathbf{B}_o r_o} \qquad (19)$$

From the known relation to calculate the electron gyromagnetic moment:

$$\frac{e}{m_o} = \frac{\mu_B}{S_z}, \text{ since } S_z = h/4\pi, \text{ we can pose } \frac{e}{m_o} = \frac{4\pi\mu_B}{h} \qquad (20)$$

which allows us to directly associate the magnetic field intensity at the Bohr radius with the Bohr magneton

$$\frac{v}{\mathbf{B}_o r_o} = \frac{4\pi\mu_B}{h} \tag{21}$$

and to calculate it from that intensity, since $h=2\pi r_0 m_0 v$ (**[3]**, Chapter **The Mechanics of the Photon**):

$$\frac{v}{\mathbf{B}_o r_o} = \frac{4\pi\mu_B}{2\pi\, r_o m_o v} \quad \text{and finally} \quad \mu_B = \frac{m_o v^2}{2\mathbf{B}_o} = 9.274008988 \quad E-24\ J/T \tag{22}$$

Let us note that the electron magnetic dipole moment can also be calculated from the Biot-Savart Law as follows:

$$\mu_B = i\,\pi\, r_o^{\ 2} = 9.27400898\,5\ \mathrm{E}-24\ \mathrm{J/T} \tag{23}$$

where i is the current in Coulombs per second, that is, the charge of the electron (e=1.602176462E-19 C) multiplied by the frequency of the energy at the Bohr orbit (f=6.579683916E15 Hz), and πr_o^2 is the surface enclosed within the Bohr orbit, that is, the radius of the orbit (r_o =5.291772083E-11 m) squared and multiplied by π.

So we have determined that the magnetic field at the Bohr orbit is equal to the force at that orbit divided by the charge of the electron and its theoretical velocity

$$\mathbf{B}_o = \frac{F_o}{e v_0} \tag{24}$$

We also determined that the Bohr magneton is equal to the energy at that orbit divided by $2\mathbf{B}_0$

$$\mu_B = \frac{m_o v^2}{2\mathbf{B}_o} = \frac{E}{2\mathbf{B}_0} \tag{25}$$

but, $\boldsymbol{\mu_B}$ in Joules per Tesla represents by definition the theoretical magnetic energy density at the Bohr radius while $\mathbf{B_0}$ would be the intensity of the related magnetic field. The magnetic energy at the Bohr orbit would thus be

$$E_m = \boldsymbol{\mu_B}\, \mathbf{B}_0 = 2.179871885\ \mathrm{E}\text{-}18\ \mathrm{J} \tag{26}$$

which is only half the energy known to be induced at that orbit[2], but which is in perfect harmony with Marmet's conclusion that magnetic energy constitutes only half the mass of the elec-

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[2] So from these considerations, we can note that although the Bohr magneton is referred to in the literature as being **the magnetic moment of the electron**, it seems that it would rather be **the magnetic moment of the carrying-energy of the electron** on the Bohr orbit, and not that of the electron proper, which implies that this magnetic dipole moment is likely to be different when the electron rests on a different orbit about a nucleus. We will define it yet more precisely further on when all required considerations have been analyzed.

Let us also note that the corresponding currently accepted value of the experimentally verified magnetic moment "of the electron" for the hydrogen atom rest orbit (**μ_e= 9.28476362 E-24 J/T**) is slightly higher than the theoretical value of the Bohr magneton and that this is considered to be an unexplained "anomaly".

tron. Since m=E/c^2, let us see from equation (26) what "mass" corresponds to the magnetic energy induced at the Bohr radius, by applying equation (6) to the Bohr radius magnetic energy:

$$M_m = \frac{E}{c^2} = \frac{\mu_B B_0}{c^2} = \frac{\mu_0 e^2}{8\pi r_0} = 2.42543459\,5E-35\,\text{kg} \tag{27}$$

so we will have

$$\mathbf{B}_0 = \frac{\mu_0 e^2 c^2}{8\pi r_0 \mu_B} \tag{28}$$

But let us recall that applying the quantized charge to the Biot-Savart law reveals that

$$\mu_B = ef\pi r^2 \tag{29}$$

so

$$\mathbf{B}_0 = \frac{\mu_0 e^2 c^2}{8\pi r_0 \mu_B} = \frac{\mu_0 e^2 c^2}{8\pi r_0 e\, f\, \pi r_0^{\,2}} = \frac{\mu_0 e c^2}{8\pi^2 r_0^{\,3} f} = 235051\ .735\, T \tag{30}$$

