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A Classic Interpretation of the Wave Function and of the Quantum Potential

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Abstract

By considering wave-particle dualism with an interpretation of the squared amplitude of the wave function $R^2(\Psi)$ compatible with the known Bohm's equations, for a 1 MeV-gamma-quantum considered as 'gammonic' (e^-e^+)- pair of electrons having the phase speed of the associated wave equal to the group speed, it results a value of the quantum potential Q equal to the particle's kinetic energy, $Q_c = ½mv^2$. For a classic model of electron composed by heavy photons, this value is explained by a generalized relation of quantum equilibrium of de Broglie type, with the associated entropy proportional to its action S, as representing a centrifugal potential given by a spinorial mass $m_s = n_v m_v \approx m_e$ resulted by n_v -vector photons explaining also a half of the electron's rest energy, by considering a low frictional component and a dynamic component of the quantum vacuum- given by quantum and sub-quantum winds which generates also a centripetal quantum force of Magnus type acting over the rotated vector photons and corresponding to a vortical potential Q_a which maintains the centrifugal potential Q_c . The spinorial energy of the vector photons contained by the electron's shell can explain the second half of its rest energy and the Lorentz force, resulted as quantum force of Magnus type. In the Galilean relativity, the resulted interpretation indicates a rest energy at least for photons of gamma quantum, in concordance with known relation for the red-shifted photon's frequency in a gravitational field.

Keywords: Bohm equations, quantum potential, electron vortex, rest energy, photon, gamma quantum, gravitational redshift

1. Introduction

It is known that- at the base of the wave –particle dualism, inserting the wave function ψ in polar form into the Schrödinger's equation, written – for simplicity, for a single particle:

$$i\hbar\frac{\partial\Psi}{\partial t} = -\frac{\hbar^2}{2m}\nabla^2\Psi + V\Psi \; ; \quad \Psi(x,t) = R\cdot e^{iS/\hbar} \; ; \; (\hbar = h/2\pi; \quad i=\sqrt{-1} \quad) \tag{1}$$

(V – classical potential; R, S - real-valued functions of space and time) and separating the real and imaginary terms, were obtained the Bohm's equations [1] :

$$\frac{\partial S}{\partial t} + \frac{(\nabla S)^2}{2m} + V - \frac{\hbar^2}{2m}\frac{\nabla^2 R}{R} = 0 \; ; \qquad -\frac{\hbar^2}{2m}\frac{\nabla^2 R}{R} = Q \tag{2}$$

$$\frac{\partial R^2}{\partial t} + \nabla\cdot\left(R^2\frac{\nabla S}{m}\right) = 0 \tag{3}$$

If $\rho = \psi\cdot\psi^* = R^2$ is interpreted as a probability density of particles distribution, Eq. (3) is the continuity equation, Eq. (2) representing the quantum Hamilton-Jacobi equation.

It is also considered that the potential Q generates an additional quantum force $F = -\nabla Q$, of particle's interaction with a sub-quantum fluid of the quantum vacuum .

According to the de Broglie-Bohm causal interpretation, the particle's path is deterministic, $R^2(\mathbf{x},t)d\mathbf{x}$ representing the probability that a particle lies between **x** and **x** + d**x**, [1].

In an interpretation given by Giovanni S., Erasmo R. and co-workers (1998, [2]) to the Bohm's quantum potential:

$Q = -(\hbar^2/2m)(\Delta\sqrt{\rho}/\sqrt{\rho})$, it is identified with the kinetic energy of a rotation motion ("zitterbewegung") associated with the spin s = ½ħ of the fermionic particle, (particularly –of the electron), in accordance with the Schrodinger's equation written in the form: $-(2s^2/m)\Delta\Psi = E\Psi$, the internal zitterbewegung velocity being: $V = \nabla\rho x \mathbf{s}/m\rho$, ($\rho = R^2$).

It is known also that –using a complex velocity: $v^i = v + i\cdot u$, and a complex action, $S^i = S_p + iS_R$, in the scale relativity theory Nottale has shown that –expressing u in terms of the modulus of $\psi = e^{iS/\hbar}$, i.e.: $u = D\nabla \ln R^2$, ($R^2 = |\psi|^2$), with the scale parameter: $D = \hbar/2m$, the variation of the u –velocity introduces a new force: $F = m(du/dt) = -\nabla Q$ which derives from a quantum potential $Q = -(\hbar^2/2m)(\Delta R/R)$, [3].

Relating to the electron's structure, it is known that the Quantum Mechanics considers the electron as being an almost point-like particle, with radius of at most 10^{-18} m, [4] , but in a classical model, this value corresponds to the radius of a dense kernel of a quantum volume of photons with inertial mass m_f which give the electron's inertial mass, m_e ,[5].

An interpretation of the Q-potential was obtained by a classic model of electron with confined photons by considering a vortical structure with a relativist speed ($v \sim r^{-3}$), of a vortexed quantum fluid, ([6], p.137) and by using the relations specific to quantum equilibrium obtained by de Broglie [7], but in the form: $\varepsilon'/k_b = iS_0/\hbar$, (ε' -the associated entropy; $S_0 = \int L dt$ –the physical action; k_b –the Boltzmann's constant; $\hbar = h/2\pi$, h -the Planck constant), specific to the case of a stationary entropy: $\varepsilon' = - k_b \ln\rho_p = - k_b \ln R$, resulting by Boltzmann's relation: $\varepsilon = k_b\cdot\ln W$, (with W = n - number of equally probable microstates of the considered state), by attributing a quantity of heat δQ acquired from the quantum vacuum to any variation: δM_0c^2 . Conform to Eq. (3), if ρ_p is interpreted as a probability density, it is necessary to take $\rho_p = R^2$, i. e.:

$$\varepsilon = - k_b\ln\rho_p = - k_b\ln R^2 , \qquad (R^2 = |\psi|^2 = e^{-\varepsilon/k}) \tag{4}$$

It was also considered [6] that the quantum potential Q can explain the genesis and the stability of the electron but considered in a classic model, of confined and vortexed photons.

Conform to the Sidharth's classic model of electron [8], the vortex of the electron's mass is extended with a circulation $\Gamma_e(r) = 2\pi rc$, (c-the light's speed) until the limit $r \le r_\lambda = \hbar/m_v c$, explaining classically the electron's spin, but in another classic (Lorentzial, spatially extended) electron model [5], the electron's mass volume has a classic radius: $r_0 = a = 1.41$ fermi corresponding to e-charge in electron's surface, the electron's spin $s_e = \hbar/2$ being given also by a vortex $\Gamma_e(r) = 2\pi rc$, extended until the limit $r \le r_\lambda = \hbar/m_v c$, (the Compton radius), but given by a total spinorial mass $m_s = m_e$ of light vector photons ($m_v \approx 10^{-40}$ kg [5]) which do not contribute to the electron's inertial mass- being weakly linked on it, conform to the same classic relation:

$$s_e = \Sigma m_f \cdot(\omega\cdot r)\cdot r = 4\pi\int r^2\rho_e(r)c\cdot r dr \approx ½ m_s\cdot c\cdot r_\lambda = \hbar/2 , \quad (\omega\cdot r = c; \;\; a \le r \le r_\lambda = \hbar/m_e c; \; m_s \approx m_e), \tag{5}$$

specific to a spherical distribution of the m_f –photons: $\rho_e(r) = \rho_e(r)(r_0/r)^2$, an identical value, $\hbar/2$, being obtained also for a cylindrical distribution of photons in a volume of Compton radius $r_\lambda = \hbar/m_e c$ and high $l_a = 2a$, [5].

Relating to the electron's mass variation with its speed, the use of the Galilean relativity was justified by the fact that Lorentz's expressions of the speed-depending longitudinal and transversal mass of a charged particle accelerated by a quanta flux pressure can be re-obtained as apparent effect generated by a real decreasing of the values of the longitudinal and transversal electric field, $E_L \sim \gamma_c^{-3}$; $E_T \sim \gamma_c^{-1}$, ($\gamma_c = 1/\sqrt{(1 - v^2/c^2)}$), and of the magnetic field: $B \sim \gamma_c^{-1}$, which explains the experimental result of the Kaufmann- Bucherer experiments by the Galilean relativity- in this case, being also re-obtained the general form of the Doppler-Fizeau effect [9].

It is known also that the 1 MeV –gamma quantum can be split into a pair e^- -e^+ in a nuclear E-field, phenomenon that suggests that it is formed as (e^-e^+)-pair of possibly degenerated electrons of opposed charges, magnetically coupled, i.e.- a 'gammon' having rest mass $m_\gamma \approx 2m_e$ –in the Galilean relativity. The conclusion that the 1 MeV- gamma quantum must have a rest energy of the same size order with its displacement energy is in concordance with the fact that the two gamma-photons resulted from the 'annihilation' of an electron with a positron have an energy equal with the electron's rest energy.

The considered "gammons" were experimentally observed [10] in the form of quanta of "un-matter" plasma, (pairs of matter and antimatter particles). However, because the speed v = c of the 1 MeV- gamma quantum, it is considered in the quantum mechanics that it is a boson with null rest mass and rest energy.

Because this contradiction, for a classic interpretation of the physical nature of the 1 MeV- gamma quantum and of the quantum potential of a moving electron, we will use the case of a "gammon" translated with $v \le c$ and considered as negatron-positron pair, by using the Galilean relativity in report with the particle's mass variation.

3. A classic interpretation of the quantum potential for a classic model of electron

3.1. The quantum potential as vortical energy of a classic electron

-Regarding Equation (2), if the m-particle has a constant total energy E(v), given by a Hamiltonian H which is not time-depending, and if R and Q are independent of time, Eq. (1) corresponds to a stationary state ($\hat{H}\Psi = E\Psi$) and separation of variables can be applied.

It is known that the electron is a fermion whose movement is described by the Dirac equation of relativistic quantum mechanics. However, Schrödinger's equation was successfully used for the computation of the hydrogen spectral series by treating the electron of the hydrogen atom moving in an electric potential well, as on a wave. Also, it is known that there is no particular need to focus on Dirac spinors in the classical theory.

From the previous observations, it follows the conclusion that- for the moving of a bosonic particle resulting as negatron-positron pair (which can be named "gammon", by analogy with a 1MeV-gamma quantum that can split in a pair e^- -e^+ in a nuclear E-field), in the Galilean relativity the basic Schrödinger equation (1) can be used also for relativist speeds.

Taking V = 0 in Schrödinger's Eq. (1) and associating to the free "gammon" of m_γ -mass and v-speed a wavelength λ and a wave function corresponding to a plane wave:

$$\Psi(x,t) = R\cdot e^{i(k\cdot x - \omega\cdot t)} = R\cdot e^{iS(x,t)/\hbar} = \Psi_0(x)\cdot e^{-iE\cdot t/\hbar}\,; \tag{6}$$

where: $S(x,t) = S_0(x) - E(v)\cdot t$, ($\nabla S_0(x) = p_\gamma = m_\gamma v$, $k = 2\pi/\lambda$, $\omega = 2\pi/T$), then eq. (2) becomes :

$$E = -\partial S/\partial t = \hbar\cdot\omega = (\nabla S)^2/2m_\gamma + Q_\gamma = E_{\gamma k} + Q_\gamma = H_\gamma \tag{7}$$

In the de Broglie's theory, the wavelength $\lambda_v = h/m\cdot v_g$ is associated to the moving particle with a speed-depending mass, m = f(v), by a group speed $v_g = c^2/v_p$, (v_p -the phase speed) , resulted by the special relativity: $v_g = pc^2/E = c^2/v_p$

So, for a free particle, $v_g = p/m = v$, (the particle's speed) also conform to the special relativity.

