WAVE SOLUTION OF GENERALIZED MAXWELL EQUATIONS AND QUANTUM MECHANICS

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Wave version for generalized Maxwell equations defined in [1] is proposed. Wave created by moving electron is described on the basis of torus model proposed in paper [2] devoted to Maxwell approach to gravity. This wave is described by torsion oscillations. Corresponding vortex carries mass. Therefore moving electrons and photons possess qualities as wave as particle. Conformity of the received results to experiments laying in at the basis of quantum mechanics is verified. It was found a fact staggered the author: electron creates independent of time standing wave, which defines Coulomb force. In particular this means that Coulomb force is a long-range one.

1.Gravitational model of electron

In paper [2] devoted to Maxwell approach to gravity description an electron model as a massive torus was proposed. Electron creating mass performs two torsion movements: in the equatorial and meridional planes. The greater circumference radius turns to be equal to $R \approx 3{,}86 \cdot 10^{-13} m$ which satisfactory coincides with Compton electron wavelength. The lesser circumference radius $\rho = \frac{R}{2} \approx 1{,}93 \cdot 10^{-13} m$, i.e. twice lesser. Torsion angular velocity of the greater circumference $\omega = 8{,}1 \cdot 10^{20} c^{-1}$ which coincides with De-Broglie frequency of electron at rest $\omega_0 = m_0 \cdot \frac{c^2}{\hbar}$, where m_0 is electron mass defined experimentally. Angular velocity of the lesser circumference is $\Omega = 2\omega_0$. Let us note that

$$R \cdot \omega = \rho \cdot \Omega = c \qquad (1.1)$$

Gravitational consideration defines mass of the vortex creating torus. It turns to be $m = 9{,}1 \cdot 10^{-31} kg$ which is also close to the mass defined experimentally.

Let us introduce necessary relations purely mathematically in vector form.

Let $\mathbf{R}$ be radius-vector from the center of the greater circumference to its points and $\boldsymbol{\rho}$ is radius-vector from the lesser circumferences centers to their points such that it extends vector $\mathbf{R}$. And let pseudovector $\boldsymbol{\omega}$ and polar vector $\boldsymbol{\Omega}$ be angular velocities of these circumferences. Let us introduce main characteristics of electron. Angular momentum

$$\mathbf{S} = m\boldsymbol{\rho} \times (\boldsymbol{\Omega} \times \boldsymbol{\rho}) = m\boldsymbol{\Omega}\boldsymbol{\rho}^2 = \frac{1}{2}\hbar \qquad (1.2)$$

Let us note that F.M. Kanarev was apparently the first one who raised a problem of vector interpretation of Planck's constant $\hbar$ [3].

Vector $\hbar$ in (1.2) is directed along angular velocity of the torus lesser circumference rotation and is proportional to its radius square.

$\hbar$ is modulo constant and takes only two values: plus or minus. It depends on the screw $\boldsymbol{\Omega}$ constitutes with electron velocity: it is left or right. This explaines well known problems of Planck's constant interpretation. Torus electric charge

$$\mathbf{e} = \frac{\boldsymbol{\omega} \times \boldsymbol{\Omega}}{|\boldsymbol{\Omega}|} \qquad (1.3)$$

Plus or minus is taken depending on right or left screw $\boldsymbol{\omega}$ constitutes with $\boldsymbol{\Omega}$. Let us note that $\boldsymbol{\Omega}$ is a polar vector.

Electric charge is polar vector modulo constant and taking only two values: parallel or antiparallel to radius $\mathbf{R}$. This characteristic is independent with respect to electron's movement and presents its inner quality. And this is in contrast to pseudovector $\hbar$, which is defined only with respect to electron's velocity. It is problem for future experiments to define what sign in (1.3) corresponds to electron. We assume sign plus and define electron by scalar equality

$$e = m\omega \approx 7{,}3 \cdot 10^{-10} \frac{kg}{s} \tag{1.4}$$

Minus in (1.4) will be taken for positive charge. If one knows dimension and value (1.4) of electric charge then all electrodynamic quantities can be expressed as mechanic ones. One can find details in [4] some results from which are reproduced below. Electric field has velocity dimension and magnetic field is nondimensional and means rotation angle. Electric constant

$$\varepsilon_0 \approx 1{,}87 \cdot 10^{8} \frac{кг}{м^3} \tag{1.5}$$

means free ether mass density. Magnetic constant

$$\mu_0 \approx 5{,}88 \cdot 10^{-26} \frac{мс^2}{кг} \tag{1.6}$$

and means free ether compressibility.
Light velocity accepts very simple hydrodynamic meaning of sound velocity in free ether

$$c_0^2 = \frac{1}{\varepsilon_0 \mu_0} \tag{1.7}$$

Electromagnetic field in general turns to be a special case of gravity as it is understood in [2]. Let us calculate electron's kinetic energy. Kinetic energy of its equatorial rotation