But we also know that the Bohr radius corresponds very precisely to the transverse electromagnetic amplitude of the wavelength of an electromagnetic photon of same energy as that induced at the Bohr radius,

$$r_0 = \frac{\lambda\alpha}{2\pi} \tag{31}$$

we can thus operate the following substitution

$$\mathbf{B} = \frac{\mu_0 e c^2}{8\pi^2 r_0^{\,3} f} = \frac{\mu_0 e c^2}{8\pi^2 (\lambda\alpha/2\pi)^3 f} = \frac{\mu_0 e c^2 8\pi^3}{8\pi^2 \lambda^3 \alpha^3 f} = \frac{\mu_0 e c^2 \pi}{\lambda^3 \alpha^3 f} \tag{32}$$

And finally, knowing that the frequency of the energy of an electromagnetic photon is equal to the speed of light divided by its wavelength, f=c/λ, we can substitute for f

$$\mathbf{B}_0 = \frac{\mu_0 e c^2 \pi}{\lambda^3 \alpha^3 (c/\lambda)} = \frac{\pi \mu_0 e c}{\lambda^2 \alpha^3} = 235051\ .\ 735\, T \tag{33}$$

This gives us a generalized equation allowing calculation of the local magnetic field of any isolated electromagnetic photon from its transverse electromagnetic wavelength, all other parameters being constants:

$$\mathbf{B} = \frac{\mu_0 \pi e c}{\alpha^3 \lambda^2} \tag{34}$$

Let us go back for a moment to the manner in which the Bohr magneton was associated to the magnetic field of the hydrogen atom least action ground state energy, with equation (25):

$$\mu_B = \frac{E}{2\mathbf{B}_0} \tag{34a}$$

This issue is discussed in a separate paper **[7]** that explains its perfectly normal relation to the electron gyroradius on the isolated hydrogen atom rest orbit.

From the new general equations for energy (11) and magnetic field (34), let us establish now the matching general equation for calculating dipole moments from the transverse wavelength of the energy considered:

$$\mu = \frac{E}{2\mathbf{B}} = \frac{\mu_0 e^2 c^2}{4\alpha\lambda}\frac{\alpha^3\lambda^2}{\mu_0 \pi e c} = \frac{ec\alpha^2\lambda}{4\pi} \tag{34b}$$

Let's compare this new equation with the standard equation for calculating the Bohr magneton:

$$\mu_B = \frac{eh}{4\pi m_e} = \frac{ec\alpha^2\lambda}{4\pi} = 9.274008985 \quad E-24\ J/T \tag{34c}$$

Isolating the wavelength in equation (34c), we effectively recover the wavelength of the carrying energy induced at the hydrogen atom ground state, which confirms the validity of equation (34b):

$$\lambda = \frac{h}{c\alpha^2 m_e} = 4.556335254 \quad E-8\,m \tag{34d}$$

Definition of a local discrete electric field for isolated photons

We know besides, that in an electromagnetic field, the density of magnetic energy per unit volume is equal to the density of electric energy (u_B=u_E)[3]

$$u_B = u_E = \frac{\mathbf{B}^2}{2\mu_0} = \frac{\varepsilon_0 \mathbf{E}^2}{2} \tag{35}$$

Now, considering that in the present context, electromagnetic fields would be caused by the presence of localized photons, any volume considered must contain at least 1 photon for any such energy density equality to be realized, meaning that the source(s) of the fields being measured must be included in the volume considered.

The recognized equality of electromagnetic energy density of both fields in any such given volume may appear surprising from our usual macroscopic viewpoint, where it is well established that macroscopic static magnetic fields (from permanent magnets for example) do exist without any trace of a detectable accompanying macroscopic static electric field; that is, macroscopic magnetic fields resulting from the addition of the submicroscopic magnetic fields of unpaired electrons that are forced into parallel spin alignment by the local electromagnetic equilibrium **[9]**.

The obvious reason for the absence of a macroscopic static electric field in this case is that forced spin alignment of unpaired electrons, involves no ionization, even though the individual magnetic fields related to the spin of the electrons involved do add up to become detectable at the macroscopic level due to their forced parallel alignment. The related discrete electric fields of the electrons involved, although present at the elementary level, being insensitive to spin alignment,

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[3] Let us note that the energy density involved here is the mean density within a particle if it is considered localized and not the traditional density calculated for wave treatment as being uniformly distributed within the reference volume (1 m^3 in MKS).

Let us also note that local equal density of electric and magnetic energy in a Maxwellian electromagnetic wave is associated to motion in straight line of any point of the wavefront in vacuum (c=**E**/**B**), and to the motion in straight line of an electron with the Lorentz equation (v=**E**/**B**).

are therefore not similarly coerced by the process to add up and become detectable as a matching macroscopic electric field, despite their confirmed presence at the elementary level.

It is also well established that static macroscopic electric fields (static charges on various objects) do build up from the addition of charges due to local ionization of materials making up these objects, without any accompanying buildup of a corresponding macroscopic static magnetic field. Since ionization does not modify the natural tendency towards lower energy antiparallel spin alignment, the best fit antiparallel spin alignment prevails, which prevents the discrete magnetic fields of the elementary particles involved from adding up to macroscopic sized magnetic fields. Of course, the individual magnetic fields of electrons remain present all the same at the submicroscopic level.