However, for an electromagnetic plane wave associated to a photon, the corresponding wavelength in a non-dispersive medium with a refractive index $n(\lambda_0)$ at wavelength λ_0 later measured in vacuum, is: $\lambda_r = \lambda_0/n$, as consequence of the fact that the wave's frequency is constant: $\nu = \nu_0$, $\Rightarrow$ $v/\lambda = c/\lambda_0$.

This constancy of the frequency: $\nu = \nu_0$ can be explained by eq.: $m_f c^2 = h\nu_0$ as the photon's mass invariance, that explains the fact that when a photon exits a non-dispersive medium of refractive index n, it has the same ν_0 -frequency as at its entrance, $\nu = \nu_0$ representing the number of components of mass $m_h = h\cdot 1/c^2$ ('quantons', [11]) that gives the mass m_f of the photon, having a speed v = c/n.

It was shown [5, 12] that a photon model compatible with this relation for the wavelength's variation, which can explain the specific wave- particle dualism, is a revised Munera model of deformable photon resulted as pair of vector photons magnetically coupled and having a speed-depending length: $l_\lambda = \lambda_v = v_g T$, whose associated wave have a phase speed v_p equal with the group speed v_g , corresponding to the photon's passing through a non- dispersive medium, ($n_p = n_g \Rightarrow v_p = v_g = v$), the electromagnetic action being given by a B-field generated by the antiparallel magnetic moments of the vector photons, of vortical nature, that induces an electric field $\mathbf{E} = \mathbf{v}\mathrm{x}\mathbf{B}$ **,** ($v \le c$), conform to the model.

In the case of the particle-wave dualism, if we consider the 1 MeV-gamma quantum as 'gammonic' (e^-e^+) pair, by $\lambda_v = h/m_f v_g$ and: $v_g v_p = c^2$ it results: $E(v) = h\nu = m_f v_p v_g = mc^2$ –relation that is in contradiction with the hypothesis of the m_f- mass invariance ($\nu = \nu_0$). This is because the relativist relation: $E(v) = \sqrt{(p^2c^2 + m_0^2c^4)} = pc^2/v_g$, which corresponds to the mass variation and which- by combination with the de Broglie's relation for λ, gives: $p = mv_g = E\cdot v_g/c^2 = E/v_p = n_p E/c$ –which is the Minkowski's formula [10], ($p = p_M$), that gives:

$$\lambda = h/m_f v_g = (m_f^c/m_f)\cdot n_g\cdot\lambda_o = (m_f^c/m_f)\cdot\lambda_o/n_p\,, \qquad (m_f^c = m_f(c);\ m_f = m_f(c)). \tag{8}$$

the Abraham's formula [9]: $p_A = E/nc$, with $v_g v_p = c^2$, giving: $n = E(v)/c\cdot p_A = c/v_g = n_g$, ($n_g\cdot n_p = 1$).

But the Minkowski's formula results also in the Galilean relativity, by $\lambda = v_p/\nu = h/m_f v_g$, which gives:

$$E(v) = h\nu = hv_p/\lambda_v = m_f v_p v_g\ , \tag{9}$$

$$\Rightarrow\ p_f = m_f v_g = E(v)/v_p = n_p\cdot E(v)/c\ ,\ (n = n_p\ ;\quad p = mv_g\,) \tag{10}$$

without the use of the relation $v_g v_p = c^2$ (specific to the mass' variation), the formula (10) for p_f being compatible with the equalities: $v_p = v_g$, ($E(v) = m_f v_p v_g = m_f v^2$) and $\nu = \nu_0$, usable for light's passing through non-dispersive media, ($n_p = n_g$).

So, maintaining the hypothesis of photon's mass' invariance- specific to the Galilean relativity, in the form: $\nu = \nu_0$, the revised Munera' model of photon [12] corresponds to the Minkowski's expression of the momentum of a refracted ray: $p_M = n\cdot E/c$, which- by eqs.: $v_p = v_g = v$ and $n = c/v$, for a photon passing through a non-dispersive medium, gives :

$$E = h\nu = hv/\lambda = mv^2 = mv\cdot c/n = p\cdot c/n\ ; \quad (\,p = E/v) \tag{11a}$$

$$\lambda_v = v_p/\nu = v_p\cdot c/c\cdot\nu = \lambda_0/n_p = \lambda_0/n\,, \quad (n = c/v) \tag{11b}$$

For a red-shifted photon, because in this case the photonic wavelength increases with the frequency' decreasing, it must be used the de Broglie's relation, having: $\lambda_B = h/m_f v = hc/m_f c\cdot v = \lambda_0 \cdot n_g$, which corresponds to the Abraham's formula: $p_A = E/n_g c$, resulted from eq. (17b) by relation: $n_g \cdot n_p = 1$, $(v_g v_p = c^2)$, so- corresponding to the photon's mass variation.

The previous conclusions are not paradoxical, being in concordance with a recent study [13] which argues that both equations, of Minkowski -for p_M and of Abraham- for p_A, can be considered as correct, but in different situations.

In conclusion, the expression $E(v) = mv_g^2$ is compatible with a vortical particle-like model of photon and by Eq. $v_p = v_g$ corresponds to the Minkowski's formula of the photon's impulse: $p = p_M$ and to the wavelength's expression: $\lambda_v = \lambda_0/n$ specific to photon's passing through a non-dispersive medium, being compatible with the de Broglie's relation for the associate wavelength, λ_B, in a Galilean relativity, and with the hypothesis of the photon's mass invariance, specific to the equality $\nu = \nu_0$.

Therefore, by similitude with a revised Munera photon model [12], we can extrapolate the relation: $E_v(n) = h\cdot\nu = m_f \cdot v_p v_g = m_f v^2$, $(v = v_p = v_g)$, specific to the light's passing through a non-dispersive medium, to the considered 'gammon' identified classically as 1 MeV-gamma quantum, this expression of E_v being compatible with the general form of the plane wave's phase:

$$\frac{S(x,t)}{\hbar} = \frac{2\pi}{\lambda}(\mathrm{x} - \mathrm{v}\cdot \mathrm{t}) = \frac{\mathrm{mv}\cdot \mathrm{x}}{\hbar} - \frac{\mathrm{mv}^2 t}{\hbar} \tag{12}$$

resulted by using of the de Broglie's relation: $\lambda = h/m\cdot v$, which can be also used for the considered m_γ- gammon, ignoring- in a first analysis, the gammon's rest energy and a possible speed-depending mass variation, i.e.- considering the invariance: $\nu(v) = \nu_0(c)$, $(m_\gamma(v) = m_\gamma(c) = m_\gamma)$.

The use of the relation $h\cdot\nu = m_f v_g^2$ (instead of $h\cdot\nu = m_f c^2$) was identified as more concordant with the experiments for describing the wave-particle characteristics of the electron also for the case of atomic electrons, ([14], p. 87).

Because in Eq. (7) the sum $E_{\gamma k} + Q_\gamma = H_\gamma$ is the Hamiltonian of a free 'gammon', Q_γ is a potential that characterizes its intrinsic energy, in this case. With the previous premises, we have by (7) and (12):

$$E_\gamma(v) = E_{\gamma k} + Q_\gamma = \hbar\cdot\omega = m_\gamma \cdot v^2 = p_\gamma^2/m_\gamma, \tag{13a}$$

$$\Rightarrow Q_\gamma = Q_c^\gamma = p_\gamma^2/2m_\gamma = E_{\gamma k} \tag{13b}$$

resulting –in this case, that: $Q_\gamma = p_\gamma^2/2m_\gamma$, i.e.- equal with the translational kinetic energy of the "gammonic" particle, being given as sum of the quantum potential Q^e_c of the "gammonic" electrons:

$$Q_\gamma = 2Q^e_c = p_e^2/m_e\ ; \ \Rightarrow\ Q^e_c = p_e^2/2m_e = E_{ek}\ ; \ (E_{ek} \text{ –the electron's kinetic energy}). \tag{14}$$

This result seems to be in contradiction with the choose of a real amplitude R, that gives an attractive (negative) Q-potential, conform to Bohm's interpretation [1], because the positive value of Q_c can be obtained only by a complex R (that can be written in its polar form: $e^{i\theta}$).

However, the Q_c –potential in Eq. (7), as part of the particle's total energy, depends on the action S as the Bohm's potential.

For a phenomenological interpretation of the previous result in the base of the Galilean relativity, we must consider the existence of the zero-point energy of the quantum vacuum as being given by a superfluid medium, composed mainly of particles of a sub-quantum medium $(m_s < h\cdot 1/c^2)$ and small quanta $(m_c \rightarrow h\cdot 1/c^2)$, having a low frictional component (Brownian), of density ρ_b^0, (ignoring the dynamic component, ρ_v^0).

If the electrons of the considered "gammon" have a super-dense kernel ('centroid') and are coupled with antiparallel spins, the gammon's displacing through this frictional medium generates a vortex of quanta around of each electronic centroid, of circulation: $\Gamma_r = 2\pi r\cdot v_h$, with $v_h = v$ for $r \leq r_\lambda$, in accordance with the laws of ideal fluids mechanics considered also for this quantum medium.

At the limit $v = c$, this Γ_r -vortex can explain classically the Q_c -quantum potential but also the electron's spin as real properties, in concordance with eq. (5) specific to a vortical, classic model, if the r_λ - limit for $v_h = v$ is: $r_\lambda = \hbar/mv$, the Γ_r -vortex being composed by photonic quanta of the quantum vacuum, in this case, conform to the resulted electron model.

These photonic quanta can be maintained on a quasi-stable circular orbital around the particle's centroid as vector photons, if its centrifugal potential $E_c = ½m_v v^2$ is equilibrated by an attractive potential that can be given by the potential $V_\Gamma(r)$ produced by a force of Magnus type generated by a vortical nature of the vector photon and by its passing through the low frictional medium of density ρ_b^0 given by quanta of lower mass, $m_c << m_v$, [12].

The resulted attractive quantum potential $Q_a = \sum V_\Gamma(r) = -Q_c$ corresponds to a real amplitude R of the wave function $\psi(r)$.