$$K_1 = \frac{1}{2} m R^2 \omega^2 = \frac{1}{2} mc^2$$

Kinetic energy of its meridional rotation

$$K_2 = \frac{1}{2} m \rho^2 \Omega^2 = \frac{1}{2} mc^2$$

Sum kinetic energy

$$K = K_1 + K_2 = mc^2 \tag{1.8}$$

We receive the same result in another way

$$\hbar \cdot \boldsymbol{\omega} = mc^2$$

Let us introduce some additional notions, which will be necessary for us in the next chapters. It was noted above that $|\mathbf{R}|$ coincides with Compton's wavelength of electron, i.e. it is electron's wavelength. Let be

$$\mathbf{R} = (R_1, R_2, R_3) \tag{1.9}$$

If the wave created by electron were monochromatic we should introduce wave vector parallel to electron's velocity $\mathbf{v}$. Vortical character of electron's wave makes us to introduce normal vector

$$\mathbf{p} = \left(\frac{2\pi}{R_1}, \frac{2\pi}{R_2}, \frac{2\pi}{R_3}\right), |\mathbf{p}| = \frac{2\pi}{|\mathbf{R}|}, \ \mathbf{p} \,//\, \mathbf{R} \tag{1.10}$$

This is convenient because hydrodinamic considerations lead us to a conclusion that torus vortex of the above defined type must move along normal to its equatorial plane. We shall not prove this concept but just declare it, as an.

ASSUMPTION 1. Velocity of electron's movement is always perpendicular to its equatorial plane. Hence

$$\mathbf{p} \perp \mathbf{v} \tag{1.11}$$

ASSUMPTION 2.

$$\mathbf{v} = const \tag{1.12}$$

This assumption is very restrictive for electrons but rather natural for photons, which are perhaps the main consideration objects here. Assumption 1 let us distinguish notions of charge and spin more accurately. Spin is proportional to angular velocity $\mathbf{\Omega}$. Spin's sign is not defined for static electron. This means that spin is an external quality of electron. It is necessary to pin point velocity in addition in order to define spin.

Charge (1.3) is directed along radius $\mathbf{R}$ inside or outside, i.e. along normal vector $\mathbf{p}$. It can also possess only two signs. But this is an inner characteristic of electron, characteristic not dependent on its movement. Therefore charge is adequately characterized with the help of scalar quantity: by vector modulus and its sign. It is necessary to pin point velocity in addition in order to define spin.

2.Wave form of generalized Maxwell equations.

In [1] it was proposed the following generalization for traditional Maxwell equations:

$$div\mathbf{E} = \frac{\rho}{\varepsilon_0} \qquad (2.1)$$

$$rot\mathbf{E} = \frac{-d\mathbf{B}}{dt} \qquad (2.2)$$

$$div\mathbf{B} = -\frac{\rho}{c\varepsilon_0} \qquad (2.3)$$

$$c^2 rot\mathbf{B} = \frac{d\mathbf{E}}{dt} \qquad (2.4)$$

Here ρ is charge density, ε_0 is electric constant, which means mass density of free ether, c is pseudoscalar light velocity (it changes its sign when right hand coordinate triple is changed for left one). One can find details in [1]. Partial solutions of this system are real function

$$\mathbf{E} = \frac{\rho}{3\varepsilon_0}\left[-\frac{\mathbf{r}\times\mathbf{v}}{c} + \mathbf{r}\right] \qquad (2.5)$$

$$\mathbf{B} = -\frac{\rho}{3\varepsilon_0 c}\left[\frac{\mathbf{r}\times\mathbf{v}}{c} + \mathbf{r}\right] \qquad (2.6)$$

One can verify this by direct substitution.

Here and in the development below $\mathbf{r}$ is radius-vector. It was also proposed a generalized Lorentz force formula, which describes fields' interaction.

The force with which charge 2 acts
on charge 1 is

$$\mathbf{F}_{21} = -grad\left[4\pi\varepsilon_0 c r^3\left(\mathbf{B}_{12}\cdot\mathbf{E}_{21}\right)\right] + \frac{d}{dt}\left[4\pi\varepsilon_0 c r^3\left(\mathbf{B}_{12}\times\mathbf{B}_{21}\right)\right] \qquad (2.7)$$

Double index means fields intensity created by the charge whose index goes first evaluated at the point where the charge whose index goes second is situated. For instance, $\mathbf{E}_{21}$ means the electric field intensity created by the second charge at the point where the first charge is situated. When functions (2.5) and (2.6) are substituted into (2.7) one gets description of two charges' interaction. This description covers all traditional cases, effects now considered in the framework of Relativity theory and results of all known to the author experiments, which cannot be explained in the framework of traditional electrodynamics. In particular it predicts Bohm-Aharonov experiment and cluster effects in electrons beams. Some new effects, which should be verified in experiment, are also predicted.