The only case where macroscopic electric and magnetic fields can be measured as having equal energy density is about a wire conducting an electrical current. In this particular case, the fundamental and irrepressible triply orthogonal alignment of both electric and magnetic fields relative to the forced common direction of motion of electrons involved, forces both fields of these electrons in motion to synchronously add up and become macroscopic size fields with equal energy density.

So considering a volume enclosing the electron and its carrier-photon in the ground state of the Bohr atom, the density of magnetic energy induced per unit volume at the Bohr orbit will thus be:

$$u_B = \frac{\mathbf{B}^2}{2\mu_0} = \frac{(235051.735)^2}{2\mu_0} = 2.198300521 \quad E16 \quad J/m^3 \tag{36}$$

The electric field corresponding to that magnetic field would then be

$$\mathbf{E} = \sqrt{\frac{2u_B}{\varepsilon_0}} = 7.04667374 \quad E13 \quad J/C.m \tag{37}$$

On the other hand, by substituting the new definition of **B** in **E**=c**B** detailed in equation (34)

$$\mathbf{E} = c\mathbf{B} = \frac{\pi\mu_0 ec^2}{\alpha^3\lambda^2} \quad \text{and substituting for} \quad \mu_0 = \frac{1}{\varepsilon_0 c^2} \tag{38}$$

we obtain

$$\mathbf{E} = \frac{\pi ec^2}{\varepsilon_0 c^2\alpha^3\lambda^2} = \frac{\pi e}{\varepsilon_0\alpha^3\lambda^2} \tag{39}$$

We have consequently defined a new generalized equation that allows calculating the electric field of any isolated photon founded on the premise that the photon is at all times localized, by integrating spherically its energy, mathematically considered to diminish radially from a maximum intensity level set at a minimal distance from its center determined by $\lambda\alpha/2\pi$, to a minimum intensity level located at infinity, as previously explained

$$\mathbf{E} = \frac{\pi e}{\varepsilon_0\alpha^3\lambda^2} \tag{40}$$

Confirming Conformity with Maxell's Equations

Now, before going further, let's see if this electric field equation (40) for a localized photon is in harmony with Maxwell's first equation, that is, Gauss's law for electric fields. In order to conform, equation (40) must represent a charge enclosed in a spherical closed surface, because Gauss's law states that the electric flux across a closed surface (Φ_E) will be equal to the product of that electric field by the closed surface considered, which should result in a flux of $\mathbf{q/\varepsilon_0}$ through this surface after integrating the energy of equation (40).

We know besides that the surface of a sphere is expressed by $\mathbf{S=4\pi r^2}$. We already identify the expression for flux $\mathbf{e/\varepsilon_0}$ in equation (40), which leaves the remainder of the expression, $\boldsymbol{\pi/\alpha^3\lambda^2}$, to represent, theoretically at this point, a spherical closed surface. Let's leave $\boldsymbol{\alpha^3}$ unattended for the moment and analyze the remaining relation $\boldsymbol{\pi/\lambda^2}$. Since the amplitude of a wavelength $\boldsymbol{\lambda}$ is $\mathbf{r} = \boldsymbol{\lambda/2\pi}$, we know that $\boldsymbol{\lambda = 2\pi}\mathbf{r}$, which means that $\boldsymbol{\pi/\lambda^2} = \boldsymbol{\pi/(2\pi r)^2} = \boldsymbol{\pi/4\pi^2 r^2} = \mathbf{1/4\pi r^2}$ which reveals that $\boldsymbol{\pi/\lambda^2}$ effectively is the inverse of the expression for a closed spherical surface!

Let's now deal with expression $\boldsymbol{\alpha^3}$. Now, fine structure constant $\boldsymbol{\alpha}$ being dimensionless, the remaining expression $\boldsymbol{\alpha^3}$ can then be included in with the representation of the closed surface since it does not introduce any unwanted units. We then observe that equation (40) effectively involves a flux divided by a closed surface:

$$\mathbf{E} = \frac{q}{\varepsilon_0 S} = \frac{e}{\varepsilon_0}\frac{\pi}{\alpha^3\lambda^2} = \frac{e}{\varepsilon_0}\frac{\pi}{\alpha^3(2\pi r)^2} = \frac{e}{\varepsilon_0}\frac{\pi}{\alpha^3 4\pi^2 r^2} = \frac{e}{\varepsilon_0}\frac{1}{\alpha^3 4\pi r^2} \qquad (40)$$