This interpretation of Eqs. (7), (13) can be argued as follows:

In accordance with de Broglie-Bohm' theory, with $\rho_p = R^2$, is defined the 'quantum impulse' [15] resulted from the formula of the expectation value of the momentum operator:

$$<P_{\rho x}> = -i\hbar\int\psi^*\partial_x\psi d^3x = \int R^2\partial_x S d^3x - \tfrac{1}{2}i\hbar\int\partial_x(R^2)d^3x; \quad (15)$$

$$<P_{\rho x}{}^2> = -\hbar^2\int\psi^*\partial_x{}^2\psi d^3x, \;= <P_{\rho x}{}^*>\cdot<P_{\rho x}> \;; \quad (\partial_x = \partial/\partial x),$$

which - for a single particle with physical impulse p = mv, gives:

$$<P_x{}^2> = <(\nabla_x S_0)^2> + <\pi_x{}^{*2}> \;;\; |P_x{}^2| = P_x\cdot P_x{}^*, \qquad \text{with } \pi_x{}^* = \hbar(\nabla_x R)/R, \text{ resulting that:}$$

$$P_x = \nabla_x S_0 - i\hbar\cdot\nabla_x R/R \;=\; p_x - i\pi_x^* \;;\quad \rho_p = R^2 = |\psi_x|^2 \;;\quad \psi_x = R\cdot e^{i\frac{S_x}{\hbar}} \;;\quad p_x = mv_x \;; \quad (16)$$

$$P^* = \nabla_x S_0 + i\hbar\cdot\nabla_x R/R \;=\; p_x + i\pi_x^* \;;$$

$\pi_x{}^* = \hbar(\nabla_x R)/R$ being the impulse of the quantum-mechanical field per m-particle [15] .

With $\varepsilon = -k_b\cdot\ln\rho_p$, ($k_b$ -the Boltzmann constant), in which $\rho_p = R^2$ is a probability density concordant with the Bohm's interpretation of $|\psi|^2$, by eq. (22) it was argued [6] that at quantum equilibrium given by $P_x^* = 0$, the particle's entropy $\varepsilon(x)$ associated with its wave property is proportional with the particle's action S_0 as in the de Broglie's relation: $\varepsilon/k_b = S_0/h$, but in the form: $\varepsilon/k_b \sim i\cdot S_0/\hbar$, conform to a generalized relation ([6]): $\varepsilon/k_b = \gamma_i\cdot(S_0/\hbar)$, ($\gamma_i$ - arbitrary proportionality constant), in accordance with the Rosen's expression for the impulse π^* of the quantum field of the associated wave, [15].

Because conform to Eq. (3) we have: $\rho_p = R^2 = e^{-\varepsilon/k}$, π^* results by equations:

$$\frac{\varepsilon(x)}{k_b} = \gamma_i\frac{S_0(x)}{\hbar}; \quad \Rightarrow \quad \pi^* = \hbar\frac{\nabla R}{R} = -\frac{\hbar}{2k_b}\nabla\varepsilon = -\frac{\gamma_i}{2}\cdot p; \quad (p = \nabla S_0 = mv) \quad (17)$$

For the obtained case (Eq. (13)), having: $Q_e = Q_c = E_{ek} = \frac{1}{2}\, m_e\cdot v^2$, for $\rho_p = R^2$ and $p_e = m_e v$ –constant, using the generalized relation (17) in the expression of the quantum potential Q, we obtain:

$$Q = -\frac{\hbar^2}{2m}\frac{\nabla^2 R}{R}; \quad R^2 = e^{\frac{-\varepsilon(x)}{k_b}}; \quad \frac{\varepsilon(x)}{k_b} = \gamma_i\frac{S_0(x)}{\hbar}; \quad (18)$$

$$Q = E_C \Rightarrow -\frac{\hbar^2}{2m}\frac{(p\cdot\gamma_i/2)^2}{\hbar^2} = -\frac{p^2}{2m}\frac{\gamma_i^2}{4} = \frac{p^2}{2m}; \quad (p = mv)$$

resulting- for $Q = Q_c = E_C = p^2/2m$, that: $\gamma_i = \pm i\cdot\gamma_r = \pm 2i$, ($\gamma_r = 2$), in this case .

The real values of $\varepsilon(r) = \gamma_r\cdot(k_b\cdot S_0/\hbar)$ and of R correspond in consequence to an attractive quantum potential: $Q_a = -Q_c$, which gives the particle's stability/equilibrium.

The interpretation of the previous result obtained by the value $\gamma_i = \pm 2i$, is obtained by taking in equation: $\varepsilon/k_b = i\cdot S/\hbar$: $S_t = S_t(x) = (S_0 + S_\omega) = 2S_0(x)$, giving a total impulse: $p_t = \nabla S_t = 2p$ – value which corresponds to a total kinetic energy of the m-particle: $E_t = p_t^2/m = 2E_C$ –given as sum of the translation and rotation energies: $E_t = E_C + E_\omega$.

Also, we have: $\varepsilon = \varepsilon^i = i\cdot\varepsilon_r$, (imaginary entropy -explained by the fact that -being associated with a dynamic quantum pressure and not with a static pressure, it represents in fact a negentropy). So, the value $\varepsilon = 0$ corresponds to $Q_c = 0$, (inert non-rotated and non-heated particle).

This interpretation results by the fact that – for $\gamma_i = -2i$, from (17) we have $\pi^* = i\cdot p$, value which verify the condition of quantum equilibrium: $P^* = 0$, the size: $p_\omega = -i\cdot\pi^* = \Sigma m_f(\omega\cdot r) = mv$ representing in this case the total rotational impulse of the m-particle, given by its photonic components, ($m = \Sigma m_f$), explaining also the wave property of the pair (e^-e^+).

For $\gamma_i = +2i$, P and P* are inversed, $|P_x{}^2| = P_x\cdot P_x{}^*$ remaining invariant.

So, the value: $P_\gamma = p_k - i\cdot\pi_x{}^* = p_k + p_\omega$, resulted by $\gamma_i = -i\cdot\gamma_r$, represents the total impulse.

Eq. (17), corresponding by $\gamma_i = -2i$ to both eqs. $P^* = 0$ and (18), gives a general form of $P(\gamma)$, for $\gamma_i = -i\cdot\gamma_r$:

$$P_\gamma = \nabla S_0 - i\hbar\frac{\nabla R}{R} = \nabla_r\left(S_0 + i\frac{\hbar}{2k_b}\varepsilon^i\right) = \nabla_x(S_0 + S_\omega) = \nabla_x S_0(1 + i\frac{\gamma_i}{2}) = p_k + p_\omega \quad (19)$$

S_ω representing the total rotational action associated with the m-particle, which gives its rotational impulse $p_\omega = \nabla S_\omega = \Sigma_v m_f(\omega\cdot r) = mv_\omega$ - that corresponds to the spinorial rotation with $(\omega\cdot r) = v_\omega$ of each sub-component and to the impulse π^* $\sim\nabla\varepsilon^i$ of the quantum field. For $\gamma_r = 0$ it results $S_\omega = 0$ and for $\gamma_r = 1$ it results: $S_\omega = \frac{1}{2}S_0$; $\Rightarrow \varepsilon^i/k_b = i\cdot S_0/\hbar$.

Logically, the quantum potential Q resulted as the total centrifugal potential Q_c of the leptonic particle's mass rotation, can be maintained only if it is equilibrated by an equal attractive potential Q_a corresponding to real R, given by $\gamma = \gamma_r$.

The previous conclusion, which can be extended for the case of the vector photon, can be better argued by identifying the Q_a –potential with a potential of vortical nature, generating a quantum attractive force, being argued that a force of Magnus type generated by the photon's movement inside a subquantum (etheronic-like) medium can explain the vector photon's stability, [12].

The previous explanation for the physical nature of the quantum potential for the case of a 1MeV-gamma- quantum is concordant with the result of some authors [16] which obtained a potential of Bohm type as enthalpy of turbulences in the quantum vacuum generated as particle-like eddies of mass m and a mean size $l = \hbar/mc$.

3.2. The correspondence with the Bohm's conclusions

From Eqs. (18) and (19) it results that the quantum equilibrium ($P_\gamma^* = 0$) corresponds only to leptons with $S_\omega = S_0$.
The resulted interpretation of the quantum potential Q for this case, of quantum equilibrium, is in concordance with the Bohm's result for the case of a "free" electron contained between two impenetrable and perfectly reflecting walls, separated by a distance L, for which the spatial part of the ψ-field is $\psi = \sin(2\pi nx/L)$, where n is an integer, (Ref. [1], p. 184), the energy of the electron being: $E = (1/2m)\cdot(nh/L)^2$. Considering that the space is not really empty, but contains an objectively real ψ-field which can act on the particle, this action is analogous to the action of an electromagnetic field, which could create non-uniform motion of the particle, thus, being considered that the ψ-field is able to transform the entire kinetic energy into potential energy of interaction with the ψ-field, because the quantum-mechanical potential for this ψ-field results precisely equal to the total energy, i.e: $Q = -(\hbar^2/2m)(\Delta R/R) = Q = -(\hbar^2/2m)(\Delta\, \psi/\psi) = (1/2m)\cdot(nh/L)^2 = E$.

This result is mathematically concordant with the previously presented conclusion by using eqs. (12), (16)-(19) which- considering the wave-particle dualism, indicated the equality between the translation energy E_k of the electron and the centrifugal quantum potential Q_c , given by the spinorial rotation of the electron's mass induced by interactions of its photonic components with the low frictional part of the etherono-quantonic medium, (disregarding the dynamic negentropic part, given by quantum and sub-quantum winds, (considered as etherono-quantonic winds in Ref. [5]).

Also, the interpretation for this particular case of the quantum potential is concordant with the fact that the expression of the quantum potential Q obtained for spin-½ fields by means of a gauge transformation as a reduction of a more complete expression is similar to that for the scalar case [17].

4. Arguments for a vortical nature of the electron's spin

4.1. The spin and the rest energy of the electron conform to a classic model

From a relativistic point of view, the previously considered case is equivalent to the case of a stationary m_0- particle with a (super)dense kernel that determines its spin, 'washed' by quantum and sub-quantum winds omnidirectionally distributed, forming a dynamic component with small quanta and quasi-null viscosity and having approximately the same total density ρ_v^0 as the previously considered low frictional etherono-quantonic medium, corresponding to a mean impulse density: $\overline{p}_v = \rho_v^0 c$, (corresponding to a mean speed $\overline{v}_c = c$):

$$\rho_v^0 \approx \rho_b^0 , \qquad (\rho_v^0 = \Sigma_i \rho_{vi}); \quad \Rightarrow \qquad p_v^0 = \rho_v^0 c \tag{20}$$

In this case- considered in a simplified way- by eq. (26), the induced relativist quantum vortex: $\Gamma_c = 2\pi r\cdot v$ (with v = c for $r \le r_\lambda = \hbar/m_e c$) can explain the electron's spin as real property, given by eq. (5) as Γ_s –vortex of a number n_v of light vector photons ($m_v \approx 10^{-40}$ kg) which do not contribute to its inertial mass (being weakly linked [6]) and which gives a spinorial mass $m_s \approx m_e$, ($n_v = m_s/m_v = m_e/m_v$), this Γ_s –vortex having a vortical energy: $E_s^v = \Sigma \in_k^v = \Sigma ½ m_v c^2 = ½ m_s c^2 \approx ½ m_e c^2$, conform to eq. (5).

The extrapolation of this conclusion to a vector photon of a heavy pseudoscalar photon (10^{-40} kg < m_f < 10^{-31} kg) retrieve the revised Munera model of pseudoscalar photon [12] by the conclusion that its vector photon has a vortical part Γ_v formed by lighter m_v -vector photons rotated around an inertial mass $m_{wi} >> m_v$ with the c-speed until the limit $r_\lambda = \hbar/m_w c$, also at rest, corresponding to a rest energy $\in_0^w = ½ m_w c^2$.

In this case, a pseudoscalar photon formed by a pair of vector photons has also a rest energy: $E_0^f = ½ m_f c^2 = ½ h\nu$.

This conclusion is in concordance with the deduction of M. Planck regarding the existence of a zero-point energy, resulted by the fact that the obtained radiation equation contains a residual energy factor, of value: *hν*/2, but which - by the previous reasons, is interpreted as vortical rest energy by the resulted model of photon.

In this case, because the electron's vibration generate the emission of pseudoscalar photons, it is logical to conclude that the electron's quantum volume of clasic radius $r_e = a$ contains pseudoscalar photons having a rest energy $E_0^f = ½ h\nu$, giving the electron's mass m_e by a number $n_f = m_e/m_f$.

The saturation value: $n_f = m_e/m_f$ of heavy photons which give the electron's mass is given approximately by the equality between the electron's rest energy $E_e = m_e c^2$ and the magnetic energy (generated by a vortex Γ_μ of smallest quanta: $m_h \approx h\cdot 1/c^2$, [5]) in the volume $\upsilon(r_\mu)$ of magnetic radius equal to the reduced Compton wavelength: $r_\mu = \hbar/m_e c$, [5].

Because this volume $\upsilon(r_\mu)$ is characterized by the equalities: $\omega\cdot r = c$ and $E = c\cdot B = c\cdot\mu_0 H$, it results that:

$$m_e c^2 = (n_f.m_f)c^2 = \tfrac{1}{2}\int(\mu_0 H^2(r))d\upsilon_\mu \approx e^2/8\pi\varepsilon_0 a, \qquad (21)$$

$$(a = 1.41\text{fm} - \text{e-charge in surface};\ \upsilon_\mu = \upsilon(r_\mu);\ r_\mu = \hbar/m_e.c)$$

By the used electron model, Eq. (21) is explained by the conclusion that the same Γ_μ -vortex of the electron's magnetic moment μ_e induces the both types of photonic vortices: Γ_s –of the electron's spinorial mass m_s and Γ_w –of the spinorial mass $m_{ws} \approx m_{wi}$ of the heavy vector photons which gives the electron's mass.

By the equality: $m_s = \Sigma m_v \approx m_e = \Sigma m_{wi}$ resulted by eq. (5), it results in consequence that the electron's rest energy can be identified with the total kinetic energy of the vortexed photons of the two vortices: Γ_s and Γ_w, which is:

$$E_{tk} = E_s^e + E_0^w = \Sigma\in_k^v + \Sigma\in_0^w = \tfrac{1}{2}(n_v.m_v)c^2 + \tfrac{1}{2}(n_f.m_f)c^2 = \tfrac{1}{2}m_s c^2 + \tfrac{1}{2}m_e c^2 = m_e c^2 \qquad (22)$$

This possibility is in concordance with the particle's "hidden" thermodynamics [7], with the difference that –conform to the model, by the dynamic component ρ_v^0 it is given negentropy (and not entropy) to electrons, photons and other particles.

From an energetic point of view, the previous explanation of Eq. (21) is formally equivalent to the explaining of the electron's rest energy $m_e c^2$ as given only as intrinsic energy of its rest mass m_e, by $n_f = m_e/m_f$ photons of energy $h\nu = m_f c^2$, i.e. rotated with the speed $v_\omega = .(\omega\cdot r) = c$ not only around their own central axis but also around the electron's axis.

In this case, by identifying the total impulse $P_\gamma = p_k - i\cdot\pi_x^*$ of the electron with the relativist quadrivector impulse-energy of the Einsteinian relativity: $P_R(p_k, E/c)$, by considering the invariance of P_R^2 and in the hypothesis of a relativist mass variation: $m(v) = m_v$, it results:

$$\langle P_R^2\rangle = P_v P^v = [p_k^2 - (E/c)^2] = \langle P_k^2\rangle = (p_k^2 - p_\omega^2) = (0 - p_{o\omega}^2), \qquad (23)$$

$$(p_\omega = m_v c = \Sigma m_f.(\omega\cdot r) = E_v/c; \quad p_{0\omega} = m_0 c), \quad \text{and:}$$

$$E_v^2 = (m_v c^2)^2 = m_v^2 v^2 c^2 + (m_0 c^2)^2, \Rightarrow E^2 = E_0^2 + p_k^2 c^2 \qquad (24)$$

i.e.–the Einsteinian form of the total energy, so P_v, P^v correspond to the Dirac Hamiltonian by replacing the impulse p with $\boldsymbol{\sigma}\cdot\mathbf{p}$, ($\sigma$ -the Pauli's matrices). The same result (30) is obtained by writing the electron's total impulse in a complex form: $P^i = p_k + i\cdot p_{0\omega}$, by the conjugate value $P_i = p_k - i\cdot p_{0\omega}$ resulting: $E_v^2 = P^i\cdot P_i c^2 = (p_k^2 + p_{0\omega}^2)c^2 = p_k^2 c^2 + m_0^2 c^4$.

For $m_v = m_0$, it results: $P^i = m_0(v + i\cdot c)$, the complex velocity: $u^i = v + i\cdot c$ being a particular case of those considered by L. Nottale [3] and corresponding to an attractive quantum potential: $Q_a = -(\hbar^2/2m)(\Delta R/R) = -Q_c$ resulted as in the Nottale's theory, by a wave function: $\psi = e^{iS/\hbar} = \psi = e^{i(S^* + iS')/\hbar} = R\cdot e^{iS^*/\hbar}$, i.e. with an amplitude: $R = e^{-S'/\hbar} = e^{-mux/\hbar}$.

This form of the wave function corresponds to the considered 'gammonic' model of 1 MeV-gamma quantum also by the known conclusion that quantal particles such as electrons, due to their interactions with the environment, move in accordance with the complex effective action $S_{eff} = S^* + \tfrac{1}{2}i\hbar\cdot\ln P$ with $\psi = \sqrt{P}\cdot e^{iS^*/\hbar}$, which was obtained following the classical Hamilton's dynamical principle but considering the motion as a whole, that is, taking averages.

So, the imaginary part: $iu = iv_\omega = ic$ corresponds to the imaginary action: $S_i = iS' = i\cdot mc\cdot x$, the real value $u = c$ corresponding to the centrifugal potential $Q_c = -Q_a$, obtained by the general form (19) of the gammon's total impulse which- in this case, by $m_s^e = m_e$ (Eq. (5)) results of value: $P_\gamma = p_k + p_{0\omega} = m_\gamma(v + u) = m_\gamma(v + c)$.

By Eq. (4), the resulted equality: $R = e^{-\varepsilon/2k} = e^{-S'/\hbar} = e^{-mux/\hbar}$, for $S' = \tfrac{1}{2}\gamma_r\cdot S^*$, (Eq. (19), retrieves the equality: $\varepsilon/k_b = \gamma_r\cdot S^*/\hbar$ specific to Eq. (17).

Also, the resulted form: $P_e = m_e(v + u)$, of the electron's total impulse, with u explaining the electron's spin, is formally equivalent to the Salesi's explanation resulted by assuming that the electron's zitterbewegung motion is equivalent to splitting its motion speed into two components, v_t and v_ω, of translational and of rotational motion [2], with: $|v_\omega| = \tfrac{1}{2}\hbar|\nabla\rho|/m\cdot\rho$, [2], by $\rho = R^2 = e^{-\varepsilon/k} = e^{-2S'/\hbar}$ (Eq. (17)) resulting: $|v_\omega| = \nabla S'/m = u$, with the observation that the electron's spin results conform to Eq. (5), by $u = c$.

A classic argument for an electron model with the m_e-mass given by vortical heavy photons having the total energy conform to Eq. (22) is also the electron's property of photon absorption and photoelectrons emission with an energy $\in_f = h\nu = m_f c^2$ per photon, in conformity with the total energy and impulse conservation laws.

By the resulted model, the fact that the two gamma-photons resulted from the 'annihilation' of an electron with a positron have an energy equal with the electron's rest energy: $E_\gamma = m_\gamma c^2 = m_e c^2$ can be explained by the conclusion that the collision between negatron and positron cancels the spinorial energy $E_0^w = \Sigma\in_0^w = \tfrac{1}{2}m_e c^2$ of the heavy vector photons of the electron's volume, the energy E_γ of the resulted γ-photon being given in consequence only by its spinorial energy and its translational energy: $E_\gamma = E_s^\gamma + E_k^\gamma = ½m_sc^2 + ½m_ec^2 = m_ec^2$ –in concordance with Eqs. (5) and (13).

Because the conversion: $(e^- e^+)^* \rightarrow 2\gamma$ cancels also the e-charge of the electrons, it is logical to also conclude that the electron's charge is given by the spinorial energy $\in_0^w$ of the heavy vector photons contained in the electron's surface, which must have in this case the spin $\mathbf{s}_w$ parallel or antiparallel with the electron's spin, $\mathbf{S}_e$, to explain the difference between the e-charge's sign, (between e^+ and e^-), the electron's surface having in this case a circulation: $\mathbf{\Gamma}_e^a = \mathbf{\Gamma}_e(a) = 2\pi\mathbf{a}\times\mathbf{c}$ parallel or antiparallel to the electron's magnetic moment, depending on the charge's sign $\zeta_e = \pm1$, conform to the resulted model.

This is possible if the heavy vector photons of the negatron's surface are oriented magnetically by vortex-tubes $\boldsymbol{\xi}_B$ which 'concretize' the lines of the **B**-field generated by the electron's magnetic moment, $\boldsymbol{\mu}_e$, and the positron has a supplementary shell of heavy vector photons, attracted magnetically by the previous shell, of vector photons oriented by the electron's B-field, so-having opposed spin in report with those of the negatron's surface.

An argument for the conclusion that the electron's photonic shell is rotated with the light speed results by the form of Magnus type of the Lorentz magnetic force [5], by considering a 'cold' quasi-cylindrical electron (barrel-like) with radius $r_e = a = 1.41$ fm and high $l_e = 2a$ and an electron's surface circulation: $\Gamma_a^* = \Gamma^*(a)$ depending on the charge's sign ζ_e, resulted from the spinorial circulation of the heavy vector photons ('vexons', [5]) contained in the surface of the electron's quantum volume:

$$\Gamma_a^* = \Gamma^*(a) = 2\pi a\cdot v_\omega\cdot\zeta_e; \quad (\zeta_e = \pm1\ ;\ v_\omega = k_c\cdot c\ ;\ k_c \leq 1) \tag{25}$$

For an electron that passes with $\mathbf{v}_e$ - speed through a magnetic field **B** of another electron having the $\rho_B(r)$- mean density of quantonic $\boldsymbol{\xi}_B$ vortex-tubes, the circulation $\mathbf{\Gamma}_a^*$ of electron's surface generates a quantonic force $\mathbf{F}_L$ of Magnus type [5, 11], acting on the moving electron with the $\boldsymbol{\mu}_e$-magnetic moment oriented parallel with the $\boldsymbol{\xi}_B$ vortex-tubes of the external **B**-field having the microphysical expression : $B = k_1\rho_B v_c$, $(k_1 = 4\pi a^2/e\ ;\ v_c \leq c)$, conform to Ref. [5].