This makes obvious that to obtain the flux related to this definition of the electric field of a photon, the generic closed surface has to correspond very precisely to $\mathbf{S=\boldsymbol{\alpha}^3 4\boldsymbol{\pi} r^2}$. So let's integrate:

$$\mathbf{\Phi}_E = \oint \mathrm{E}\cdot d\mathbf{S} = \left(\frac{e}{\varepsilon_0}\frac{1}{\alpha^3 4\pi r^2}\right)\alpha^3 4\pi r^2 = \frac{e}{\varepsilon_0}$$

which confirms that this definition of the electric field of a localized photon is in perfect harmony with Maxwell's first equation as as Louis de Broglie hypothesized. Furthermore, it will be possible to correlate this surface ($\boldsymbol{\alpha^3 4\pi}\mathbf{r^2}$) with the **theoretical stationary isotropic volume** that we will shortly define, and that can also be related to the magnetic field equation for localized photons that we will explore a little further on.

We observe finally that it is now possible to directly correlate the wavelength of a localized photon to Maxwell's first equation.

Establishment of the Theoretical Stationary Isotropic Volume of the Oscillating Kinetic Energy of a Localized Electromagnetic Particle

Now let's see how the values obtainable from this equation compare with the values from more traditional non-local electromagnetism. An easy way to tackle this issue is to assume the presence of n monochromatic photons in the MKS 1 cubic meter reference volume of the electromagnetic energy density equation:

$U = \varepsilon_0 \mathbf{E}^2$ whose units are joules per cubic meter (J/m^3)

If we assume the presence of only one photon in our reference volume, U will of course be equal to the energy of that single photon. Working again with our familiar reference Bohr ground state energy of 27.21138345 eV, that is 4.359743805E-18 J, we can say:

$$U = 4.359743805\text{E-18 J/m}^3 \tag{40a}$$

and of course

$$\mathbf{E} = \sqrt{\frac{U}{\varepsilon_0}} = 7.017075019 \text{ E} - 4 \; J/C\cdot m \tag{40b}$$

Let us note that this value mathematically amounts to considering the energy of that single photon as being uniformly spread out within the whole 1 m^3 reference volume, and does not allow localizing the photon with any precision within that volume. Now, let us compare this to the value we found with equation (37), that we can now calculate from the Bohr ground state energy wavelength of (λ = hc/E = 4.556335256E-8 m):

$$\mathbf{E} = \frac{\pi e}{\varepsilon_0 \alpha^3 \lambda^2} = 7.04667374 \; E13 J/C \cdot m \tag{40c}$$

We can immediately see that equation (40c) provides a field intensity immensely higher than traditional equation (40b), which immediately hints that the energy must be much more concentrated and localized than the 1 m^3 reference volume would warrant. We will now proceed to determine what local volume is coherent with this very large intensity revealed with equation (40c). Let us first calculate the associated energy density:

$$U = \varepsilon_0 \mathbf{E}^2 = \varepsilon_0 \left(\frac{\pi e}{\varepsilon_0 \alpha^3 \lambda^2} \right)^2 = \frac{\pi^2 e^2}{\varepsilon_0 \alpha^6 \lambda^4} = 4.396601042 \; E16 \;\; J/m^3 \tag{40d}$$

which confirms an apparent energy density way higher than with the traditional non-localized value provided with equation (40a).

Now, the question is: What volume can be associated with such a high local energy density?

We know that ***U*** is made up of an energy value in Joules divided by a volume in m^3. So let's see if we can give that form to the equation. Going back to equation (11) that defines the energy in joules in the present equation set, and comparing it with equation (40d), we observe that equation (11) is a subset of equation (40d). So, let us separate the part of (40d) that has the form of an energy in Joules from the rest of the equation:

$$U = \frac{\mathrm{e}^2}{2\varepsilon_0 \alpha \lambda} \times \frac{2\pi^2}{\alpha^5 \lambda^3} \tag{40e}$$

The remainder of the equation now has to take the form of a volume dividing the energy value, so let's proceed:

$$U = E \times \frac{1}{V} = \frac{e^2}{2\varepsilon_0 \alpha \lambda} \times \frac{1}{\left(\frac{\alpha^5 \lambda^3}{2\pi^2} \right)} \tag{40f}$$

We can now observe that since $\boldsymbol{\alpha}$ and $\boldsymbol{\pi}$ are dimensionless, the units of the part of the divisor meant to represent a volume are correct, that is, cubic meters (m^3), and all that remains to be done now is to see if it can represent a spherical volume. Since the circumference of a sphere is equal to **2πr**, we can easily adapt the traditional equation for calculating the volume of a sphere to use the circumference of the sphere which amounts to the wavelength (λ) of the cyclic electromagnetic motion of the energy of our photon, since its amplitude would be λ/2π:

$$V = \frac{4\pi r^3}{3} = \frac{4\pi}{3}\left(\frac{\lambda}{2\pi}\right)^3 = \frac{4\pi}{3}\frac{\lambda^3}{8\pi^3} = \frac{\lambda^3}{6\pi^2} \tag{40g}$$