For $r \leq r_\mu = \hbar/m_ec$ we have $E(r) = c\cdot B(r)$ - relation which can be verified for $r = r_\mu$ by the known relation: $B(r_\mu) = (\mu_0/2\pi)\cdot\mu_e/r_\mu^3 = E(r_\mu)/c$, resulting that: $B(r_\mu) = k_1\rho_B\cdot c$, $(E(r_\mu) = k_1\rho_E\cdot c^2$, with $\rho_E = \rho_B$; $k_1 = 4\pi a^2/e)$, and:

$$\begin{gathered} F_L = 2a\cdot\Gamma_a^*\cdot\rho_B\cdot v_e = 4\pi a^2 v_\omega\cdot\rho_B\cdot v_e\cdot\zeta_e = e\zeta_e\cdot k_c(k_1\rho_B c)\cdot v_e = \zeta_e e\cdot B\cdot v_e\ ;\ \Rightarrow k_c = 1; \\ (v_\omega = k_c c;\ \ k_1 = 4\pi a^2/e;\ \ \Gamma_a^* = 2\pi\cdot a\cdot k_c c\cdot\zeta_e\ ;\ \zeta_e = \pm1) \end{gathered} \tag{26a}$$

(e-charge depending on Γ_a^*). So, it results from Eq. (26a) that $v_\omega = k_cc = c$; $\Gamma_a^* = 2\pi ac$.

- This possibility is in concordance with the fact that the electric interaction quanta must be logically vector photons with opposed chiralities for opposed electric charges [5].

Assimilating an electron having a surface circulation Γ_a^* with a heavy vector photon m_w of a splitted gamma quantum, it results that the force F_l of Magnus type that equilibrates the centripetal force $F_c = m_vc^2/r$ generated by the rotation of a vector photon of mass m_v and radius r_v with the speed $v_\omega = c$ on a vortex –line $l_r = 2\pi r$ around an electron having a dense centroid is given by a more general form of (26a), the dynamic equilibrium being realized in the entire volume of Compton radius: $r_\lambda = \hbar/m_ec$ if the local variation of the low frictional medium's density is: $\rho_b(r) = \rho_b^0\cdot(r_0/r)$; i.e. :

$$\begin{gathered} F_l = 2r_v\cdot\Gamma_c(r_v)\cdot\rho_b(r)\cdot c = 4\pi\cdot r_v^2c^2\cdot\rho_b^0\cdot(r_0/r) = m_vc^2/r = F_{cf}\ ; \qquad r \leq r_\lambda\ ; \\ (m_v \approx 2\pi\cdot r_v^3\rho_v\ ;\ \Gamma_c(r_v) = 2\pi r v_\omega\ ;\ v_\omega = c\ ) \end{gathered} \tag{26b}$$

with: ρ_b^0- the density of the low frictional medium at the surface of vector photon's inertial mass, of radius r_0 .

Because for a stationary electron ρ_b^0 and r_0 are of constant values, it results from (26b) that only the vector photons which fulfills the condition: $r_v\rho_v = 2\rho_b^0\cdot r_0$ = constant can give the electron's spinorial mass $m_s = m_e$,

Considering a density of the vector photon's inertial mass equal with the value obtained in Ref. [5] for the electronic kernel's radius: $r_0 \approx 10^{-18}$ m density: $\rho_v = \rho_0 \approx 10^{19}$ kg/m^3, and supposing that the spinorial mass $m_s = m_e$ is given by a vector photon of far-infrared radiation of mass $m_v \approx 10^{-39}$ kg (with a radius $r_v \approx 3\times10^{-20}$ m), it results: $\rho_b^0 = ½\rho_v\cdot(r_v/r_0) = 3\times10^{17}$ kg/m^3, (comparable to that of a nucleon), this value resulting as plausible if it is given by a majority proportion of etherons.

So, the total potential $Q_l = \sum_n V_l(r, m_v)$, with $n = n_v$ and $F_l = -\nabla V_l$ given by Eq. (26b), can be identified with the attractive quantum potential $Q_a = - Q_c$ which explains the maintaining of the electron's spinorial vortex Γ_s , conform to the model.

It can be also argued that the electron's magnetic moment vortex Γ_μ can explain not only the B-field's generating [5] but also effects of the magnetic potential A such as the Aharonov-Bohm effect, by the conclusion that the etheronic part Γ_a of Γ_μ generates a transversal force in the proximity of a screened solenoid, resulted as Magnus type force- conform to Eq. (26).

The signification of the real entropy ε_r associated to the electron can be deduced by taking for the amplitude R^* of the wave function $\psi_f^*(r)$ associated to the photonic vortex $\Gamma_e(r,v_\omega^e)$ of the electron's quantum volume of classic radius a =

1.41fm, the expression: $R^{*2} = n(r) = n_0 \cdot e^{-r/\eta} = n_0 \cdot e^{-\delta\varepsilon/k}$, specific to an exponential decreasing of the concentration of photons n(r), (conform to a Boltzmann-type distribution characterizing also a mixture of fermions and bosons), with: $\delta\varepsilon(r) = -k_b \cdot \ln(n/n_0) = -k_b \cdot \ln(\rho/\rho_0)$ – relative entropy density of the electron's volume. By Eq. (17) we can write in this case:

$$\delta\varepsilon/k_b = \gamma_r \cdot \delta S_m/\hbar = r/\eta, \quad (\delta\varepsilon = -k_b \cdot \ln(n/n_0);\ \delta S_m = \int_{2\pi} m_h \cdot v_\omega \cdot dx;\ dx = r \cdot d\theta) \qquad (27)$$

with: $\delta S_m = 2\pi r m_f v_\omega$ -the total action of a m_f -photon on a vortex -line l_r of the Γ_e-vortex.

For constant values of v_ω, m_f, it results: $\gamma_r = \hbar/2\pi\eta m_f v_\omega$ –constant, in conformity with Eq. (17); ($\eta \approx 10^{-15}$m –constant, [5]).

The increasing of $\delta\varepsilon$ with r is explained by the relation $n(r) = n_0 \cdot e^{-r/\eta}$ by the fact that the local negentropy is associated with the local dynamic pressure $P_d(r) = ½\rho_v(r) \cdot c^2$ given by the ρ_v^0 –component of the quantum vacuum, the entropy density $\delta\varepsilon(r)$ being associated with the local static pressure $P_s(r)$- given by the ρ_b^0 –component, the sum being constant conform to Bernoulli's law applied to the considered quantum and sub-quantum medium of total mean density: $\rho_T^0 = \rho_v^0 + \rho_b^0$ –constant and given mainly by etherons, i.e.: $P_d(r) + P_s(r)$ = constant at least locally, (in a volume that contains the electron's volume).

Also, if the electron's spin s_e is given by eq. (5), by a vortical energy: $E_S = ½m_s c^2 = k_b T = \delta Q_e$ of light photons with total impulse: $p_e = \Sigma m_v.(\omega \cdot r) = m_s c$ and an associated negentropy $\delta\varepsilon_s^i = i \cdot \delta\varepsilon_r$, for a cylindrical or spherical distribution of photons in a volume υ_λ of Compton radius: $r_\lambda = \hbar/m_e c$ which gives the spinorial mass $m_s \approx m_e$, by Eqs. (5), (27), for $r \le r_\lambda$ and with $\delta\varepsilon_r = \delta Q_e/T = k_b$, we have:

$$\int\delta\varepsilon_s^i/k_b = \delta Q_e/k_b T = i = \gamma_s \cdot \int\delta S_s/\hbar = \gamma_i \cdot s_e/\hbar = \gamma_i/2\ ; \qquad (28)$$

$$(s_e = \Sigma m_v.(\omega \cdot r) \cdot r \approx ½m_s \cdot c \cdot r_\lambda = \hbar/2\ ; \quad a \le r \le r_\lambda = \hbar/m_e c),$$

resulting by $E_S = ½m_s c^2 \approx ½m_e c^2$, that: $\gamma_i = 2i$ -value which corresponds to Eq. (18) .

4.2. Arguments for a rest energy of the gamma photon

For the case of a γ-photon, Eq. (13) indicates that –ignoring the existence of the dynamic component ρ_v^0 of the considered low frictional medium, for v = 0, the photon's intrinsic energy given by the centrifugal potential $Q_c^\gamma = E_{\gamma k}$ is canceled.

Identifying Q_c^γ with the spinorial kinetic energy of the paired vector photons of the γ-quantum (Eq. (13) but also with the Einsteinian expression of the rest energy: $E_k^0 = m_\gamma^0 c^2$, this indicates either a rest mass m_γ^0 without internal kinetic energy or a null rest mass of the photon, (conclusion that corresponds to the Quantum-relativist Mechanics).

However, taking into account also a dynamic component ρ_v^0 of the quantum vacuum, the similitude between the revised Munera model of pseudo-scalar photon [12] and a 1MeV-gamma quantum considered as relativist 'gammon', suggests the possibility to extrapolate the previous conclusions regarding the electron's rest energy to the case of a vector photon at least for the gamma radiation quantum with energy E_γ < 1MeV, by the conclusion that the rest mass of the electrons generated by a 1MeV-gamma quantum corresponds to the rest mass of two vector photons without electric charge but with magnetic moment and by the observation that the law: $\lambda_r = \lambda_0/n$ of photon's wavelength variation in a non-dispersive medium with $n(\lambda_0) = c/v$ corresponds to a constancy of the wave's frequency that imply the photon's mass invariance, ($\nu = \nu_0 = m_\gamma^0 c^2/h$).

For this case (E_γ < 1MeV), considering a non-rotated inertial mass of the vector photons which compose the γ-quantum, by extrapolation it results that- if the dynamic component ρ_v^0 (considered as being given by the etherono-quantonic winds, [5]) fulfils the equality (20), the vortical energy $E_\omega^w = Q_v^0 = ½ \cdot m_w c^2$ of a heavy vector photon ('vexon' [5]) is given – conform to Eqs. (5) and (13), by its spinorial energy, i.e. by a vortex Γ_s^w of n_v lighter photons ('vectons', m_v, [5]) giving the vexon's spinorial mass $m_s^w \approx m_w$, (conform to Eqs. (5), (27)), Γ_s^w being induced by the vortical energy of the vexon's magnetic moment, μ_w, (maintained by the dynamic component ρ_v^0 of the quantum vacuum, conform to the model, [5]).