So, we can see by observing equation (40g) that we only need to multiply and divide the parenthesized divisor of equation (40f) by mutually canceling values 3 to obtain the required spherical volume equation:

$$U = E \times \frac{1}{V} = \frac{e^2}{2\varepsilon_0 \alpha\lambda} \times \frac{1}{3\alpha^5\left(\frac{\lambda^3}{6\pi^2}\right)} \tag{40h}$$

Let us now resolve this equation for our reference energy:

$$U = \frac{e^2}{2\varepsilon_0 \alpha\lambda} \times \frac{1}{3\alpha^5\left(\frac{\lambda^3}{6\pi^2}\right)} = \frac{4.359743805\ E-18J}{9.916168825\ E-35m^3} \tag{40i}$$

So we have our exact reference energy in joules divided by the volume that determines the energy density within that volume. From (40g) and (40i), we draw the following equalities:

$$\mathrm{V} = \frac{\alpha^2}{} \frac{\lambda^3\alpha^3}{2\pi^2} = 9.91616882\ 5\mathrm{E}-35\mathrm{m}^3 \tag{40ii}$$

Which means that from (40g), we obtain the following radius:

$$\mathrm{r} = \sqrt[3]{\frac{3\mathrm{V}}{4\pi}} = 2.87134317\ 3\mathrm{E}-12\mathrm{m} \tag{40j}$$

Now what is the meaning of this radius? Let us compare it with the amplitude of the wavelength of our reference energy (4.359743805E-18 J), which will be:

$$A = \frac{\lambda}{2\pi} = \frac{hc}{2\pi E} = 7.251632784\ E-9m \tag{40k}$$

and with the lower limit of integration of that photon's energy which is at the origin of the development of the present equation set:

$$r_0 = \frac{\lambda\alpha}{2\pi} = \frac{hc\alpha}{2\pi E} = 5.291772086\ E-11m \tag{40l}$$

So we observe from comparing the radius (40j) of the spherical volume defined by energy density equation (40i) that this volume is smaller than the volume that can be determined by the amplitude of the full wavelength of the photon's energy (40k) and that it is even smaller than the volume that can be determined by the lower limit of spherical integration of its energy (40l). In fact, it is exactly 18.42960512 times smaller than this lower limit of integration.

Consequently, we observe that the volume determined with equation (40h) is definitely coherent with the photon being permanently localized, and localizable at any point along whatever trajectory it may follow.

Note however that this volume cannot possibly reflect the actual physical extent of the transverse electromagnetic oscillation of the energy the localized particle, which, in the present state of this analysis, seems to correspond to the transverse amplitude obtained from the wavelength of its energy, multiplied by the fine structure constant ($r = \lambda\alpha/2\pi$), which is also the lower limit of integration of an electromagnetic particle's energy, as put in perspective at the beginning of this analysis (ref: equation (8) and related discussion).

This volume (40i) simply is the minimum volume within which the amount of kinetic energy "substance" of a photon would be contained if it was immobilized and distributed with uniform density *U* after spherical integration to infinity (∞) from a distance from r=0 corresponding to $\lambda\alpha/2\pi$ as can be extrapolated from Marmet's paper.

Consequently, the actual volume of space within which the electric and magnetic fields of an elementary particle are bound to oscillate has to be markedly larger with much lower density than this limit suggests.

Using this concept to geometrically set this smallest stationary isotropic volume of energy back into oscillating motion at its natural frequency would be interesting indeed! Presently, the possible internal dynamic motion of a photon's energy is fully described in separate papers [8, 11].

Let's now continue our analysis of the **E** and **B** fields equations (40) and (34) of this new equations set. If we multiply and divide equation (40) by mutually reducible values "2e" and rearrange, we can see that the new energy equation (11) is a subset of the **E** field equation, so we can write:

$$\mathbf{E} = \frac{\pi e}{\varepsilon_0 \alpha^3 \lambda^2}\frac{2e}{2e} = \frac{2\pi}{e\alpha^2\lambda}\frac{e^2}{2\varepsilon_0\alpha\lambda} = \frac{2\pi E}{e\alpha^2\lambda} \tag{41}$$

Similarly, if we multiply and divide equation (34) by mutually reducible values "2ce" and rearrange, we can write:

$$\mathbf{B} = \frac{\mu_0 \pi e c}{\alpha^3\lambda^2}\frac{2ce}{2ce} = \frac{2\pi}{ce\alpha^2\lambda}\frac{\mu_0 c^2 e^2}{2\alpha\lambda} = \frac{2\pi}{ce\,\alpha^2\lambda}\frac{e^2}{2\varepsilon_0\alpha\lambda} = \frac{2\pi E}{ce\alpha^2\lambda} \tag{42}$$

We observe now that the only difference between these new definitions of electric and magnetic fields is that the magnetic field is equal to the electric field divided by the speed of light "c". Let us verify the soundness of these new generalized equations with the well known energy induced at the Bohr radius, that is, 4.359743805E-18 J. From equations (41) and (42), we get:

$$\mathbf{E} = \frac{2\pi E}{e\alpha^2\lambda} = 7.04667373\ 1\ \text{E13 J/Cm} \quad \text{and} \quad \mathbf{B} = \frac{2\pi E}{ce\alpha^2\lambda} = 235051\ .\ 7347\ \text{T} \tag{43}$$

This means that if we divide these two equations term for term and simplify, we will recuperate equation $c=\mathbf{E}/\mathbf{B}$, which was previously derivable only from Maxwell's 4th equation:

$$\frac{\mathbf{E}}{\mathbf{B}} = \frac{2\pi \mathrm{E}}{\mathrm{e}\alpha^2\lambda}\frac{\mathrm{c}\,\mathrm{e}\alpha^2\lambda}{2\pi \mathrm{E}} = \mathrm{c} \tag{44}$$

We now of course obtain the speed of light from the values obtained with equations (43):

$$c = \frac{\mathbf{E}}{\mathbf{B}} = \frac{7.046673731\ E13}{235051.7347} = 299{,}792{,}458\ m/s \tag{45}$$

which is exact, and will be for any individual localized photon, whatever its energy.

Defining the general relativistic magnetic field equation for moving massive particles

Our prior use of the energy induced at the Bohr radius to verify some actual figures was not totally innocent. It was also meant to highlight the fact that although this amount of free energy will move at the speed of light, it can move only at the known theoretical velocity associated with the Bohr orbit when it is associated with an electron, because it is then slowed down as a function of the “inert” mass of the electron that it is now forced to “carry”, so to speak (2,187,691.252 m/s by classical calculation and 2,187,647.566 m/s by relativistic calculation).

Since from considerations outside the scope of this paper, this carrying energy seems to be of the very same nature as free moving electromagnetic energy, although captive of the electron, we will attempt to see if we can coherently associate the electric and magnetic fields that we just defined for free moving photons to the energy of a moving electron to confirm this identity.

Let us recall that the equation we just used to calculate the speed of light from the electric and magnetic fields of a photon is derived from Maxwell's 4th equation (Ampere's law generalized).

$$\mathrm{c} = \frac{\mathbf{E}}{\mathbf{B}} \tag{46}$$

Let us also put in perspective that the Lorentz equation

$$\mathbf{F}_{(x,t)} = q(\mathbf{E} + \mathbf{v} \times \mathbf{B}) \tag{47}$$

allows deriving a very similar equation for charged particles in motion, that allows calculating the straight line velocity of an electron from the intensities of constant external orthogonal electric and magnetic fields in which the particle is placed

$$\mathrm{v} = \frac{\mathbf{E}}{\mathbf{B}} \tag{48}$$

The condition for straight line motion in this context is precisely that **E**=v**B**, which results in zero net transverse forces being applied to the moving electron, because the opposing transverse electric and magnetic resultant forces cancel each other out, which causes the particle to move in a straight line in the field, which is a case very familiar in high energy accelerator circles.

Let us now see if it is possible to convert the equation drawn from Maxwell's 4th for a normal photon to that other equation drawn from Lorentz, to calculate the relativistic velocities of an electron by associating the energy of an electron to that of a normal photon, since we postulate here that the energy that determines the velocity of an electron would precisely be that of a perfectly normal photon that would simply be slowed down by the inert energy of the electron mass that it would be forced to "carry".

In fact, this is precisely what is confirmed in a separate paper that describes how Newton's kinetic energy equation can be step by step upgraded to full relativistic status **[10]**.

It could be considered in a simplistic way that we only need to add the electron fields to those of a photon to obtain the corresponding velocity. Interestingly, this can indeed be done directly for the magnetic fields of the electron and of the carrier-photon, as Marmet indirectly demonstrated (**[1]**, p. 1 to 7).

The magnetic resultant field for a moving electron would then be

$$\mathbf{B} = \frac{\pi\mu_0 ec}{\alpha^3\lambda^2} + \frac{\pi\mu_0 ec}{\alpha^3\lambda_C{}^2}, \quad \text{that is} \quad \mathbf{B} = \frac{\pi\mu_0 ec}{\alpha^3}\frac{\left(\lambda^2 + \lambda_C{}^2\right)}{\lambda^2\lambda_C{}^2} \tag{49}$$

where λ is the wavelength of the carrier-photon (λ = c h/(Energy of the photon)), and λ_C is the Compton wavelength, which is the wavelength of the invariant energy of the electron.