If the vexon's rest mass m_w^0 is considered conventionally by the Einstein's relation: $E_w^0 = Q_v^0 = m_w^0 c^2$, in the base of the equality: $m_s^w \approx m_w$ the vexon's rest mass results of an apparent value: $m_w^0 = ½m_w(c)$ obtained by identifying the vexon's rest energy with the quantum potential Q_w resulted as centrifugal potential, i.e.:

$$\rho_v^0 \approx \rho_b^0 \ \Rightarrow\ E_w^0 = m_w^0 c^2 = Q_w^0 = \Sigma E_\omega^v = ½ \cdot n_v m_v(\omega \cdot r)^2 = ½ \cdot m_s^w c^2 = ½ \cdot m_w c^2 \qquad (29a)$$

The total energy of a heavy vector photon having a speed v = c results in this case of value:

$$E_w^c = Q_w(c) + E_k^w(c) = Q_w^0 + E_k^w = E_0^w + E_k^w(c) = m_w c^2; \qquad (Q_w^0 = Q_w(v{=}0)), \qquad (29b)$$

This result is in concordance with the case: $\nu = \nu_0$ specific to the photon's passing through a non-dispersive medium, that imply the photon mass invariance and which corresponds to a wave function of the form:

$$\Psi(x,t) = \Psi_0(x) \cdot e^{-iE \cdot t/\hbar}, \quad \text{with:} \quad \Psi_0(x) = e^{iS(x)/\hbar} \text{ and } S(x) = (m_f v + m_f c)x; \quad (m_f = 2m_v). \qquad (30)$$

The total energy E_w^c can be written also by a complex speed: $E_w^c = ½\cdot m_w u^i u_i$; ($u^i = v + i\cdot c$; $u_i = v - i\cdot c$).
The case $Q_w^0 = 0$, specific to a photon with null rest mass, retrieve the known form of the electromagnetic plane wave: $\Psi(x,t) = e^{i(k\cdot x - \omega^*\cdot t)}$, ($k = 2\pi/\lambda = m_f v/\hbar$; $\omega^* = 2\pi\nu$).
Also, the case (29a) is compatible with a relativist-Galilean apparent variation of the vector photon's mass: $m_w(v) = m_w^r$, according to Equation:

$$E(v) = m_w^r c^2 = m_0 c^2 + \tfrac{1}{2} m_w^r v^2 = E_0 + E_c ;\qquad \Rightarrow m_w^r = m_w(v) = m_0/(1 - v^2/2c^2) = m_0/\alpha \tag{31}$$

that gives a value of the rest energy $E_0 = m_0c^2 = ½\, m_w(c)c^2$ and a classic lagrangian:

$$L_w(v) = -m_0c^2\cdot \ln(1 - v^2/2c^2),\qquad (p^r = m_w^r\cdot v = \partial L_w/\partial v) \tag{32}$$

and which- by expressing $\ln\alpha$ in series: $\ln\alpha = (\alpha-1)/\alpha + ½\cdot[(\alpha-1)/\alpha]^2 + {}^1/_3\cdot[(\alpha-1)/\alpha]^3 + \ldots$, retrieve the expression of the kinetic energy by the first term (by neglecting the terms of higher order): $L_w \approx -m_0c^2(\alpha-1)/\alpha = ½\cdot m_w^r v^2$.
By quantization, Eq. (31) gives a time independent equation of the form (1) with $\Psi = \Psi(x)$ but with $E_0 = Q_w^0 = m_0c^2$ instead of the potential V, similar to the wave equation found by Schrödinger for electron:
$i\hbar\partial\psi/\partial t = (m_e c^2 - (-i\cdot\hbar\nabla)^2/2m_e)\psi$.
It results also that the electromagnetic properties of a single photonic quantum are given by antiparallel magnetic moments $\boldsymbol{\mu}_f$ of the coupled vector photons, inducing electric field E_f .
The vector $\mathbf{B}_f /\!/ \boldsymbol{\mu}_f$ can be connect with the quantum wave function (ψ) by a polarization factor $\in_k$ which specifies the orientation of $\mathbf{B}_f$, by the relation: $\mathbf{B}(x, t) = \in_{\mathbf{k}}\psi(x, t)$.
For a pseudoscalar photon, with mass $m_f = 2m_v$, Eq. (31) gives: $E_f(v) = h\nu = m_f(v)c^2$; $E_f(c) = m_f^c c^2 = hc/\lambda_0 = h\nu_0$.
By re-obtaining the equality: $E_v = h\nu = m_f(v)c^2$ of Q. M. with the apparent mass variation of m_f conform to (31), we re-obtain de Broglie's equation for the case: $v_p \neq v_g$:

$$v_p = \omega/k = E/p = m_f c^2/m_f v_g ,\ \Rightarrow\ v_p\cdot v_g = c^2 ;\quad (v_g = \partial E_k/\partial p = \partial(p^2/2m)/\partial p;\ m_f = m_f(v)) \tag{33}$$

So, supposing that the photon's mass is variable according to Eq. (31), the relation: $\lambda_M = \lambda_0/n$ of the photon's passing through a non-dispersive medium, specific to Minkowski's formula of photon's impulse and the relation: $\lambda_A = \lambda_0\cdot n$ - specific to the Abraham's formula, can be obtained by the equations:

$$\lambda_r = v/\nu = hv_p/m_f c^2 = (m_f^c/m_f)\cdot(\lambda_0/n_p) = (\lambda_0/n_p)\cdot 2(1 - v^2/2c^2) = \lambda_M \tag{34}$$

which- for $v = v_g \to c$, gives: $\lambda_r \approx \lambda_0/n_p$ (corresponding to the m_f- mass' invariance), and:

$$\lambda_r = v_p/\nu = hv_p/m_f c^2 = h/m_f v_g = (m_f^c/m_f)\cdot(\lambda_0\cdot n_g) = (\lambda_0\cdot n_g)\cdot 2(1 - v^2/2c^2) = \lambda_A \tag{35}$$

which- for $v_g \to c$, gives: $\lambda_B = \lambda_0\cdot n_g$, ($n_g = c/v_g = 1/n_p$).
Also, by: $v_p\cdot v_g = c^2$, Eq. (33) corresponds to a dispersion relation associated to the resulted photon, of the form:

$$\omega = (c/2)\cdot(k/n_g + k^c)\ \text{ with: }\ k^c = 2\pi/\lambda_0 = m_f^c c/\hbar ,\ (m_f^c = m_f(c) = 2m_f^0), \tag{36}$$

The previous theoretical considerations regarding the existence of a rest energy $E_f^0 = 2E_\omega^v = ½\cdot h\nu$ of vortical nature, given by a dynamic (field-like) component of the quantum vacuum, at least in the case of the photon of 1 MeV-gamma radiation, are in concordance with the fact that the electrons generated by a 1MeV-gamma quantum splitted in a nuclear E-field maintain their normal mass m_e also at rest and imply the conclusion that the γ -photons generated in the reaction:
$(e^- + e^+) \to 2\gamma$ must have a similar structure with the electrons (excepting the part that generates the e-charge);
(if we consider that the dense kernels of the γ-quantum's vector photons is of a negligible mass which cannot sustain a vortex that can increase the vector photon's mass, (i.e. of finer quanta), it would be difficult to explain how the same vortex centers can explain the rest mass of the resulting electrons).
Also, the hypothesis of the existence of a dynamic (field-like) low frictional component of the quantum vacuum, given by quantum winds of quanta of $\in = h\cdot 1$- energy and by sub-quantum (etheronic) winds, is in relative concordance with the quintessence model of the dark energy, which considers a scalar field as an explanation of the observation of an accelerating rate of expansion of the universe, whose potential $V(\varphi)$ implies nearly massless excitations of the field, with an upper limit: $m_L = 10^{-33}$ eV/$c^2 \approx 1.7\times10^{-69}$ kg ,[18], i.e. of a value considered as corresponding to those of the gravitonic etherons [19].
In conclusion, by Eq. (31) it can be avoided the hypothesis of photon's null rest mass, in concordance with the relation: $h\nu = m_f(v)c^2$ but considered in a Galilean relativity.

The generalization of the previous conclusions to photons with lower energy results in concordance with the revised Munera model of photon [12] and with the fact that the electromagnetic wave (field) inside a waveguide (with bound conducting walls) behaves as a particle-wave with mass [20, 21], analogous to the quanta described by the Klein-Gordon equation with a massive field, fact explained by the quantum mechanics' conclusion that similarly to a free particle constrained to move inside a potential well, when its energy is constrained too, when an electromagnetic wave (light) travels inside a waveguide (of rectangular shape) it behaves like a particle, the mass of the photon being connected to the propagating frequency (ν) of the wave in the waveguide by the relation $m_\gamma = (n^2/c^2)h\nu$, where n is the refractive index of the waveguide material, this case corresponding to: $\epsilon_f = h\nu = m_v v^2$, i.e. –to the case of the photon's passing through a non-dispersive medium, characterized by Eq. $v = v_g = v_p$ corresponding to the Minkowski's formula of the photon's impulse and to: $\lambda_v = \lambda_0/n$, ($\nu_v = \nu_0$; $m_f(v) = m_f^0$).

4.3. The rest energy of the 1MeV-gamma photon

Conform to Quantum Mechanics, a gamma quantum with energy hν > 1 MeV can be split in a nuclear E-field into a pair of electrons with opposed e-charges and normal rest mass, conform to an energy conservation law of the form:

$$h\nu = E_- + E_+ = K_- + K_+ + 2m_ec^2 \tag{37}$$

$K_\pm$ representing the resulting kinetic energy of electron with the rest energy m_ec^2.

Conform to Eq. (37), it seems that a 1MeV-quantum can be converted into a (e^- e^+) - pair with null total kinetic energy.

However, compared to Eq. (37), the Eq. (31) corresponds to a photon with rest energy: $E_0^\gamma = m_ec^2$, (given by two vector photons with rest energy: $E_0^v = ½\cdot m_ec^2$), while in the case of the used "gammonic" model of 1 MeV-gamma quantum, the electron's rest energy $E_e^0 = m_ec^2$ is interpreted as resulted conform to Eq. (22), by its spinorial energy and by the spinorial energy of the heavy vector photons which gives the electron's mass: $E_0^e = E_s^e + E_0^w = m_ec^2$.

It results two possible cases:

a) either the 1-MeV gamma quantum is composed by two vector photons with rest energy $E_0^v = ½\cdot m_ec^2$, in concordance with Eqs. (31) and (37), and the resulted electrons are generated at its splitting,

b) or the 1-MeV gamma quantum is composed by two electrons magnetically coupled, with the rest energy $E_0^e = m_ec^2$.

-In the first case, is necessary to conclude that the freedom obtained by the two vector photons and their relativist speed generate the electron's charge, but in this case is not explained why similar γ-photons resulted at (e^--e^+)- annihilation not re-obtain an e-charge.

-In the second case b), the total energy of the 'gammonic' electron results classically by adding its translation energy: $E_k = ½\cdot m_ev^2$, ($v \le c$) to its rest energy m_ec^2, conform to the classic relation:

$$E^e(v) = E_e(0) + E_k(v) = m_ec^2(1+ v^2/2c^2) = m_e^a c^2; \quad (E_k = ½m_ev^2 ; E^e(v) = ½E^\gamma(v)) \tag{38}$$

with $m_e^a = m_e\cdot(1+ v^2/2c^2)$, (the apparent motion mass), which is in concordance with the possibility to explain the gamma-radiation quantum with $E^\gamma(c) = 1.53$ MeV as relativist 'gammon' resulted as (e^-e^+)-pair with: $E^\gamma(c) = 3m_ec^2 \approx 1.53$ MeV.