But the situation is much more complex for the electric field, since from considerations clarified in **[3]**, the invariant electron energy corresponding to its electric field is apparently unidirectional and is oriented orthogonally with respect to that corresponding to the electric field of its carrier-photon.

The combined electric field of the carrier-photon and electron should thus be a vectorial resultant of the complex product of these electric fields. Such a direct calculation could prove extremely difficult in the current state of our comprehension, but we have alternately at our disposal a much simpler method to define this relation, by using the relation equivalent to **E**=c**B** when dealing with moving massive charged particles, that is **E**=v**B**.

This involves first establishing an equation to obtain relativistic velocity "v" from a redefinition of the relativistic gamma "**γ**" factor.

Redefining gamma

After having clearly defined the combined magnetic **B** field of the electron in motion thanks to Marmet's contribution, we now need to establish a clear definition of v. The resolution of both **B** and v will ultimately allow us to clarify the complex structure of combined electric field **E** in the case of a moving electron.

We know to start with, that the velocity involved will have to be the relativistic velocity of the particle, so we will start from the well known standard equation for calculating relativistic velocities.

$$E = \gamma mc^2 \quad \text{from which we derive of course} \quad v = c\sqrt{1 - \left(\frac{mc^2}{E}\right)^2} \tag{50}$$

We know on the other hand that "E" in this equation represents the energy contained in the relativistic mass of a particle moving at any given velocity, and is thus made up of the rest mass energy of the particle plus half of its carrying energy **[10]**, so we can write:

$$v = c\sqrt{1-\left(\frac{mc^2}{mc^2+E_P/2}\right)^2} \tag{51}$$

consequently, we can operate the following transformation

$$v = c\sqrt{1-\left(\frac{mc^2}{mc^2+E_P/2}\right)^2} = c\sqrt{1-\frac{1}{\left(\frac{mc^2+E_c/2}{mc^2}\right)^2}} = c\sqrt{1-\frac{1}{\left(1+\frac{1}{mc^2}\frac{E_P}{2}\right)^2}} \tag{52}$$

From the definition of energy clarified in equation (10),

$$E_P = \frac{e^2}{2\varepsilon_0\alpha\lambda}, \qquad \text{and} \qquad m_0c^2 = \frac{e^2}{2\varepsilon_0\alpha\lambda_C} \tag{53}$$

Substituting equations (53) in equation (52)

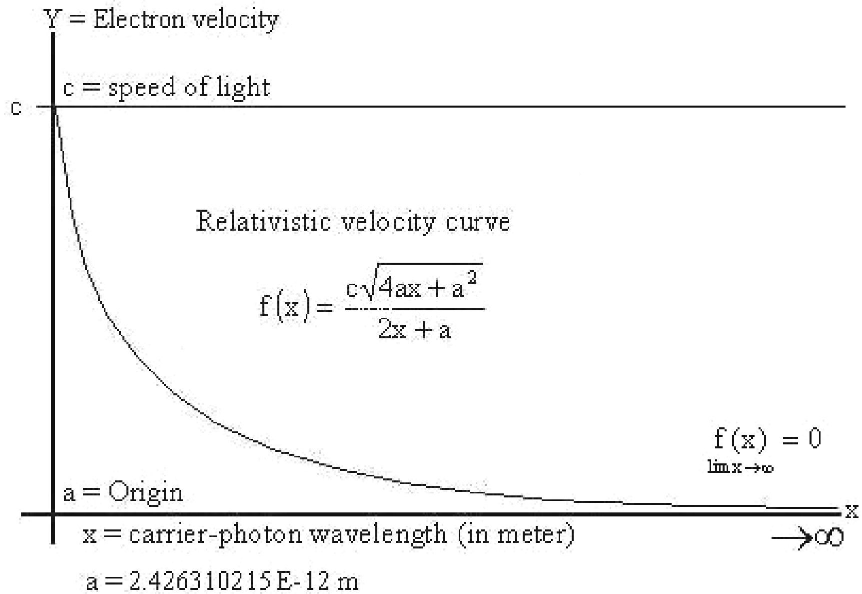
$$v = c\sqrt{1-\frac{1}{\left(1+\frac{1}{mc^2}\frac{E_P}{2}\right)^2}} = c\sqrt{1-\frac{1}{\left(1+\frac{2\varepsilon_0\alpha\lambda_C}{e^2}\frac{e^2}{4\varepsilon_0\alpha\lambda}\right)^2}} = c\sqrt{1-\frac{1}{\left(1+\frac{\lambda_C}{2\lambda}\right)^2}} \tag{54}$$

Simplifying equation (54) to its simplest expression, we obtain a simplified equation to calculate the relativistic velocity of an electron that uses only one variable, that is, the wavelength of the carrying energy.