Another possibility is to explain the 1MeV-gamma as $(e^-e^+)^*$-pair of degenerate electrons with degenerate mass $m_e^* = {}^2/_3 m_e$, with the total energy: $E^\gamma(v) = 3m_e^*c^2 \approx 2m_ec^2 = 1$ MeV but with translation energy $K_\pm = m_e^*c^2$, which- at separation, gives an (e^--e^+)-pair with a total rest energy: $2m_ec^2$ but with $K_\pm = 0$, (conform to Eq. (37)).

For the de Broglie's wavelength associated to a 'gammon', Eq. (38) gives:

$$\lambda_B(v) = h/m_\gamma(v)v = (h/m_\gamma^0 v)/(1+ v^2/2c^2) \;; \quad (m_\gamma^0 = 2m_e^*) \tag{39}$$

which is the same for a single electron ($m^0 = m_e$) and which– for v = c, gives:

$$\lambda_B^0(c) = \frac{2h}{3m_\gamma^0 c} = \frac{h}{m_\gamma^c c}, \quad (m_\gamma^c = m_\gamma(c)); \qquad \lambda_B(v) = \frac{3}{2}\frac{n_g \lambda_B^0(c)}{(1+v^2/2c^2)} \tag{40}$$

An argument for the possibility corresponding to the case b) is the possibility to explain the necessity of an intense E-field for 1 MeV-gamma quantum' splitting by the existence of a binding energy of value $E_b = 1.02$MeV between the 'gammonic' electrons, in the next way:

- Considering the gamma-quantum as relativist "gammon", the value $E_b = 1.02$MeV can be explained as sum of the electrostatic energy and the magnetic energy of the (e^+-e^-) pair, i.e:

$$E_\gamma = 2m_ec^2 = V_e(d_i) + V_\mu(d_i) = e^2/4\pi\varepsilon_0 a\,; \tag{41}$$

$V_e(d_i) = e^2/4\pi\varepsilon_0 d_i$; $V_\mu(d_i) = \mu_r \cdot B(d_i) \approx e^2/8\pi\varepsilon_0 \cdot d_i$; $\Rightarrow d_i = 1.5a$, ($a = 1.41$fm).

The expression of $V_\mu(d_i)$ results as consequence of the fact that –under the electron's Compton radius r_λ , for $d_i \le r_\lambda = h/2\pi m_e c = 386$ fm, (defined physically as the value until to the magnetic moment's quanta have yet the light speed [6]), we have the relation: $B = E/c$, (characteristic also to an electromagnetic wave), the relative radius r_μ^* of the relative magnetic moment μ_r of a degenerate electron resulting according to:

$$B(d) = \frac{\mathrm{E(d)}}{\mathrm{c}} = \frac{e}{4\pi\varepsilon_0 \cdot d^2 c} = \frac{\mu_0}{2\pi}\frac{\mu_r}{\mathrm{d}^3} = \frac{\mu_0}{2\pi}\frac{e \cdot r_\mu^* c}{2 \cdot d^3}, \qquad (\mathrm{d} \le \mathrm{r}_\lambda = \frac{h}{2\pi m_e c}) \tag{42}$$
$$\Rightarrow \mathrm{r}_\mu^* = d \ ; \quad \mu_r = \mu_e (d/\mathrm{r}_\lambda); \qquad \mathrm{V}_\mu^{\mathrm{r}} = \mu_r \cdot B_r(d) = e^2/8\pi\varepsilon_0 d$$

So, the hypothesis of 1 MeV- gamma quantum's forming as 'gammonic' $(e^-e^+)^*$-pair, with non-null rest mass, can be sustained by the Galilean relativity, avoiding- by eq. (39), the paradoxical conclusion of a quasi-null wavelength of a relativist (pseudo)quantum with non-null rest mass, resulted by the Einsteinian formula of mass variation.

The possibility of considering the gamma quantum as "gammonic" pair of degenerate electrons with opposed charges, magnetically coupled, is also argued by the experimentally producing of quanta of "un-matter" plasma [10] and it also allows -by Eq. (41), the hypothesis of the forming of scalar gamma-quantum as a doublet of two $(e^-e^+)^*$-pairs with degenerate electrons with opposed charges, magnetically and electrically coupled.

5. The correspondence with the gravitational redshift of a photonic quantum

It is known that the photon energy $E_v = h\nu = m_f c^2$ is decreased or increased with a value $\Delta E_v = m_f g \Delta h$ in a gravitational field with the gravitational acceleration **g** parallel to the photon's impulse $\mathbf{p}_v = m_f \mathbf{c}$ to a distance Δh , resulting a redshift (or blueshift): $z = \Delta\lambda/\lambda = \Delta\nu/\nu_0 \approx g\Delta h/c^2$, (for g quasi-constant), explained also by the Einsteinian relativity, this effect being verified in 1959, (Pound–Rebka experiment [22]).

According to the obtained interpretation of the Bohm's quantum potential for a free 1 MeV-gamma quantum, by considering this quantum as pair of vector photons or as $(e^- - e^+)$-pair, it results that its energy decreasing or increasing implies the variation of its translation energy but with mass' invariance. We have also two cases:

a) Considering the 1MeV- gamma quantum as pair of vector photons, ('vexons', [5]), we can use the classical Eq. (31) of the apparent mass variation (corresponding to $\hbar\omega = m_f(v)c^2$), which incorporates the translation energy and the quantum potential $Q_c^0 = E_k^c = ½\, m \cdot c^2$ identified as the vexon's rest energy, E_γ^0 .

For a pseudo-scalar γ-photon with the impulse $p_f = m_f v_f \,||\, r$, in a field of gravitational potential $V_g(r)$, because $m_f = 2m_w$ and: $S(x,t) = S_0(x) - E(v)\cdot t$, $(\nabla S_0(x) = p_f)$, the energy conservation law results in concordance with Eq. (2):

$$E(v) = m_f(v)c^2 + V_g(h) = \text{constant}, \quad (V_g(h) = m_f \cdot g \cdot h; \; m_f c^2 = h\nu) \tag{43}$$

with an apparent mass variation:

$$m_f(v) = m_f(c)/2(1-v^2/2c^2) = (\hbar\omega_0)/(2c^2 - v^2) \tag{44}$$

Eq. (43) express the conservation law of the total energy (kinetic- translational + rotational and potential energy). If $h_0 = 0$ at $t = 0$, (h_0 -the initial position), then $\hbar\omega_h = \hbar\omega_0 = m_f^c c^2$.

Because $m_f^c = m_f(c)$ is also the gravitational mass of photon and because in eq. (44) its variation is apparent (eq. (31)), with: $E(v) = p\cdot v_p = m_f v_f v_p = m_f(v)c^2 = \hbar\omega$ it results from Eq. (43) that:

$$\hbar(\omega_0 - \omega) = \Delta E_v = m_f g \Delta h; \;\Rightarrow\; z = \Delta\lambda/\lambda \approx (\omega_0 - \omega)/\omega_0 = \Delta E_v/m_f^c c^2 = g\Delta h/c^2 \tag{45}$$

$(\omega_0 - \omega)$ being negative (blue-shift) if Δh is negative ($h_2 < h_1$, i.e. $p_f \downarrow\uparrow r$), the red-shift effect of the V_g - potential being relative similar to that of a refractive medium with refractive index n , because it reduces the photon's speed.

It also results that the quanta of a blue-shifted radiation have a v_f - speed that exceeds the light speed, ($\sqrt{2}c > v_f > c$). This possibility results by the Fatio-LeSage's theory of gravitation in which the gravitonic quanta are considered etherons [19], if the un-compensated component of the flux $\delta\phi_g = \rho_g v_g^2$ of gravitonic etherons which generate the gravitation force $f_g = m\cdot g \sim \rho_g(v_g - v_f)^2$ by their pressure acting over the photon's inertial mass have a tachyonic speed, (because the value $(v_g - v_f)$ must be non-null).

Interpreting the value $v_c = \sqrt{2}c$ of Eq. (31) as the maximal theoretic value of the v_f –speed of a blue-shifted photon in a gravitation field, it results $v_g \approx v_c = \sqrt{2}c$ in report with the mass M that generates the gravitation, conform to Eq. (31) written in the form:

$$m(v) = m_o/\alpha = m_o/(1 - v^2/2c^2)) \approx m_o/(1 - v^2/v_g^2)), \;\Rightarrow\; v_g \approx \sqrt{2}c \tag{46}$$

b) -In the hypothesis that the gamma-quantum of ~ 1MeV represents a 'gammonic' $(e^- - e^+)^*$-pair of degenerate electrons with the total mass $m_\gamma^0 = 2m_e^*$, taking into account the electron's rest energy $m_e c^2$ conforming to Eq. (38) it results that the loss or increase of its energy in a gravitational field is caused by the variation of its translation energy, $E_k(v)$, and by Eqs. (22) and (38) we have:

$$\hbar\omega' = m_\gamma(v)c^2 = m_\gamma^0 c^2(1 + v^2/2c^2) = m_\gamma(c)c^2 \pm m_\gamma^0 g\Delta h \, ; \qquad (47)$$

$$(m_\gamma^0 = 2m_e^* \, ; \; {}^2/_3 m_e \le m_e^* \le m_e \, ; \; m_\gamma(c)c^2 = {}^3/_2 m_\gamma^0 c^2 = \hbar\omega_0)$$

From Eq. (47) it results that:

$$z = \frac{(\hbar\omega_0 - \hbar\omega')}{\hbar\omega_0} = \frac{\Delta E_v}{m_\gamma^c c^2} = \frac{g\Delta h}{c^2}\frac{m_\gamma^0}{m_\gamma^c} = \frac{2}{3}\frac{g \cdot \Delta h}{c^2}; \qquad (m_\gamma^c = m_\gamma(c)) \qquad (48)$$

$$(\Delta E_v = (\hbar\omega_0 - \hbar\omega') = (m_\gamma^c - m_\gamma^v)c^2 = \tfrac{1}{2} m_\gamma^0 (c^2 - v^2))$$

resulting a value of z equal to (2/3) of the value given by the known Eq. (45), explained by the conclusion that the rest energy of its electrons was given by eq. (22) , by the addition of the spinorial energy of the electron's vector photons to the vortical energy of its spinorial mass $m_s = m_e$, (Eq. (5)), the frequency variation of the 'gammonic' quantum being given by the variation of its kinetic energy, as in the case of the photon's passing through a non-dispersive medium.

These conclusions are not contradictory, because the relation $E = mc^2$ was deduced previously for photons, whose energy $m_f c^2$ can be explained by Eq. (29b), as a sum of the rotational (spinorial) and its translational energy, the extrapolation for the rest energy of heavier particles, realised mathematically by the Einsteinian special relativity, implying- at least in the classic electron's case, the hypothesis of a total energy $m_e c^2$ given by $n_f = m_e/m_f$ photons with energy per photon: $m_f c^2$.

The previous conclusions are in concordance with other observations [23] arguing that the mass-energy equivalence is a consequence of the wave-particle properties which –for the used classic electron model, are given by the rotation of its spinorial mass $m_s = m_e$, conform to Eqs. (5) and (13).