$$v = c\sqrt{1-\frac{1}{\left(1+\frac{\lambda_C}{2\lambda}\right)^2}} = \frac{c\sqrt{\lambda_C\left(4\lambda+\lambda_C\right)}}{\left(2\lambda+\lambda_C\right)} \tag{55}$$

If we now give equation (55) the generic form required to trace the relativistic velocities curve for the electron, we obtain

$$f(x) = c\frac{\sqrt{4ax+a^2}}{2x+a} \tag{55a}$$



Defining the general relativistic electric field equation for moving massive particles

So we now have at our disposal clear definitions of both terms located to the right of equation **E**=v**B**. Substituting for "v" and "**B**", we obtain:

$$\mathbf{E} = \frac{c\sqrt{\lambda_C(4\lambda+\lambda_C)}}{(2\lambda+\lambda_C)}\frac{\pi\mu_0 ec}{\alpha^3}\frac{(\lambda^2+\lambda_C{}^2)}{\lambda^2\lambda_C{}^2} \tag{56}$$

Substituting for $\mu_0=1/\varepsilon_0 c^2$:

$$\mathbf{E} = \frac{c\sqrt{\lambda_C(4\lambda+\lambda_C)}}{(2\lambda+\lambda_C)}\frac{\pi ec}{\varepsilon_0\alpha^3 c^2}\frac{(\lambda^2+\lambda_C{}^2)}{\lambda^2\lambda_C{}^2} \tag{57}$$

and simplifying, we obtain an electric field equation for the electron in motion whose first part is identical to that of a free photon of same energy as the carrying energy of a massive particle, multiplied by the resolved complex ratio of the orthogonal relations of the electrical energy of the electron and the carrier-photon:

$$\mathbf{E} = \frac{\pi\, e}{\varepsilon_0\alpha^3}\frac{(\lambda^2+\lambda_C{}^2)}{\lambda^2\lambda_C{}^2}\frac{\sqrt{\lambda_C(4\lambda+\lambda_C)}}{(2\lambda+\lambda_C)} \tag{58}$$

We now have at our disposal two equations (49) and (58) for the electric **E** and magnetic **B** fields of a moving electron that require only one variable, that is, the wavelength of the carrier-photon, similarly to those that we previously defined for individual photons.

Let's confirm with an example that these relativistic field equations will provide true relativistic velocities. For an energy of 4.359743805E-18 J (27.2 eV), whose wavelength is λ= ch/E = 4.556335256E-8 m, we obtain with equation (58) an electric field of:

$$\mathbf{E} = \frac{\pi e}{\varepsilon_0 \alpha^3} \frac{\left(\lambda^2 + \lambda_C{}^2\right)\sqrt{\lambda_C\left(4\lambda + \lambda_C\right)}}{\lambda^2 \lambda_C{}^2 \quad \left(2\lambda + \lambda_C\right)} = 1.813341121 \ \ E13 \ J/Cm \qquad (59)$$

and with equation (49) a magnetic field of:

$$\mathbf{B} = \frac{\pi \mu_0 e c}{\alpha^3} \frac{\left(\lambda^2 + \lambda_C{}^2\right)}{\lambda^2 \lambda_C{}^2} = 8.289000246 \ \ E13 \ Js/Cm^2 \qquad (60)$$

Resolving the velocity equation, we obtain:

$$v = \frac{\mathbf{E}}{\mathbf{B}} = 2{,}187{,}647.566 \ m/s \qquad (61)$$

which is the precise relativistic velocity of an electron moving in straight line with an energy corresponding to the Bohr ground state energy.

Calculation with various energies will show that the velocities curve obtained is exactly the same as with the traditional relativistic velocity equation.

Conclusion

Here are the implications of these field equations, (34) and (40) for photons, and (49) and (58) for moving massive particles, that require only the wavelengths of localized electromagnetic events to determine their velocity:

1) That the existence of permanently localized photons is directly reconcilable with Maxwell's electromagnetic equations, as hypothesized by Louis de Broglie (**[4]**, p. 277).
2) That it is possible to calculate the individual electromagnetic fields of electrons and for their carrying energy, which hints at the possibility of establishing similar fields equations for up and down quarks inside nuclei and atoms, which also are charged and massive elementary particles, and for their carrying energy, and thus determine the contribution of each of them to the resulting electromagnetic equilibrium inside atoms **[9]**.
3) That the energy induced in electrons and sets them in motion is electromagnetic in nature, and is of the same nature as that making up free moving electromagnetic photons.
4) While Newton's First Law describes the tendency of massive bodies to move in straight line and maintain their state of motion when no outside force is acting on them, these electromagnetic equations for free moving electromagnetic photons and massive particles in motion, describe and explain why they behave according to this law, simply due to the fact that both electric and magnetic fields of their carrier-photons stabilize at equal densities by structure when no transverse force is acting on them **[11]**.

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