Also, it results that when the gamma-quantum pass through a medium with increased quantum density, (with refraction index $n = c/v_p > 1$), particularly- through a Bose-Einstein condensate of atoms cooled at $T \rightarrow 0K$, will be reduced the both energies of gamma-quantum: of translation and of spinorial rotation of the m_s –mass of component degenerate electrons, resulting as logical also a measurable reducing of the (degenerate) electron's magnetic moment and of the gamma-quantum's electromagnetic properties, according to the used model.

9. Conclusions

By considering the wave-particle dualism with an interpretation compatible with the known Bohm's equations, for the electrons of a 'gammonic' $(e^- e^+)$-pair having the phase speed of the associated wave equal with the group speed, it results a value of the Bohm's quantum potential Q equal to the electron's kinetic energy, $E_k = ½mv^2$.

For a classic model of electron composed by heavy photons, this value is explained by a generalized relation of quantum equilibrium of de Broglie type: $\varepsilon/k_b \sim S/\hbar$, as centrifugal potential Q_c given by the rotation with the same v-speed of n_v –vector photons of inertial mass m_v giving a spinorial mass $m_s = n_v m_v \approx m_e$, determined by a vortex of circulation $\Gamma_r = 2\pi r \cdot v$ induced by the particle's passing through a low frictional medium of fine quanta (etherono-quantonic, [5]), of density ρ_b^0 and maintained by a corresponding vortical potential $Q_a = -Q_c$ generated in accordance with the laws of the ideal fluids applied to the considered low frictional medium of the quantum vacuum by a dynamic component, ρ_v^0, given by quantum and sub-quantum (etherono-quantonic) winds, the low frictional component ρ_b^0 generating a centripetal quantum force of Magnus type acting over the rotated vector photons.

The circulation of the heavy vector photons which give the electron's inertial mass m_e - considered as contained in a volume of classic radius corresponding to the e-charge in its surface, can explain also the Lorentz force by a kinetics corresponding to a multi-vortical lepton, with secondary vortices of light vector photons rotated with c-speed around the inertial mass of heavier vector photons contained by the electron's surface, which gives also the electron's charge.

The forming mechanism seems to be similar to the multi-vortex tornado phenomenon.

The value of ~ 10^{-18} m of the electron's radius indicated by some experiments [4], is explained by the conclusion that it represents the radius of an electronic super-dense kernel, which ensures the stability of the electron's vortical structure [5].

This vortical electron model explains the electron's spin ½ħ in concordance with other theoretical observations [24] showing that the electron's spin can be explained by a non-relativistic theory based on the Galilean relativity, that allows nonrelativistic wave equations for any spin, in concordance with Galilean electromagnetism and invariance.

Extrapolating the conclusions resulted from the used electron model to the vector photon of a pseudo-scalar γ- photon considered in a revised Munera' model [12] leads to the conclusion that the considered quantum/sub-quantum (etherono-quantonic) winds gives similarly rest energy and a rest mass also to γ- photons, this conclusion being non-contradictory in the Galilean relativity.

Even if this conclusion is in contradiction with conclusions of quantum-relativist mechanics, it is in concordance with Minkowski's expression of the momentum of a refracted ray: $p = E_n/c = m\cdot v$, and with the experimentally evidenced possibility of obtaining a Bose-Einstein condensate of photons [25].

Because the considered dynamic component ρ_v^0 of the quantum vacuum can explain also the e-charge's magnetic moment as etherono-quantonic vortex [5], by its etheronic part the nuclear magnetic moment can also explain the perpetual rotation of the atomic electrons around the atomic nucleus [5].

Related to the discrepancy between the density of the vacuum energy of the free space resulting from the upper limit of the cosmological constant: $\sim 10^{-26}$ kg/m^3 and that estimated in quantum electrodynamics: 10^{94} kg/m^3, [26], it can be observed that supposing a quark model formed as cluster of degenerate electrons (i.e. as Bose-Einstein condensate of "gammons", [5]), the resulted model supposing etheronic and photonic vortices generated by the quantum vacuum's energy do not imply the necessity of a density of the low frictional medium of the quantum vacuum (resulted as preponderant etheronic) higher than that of the nucleon, the value of $\sim 10^{-26}$kg/m^3 specific to the cosmological constant representing in this case only an un-compensated dynamic component that generate the cosmic expansion, (whose pressure is not compensated by an opposed pressure of another component, [5]).

This is a logical conclusion because it is plausible that the gravitational field's energy is given by similar quanta as those of the 'dark energy'.

Also, it is known that it resulted experimentally the absence of time delays associated with forces of the magnitude needed to explain the phase shift observed in the Aharonov-Bohm effect to an electron that pass through a zone with null magnetic B-field but non-null magnetic potential A [27]. In the late's, The existence of a quantum force, predicted in 1990 as physical explanation for the Aharonov-Bohm effect [28], was evidenced in an experiment [29] as transverse force derived from a potential of Bohm type: $Q = -(\hbar^2/2m)(\nabla^2 R/R)$. Qualitatively, this result corresponds to the obtained physical interpretation of A-potential, of Q_c and of Q_a , by the conclusion that A-potential is given as (pseudo)vortex of etherons induced around elementary particles by etheronic winds which penetrates the atoms and which can exists also around a magnetically shielded solenoid [5], the Q_a-potential resulting as given by a quantum force of Magnus type, conform to Eq. (26b).

The fact that in the Aharonov-Bohm effect it resulted experimentally the absence of time delays associated with forces on the longitudinal direction $x // v_e$ and the fact that we receive photons also from far gallaxies can be explained in this case by the d'Alembert' paradox [30], by the property of superfluid of the low frictional medium (preponderant etheronic) with very low kinematic viscosity, that generates a low drag force, specific to a redshift effect given by 'radiation's aging': $F_R \approx f_a\cdot S_v \rho_b^0 v^2$, ($S_v$ = section of vecton's interaction with the quantum vacuum's medium), corresponding to a variation of the photon's speed (in the hypothesis of photon's mass invariance), giving an exponential variation of the electron's E-field by eq. (5), of the form :

$$E(r) = k_1\rho_c v_c^2 = (e/4\pi\varepsilon_0 r^2)\cdot e^{-k'r} = E_0(r)\cdot e^{-k'r}\ ; \quad v^2 = c^2\cdot e^{-k'r}\ , \tag{49}$$

$$(k' = m_f^0 c/\hbar = f_a\cdot m_v c/\hbar\ , \quad m_f^0 \approx 1.7\text{x}10^{-50}\text{Kg},\ [31])$$

with: f_a- form factor, taking into account the d'Alembert's paradox ; m_f^0 –the upper limit of the photon's rest mass resulted from experiments of electrostatic field's action [31]; m_v - the mass of the vector photons that give the E-field, $k' = 2\pi f_a/\lambda_v$ representing the m_v-photon's energy attenuation coefficient in quantum vacuum.

With $m_v \approx 10^{-40}$ kg, (the mass of the E-field's vector photon - conform to Ref. [5]), it results: $f_a = m_f^0/m_v \approx 10^{-10}$.

The form (49) of the E-field corresponds to the Maxwell-Proca equations of electromagnetism, the Maxwell's equation resulting as acceptable approximation resulted by the very small value of k', ($\sim 3\text{x}10^{-8}$ m^{-1}).

Also, the conclusion of photon's speed and energy attenuation also in vacuum depending on the photon's mass, as in Eq. (49), is in concordance with the experimentally observed Lorentz-invariance of the photon's mass of a very large but finite numbers of non-collinear photons of light pulses propagating in vacuum whose velocity was a little lower than the light speed in vacuum, the resulted difference being related directly with the invariant mass of a pulse, [32].

The super-fluidity of the preponderant etheronic low frictional medium of the quantum vacuum is in concordance with the fact that the vacuum is a dielectric medium, in which the displacement current ($\partial D/\partial t$) does not vanish.

These arguments sustain a particles cold genesis scenario supposing vortices in a quantum and a sub-quantum (etheronic) medium generated as effect of chiral fluctuations at high densities of this medium, comparable to those of a magnetaric magnetic field, the considered etherono-quantonic vortical nature of the magnetic field being concordant with the basic laws of electromagnetism [5] but also with the observations regarding the generating of quantized vortices in a superconducting thin film of Nb, [33], which reported the observing of vortices and antivortices which annihilate each other, generated when a 100 Gs magnetic field applied to the thin film of Nb is suddenly reversed and its magnitude increases (generating the anti-vortices).

The concept of 'etheronic medium' used in the paper is compatible with the concept used in other similar approaches such as those used in Ref. [34] and with the field-like nature of the 'dark energy', evidenced also by some astrophysical observations [35] .

The conclusion of the creation of etheronic vortices in the quantum vacuum corresponds indirectly to the conclusion of superluminal propagation of the quantum potential, introduced in the Vigier's model [36], which considers that the quantum potential is a real interaction among the particles and the sub-quantum fluid polarized by the presence of the particles [37] and therefore is considered to be a true stochastic potential [38].

Mathematically, the resulting interpretation of the quantum potential does not exclude other interpretations corresponding to other premises and values for R, for example- as in the case of the interpretation of Perelman [39] which correlated the quantum Bohm potential with an antigravitational potential V_g , possibly implied in the Universe' expansion.

The obtained interpretation is in concordance with the fact that the previous attempts to explain the spin and the magnetic moment of the electron implied the conclusion of its mass and charge rotation with the light's speed [40] .

An argument for the conclusion that the photons can form vortical clusters is also the experimentally evidenced possibility to create optical vortices by light beams twisted around their axis of travel, [41].

Another argument is the experimentally evidenced possibility to "freeze" photons inside a crystal for up to a minute by the technique of electromagnetically induced transparency, the trapped photons inside the opaque crystal being converted inside the crystal (having controlled transparency) into atomic spin excitations ("spin waves") which thereafter were turned back into photons of emitted light, [42].

It was also argued that the electromagnetic properties of a single photon of a gamma quantum are given by antiparallel magnetic moments $\boldsymbol{\mu}_f$ of the coupled vector photons, that induce an electric field E_f .

Also, the conclusion that the electron's e- charge is contained in its surface shell was argued and by other studies [43].

By a classic expression of the gamma quantum's energy based on the obtained theoretic model, the expression of the gravitational redshift is retrieved, but with the observation that in the case of a gamma-quantum considered as relativist 'gammonic' ($e^{*-}e^{*+}$)-pair of degenerate electrons it results a value of 2/3 from that given by the known relation, this difference being caused by its rest energy $E_0 = 2m_e^* c^2$, resulted by adding the spinorial energy of the electron's heavy vector photons to the vortical energy $\frac{1}{2}\Sigma m_s c^2 = \frac{1}{2} m_e c^2$ of the electron's spinorial mass- resulted as equal with its inertial mass but without contributing to its value, conform to the resulting model.

The possibility to explain some basic magneto-electric and kinetic properties of the electron by the hypothesis of a main composition of the quantum vacuum given by a low frictional component, by the resulting vortical electron model argues a fractal mechanism of its forming and an etheronic or etherono-quantonic nature of the "dark" energy, in our opinion.

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