Now we are to pass from description of fields created by moving electron to description of waves created by such movement. In order to fulfil this task we are to pass from real equations (2.1)-(2.4) to the following system of complex equations

$$div\mathbf{E} = i\omega \exp\{i(\mathbf{p}\cdot\mathbf{r})\} \qquad (2.8)$$

$$rot\mathbf{E} = -\frac{d\mathbf{B}}{dt} \qquad (2.9)$$

$$div\mathbf{B} = \frac{i\omega}{c}\exp\{i(\mathbf{p}\cdot\mathbf{r})\} \qquad (2.10)$$

$$c^2 rot\mathbf{B} = \frac{d\mathbf{E}}{dt} \tag{2.11}$$

Here i is imaginary unit, ω is angular velocity of electron torus, i.e. De-Broglie frequency of electron in rest $\left(\frac{mc^2}{\hbar}\right)$, $\mathbf{r}$ is radius-vector from coordinate triple origin to electron, $\mathbf{p}$ is normal vector defined in the previous section. One can verify by direct substitution that functions

$$\mathbf{E} = \omega \exp\{i(\mathbf{p}\cdot\mathbf{r} - \omega t)\}\left[\frac{\mathbf{p}\times\mathbf{v}}{p^2 c} + \frac{\mathbf{v}}{\omega}\right] + \omega \exp\{i(\mathbf{p}\cdot\mathbf{r})\}\frac{\mathbf{p}}{p^2} \tag{2.12}$$

$$\mathbf{B} = \frac{\omega}{c}\exp\{i(\mathbf{p}\cdot\mathbf{r} - \omega t)\}\left[\frac{\mathbf{p}\times\mathbf{v}}{p^2 c} - \frac{\mathbf{v}}{\omega}\right] + \frac{\omega}{c}\exp\{i(\mathbf{p}\cdot\mathbf{r})\}\frac{\mathbf{p}}{p^2} \tag{2.13}$$

satisfy system (2.8)-(2.11). Functions (2.12)-(2.13) define two waves. One wave is a traveling wave. Its amplitude is a sum of two mutually perpendicular vectors: one is directed along velocity vector and the other one is perpendicular to it.

The second wave is a standing one. Its oscillations are independent of time. Vector amplitude of this wave is directed perpendicular to the plane defined by traveling wave amplitude.

Let us verify by direct substitution that functions (2.12) and (2.13) are really solutions of (2.8)-(2.11) system.

$$\begin{gathered} div\mathbf{E} = i\omega \exp\{i(\mathbf{p}\cdot\mathbf{r} - \omega t)\}\left[\frac{\mathbf{p}\times\mathbf{v}}{p^2 c} + \frac{\mathbf{v}}{\omega}\right]\cdot\mathbf{p} + \\ + i\omega\exp\{i(\mathbf{p}\cdot\mathbf{r})\}\frac{\mathbf{p}\cdot\mathbf{p}}{p^2} = i\exp\{i(\mathbf{p}\cdot\mathbf{r})\} \end{gathered} \tag{2.14}$$

The first item here is null because p is perpendicular to vectors in square brackets.

Equality (2.10) is verified in the same way. Let us verify (2.9) equality.

$$\begin{gathered} rot\mathbf{E} = i\omega\exp\{i(\mathbf{p}\cdot\mathbf{r} - \omega t)\}\mathbf{p}\times\left[\frac{\mathbf{p}\times\mathbf{v}}{p^2 c} + \frac{\mathbf{v}}{\omega}\right] + \\ + i\omega\exp\{i(\mathbf{p}\cdot\mathbf{r})\}\frac{\mathbf{p}\times\mathbf{p}}{p^2} = i\exp\{i(\mathbf{p}\cdot\mathbf{r})\}\left[\frac{\mathbf{p}\times\mathbf{v}}{\omega} + \frac{\mathbf{v}}{c}\right] \end{gathered} \tag{2.15}$$

$$\begin{gathered} -\frac{d\mathbf{B}}{dt} = -\frac{\omega}{c}(\mathbf{v}\cdot grad)\left\{\begin{matrix} \exp\{i(\mathbf{p}\cdot\mathbf{r} - \omega t)\}\left[\frac{\mathbf{p}\times\mathbf{v}}{p^2 c} + \frac{\mathbf{v}}{\omega}\right] - \\ -\frac{\omega}{c}\exp\{i(\mathbf{p}\cdot\mathbf{r})\}\frac{\mathbf{p}}{p^2} \end{matrix}\right\} + \\ + \frac{i\omega^2}{c}\exp\{i(\mathbf{p}\cdot\mathbf{r} - \omega t)\}\left[\frac{\mathbf{p}\times\mathbf{v}}{p^2 c} + \frac{\mathbf{v}}{\omega}\right] \end{gathered} \tag{2.16}$$

The first item here is a convective derivative of $\mathbf{B}$. It is null because

$$grad(\exp\{i(\mathbf{p}\cdot\mathbf{r} - \omega t)\}) = i\mathbf{p}(\exp\{i(\mathbf{p}\cdot\mathbf{r} - \omega t)\})$$

and vector $\mathbf{p}$ is perpendicular to $\mathbf{v}$. This means that when t is fixed the wave moves along level curves $\mathbf{E}(x_1, x_2, x_3, t) = const$ and $\mathbf{B}(x_1, x_2, x_3, t) = const$. Condition $\mathbf{p}\cdot\mathbf{r} = const$ defines a surface for any t. In our case this is just a plane. Let us note that trajectory lies in this plane in contrast to planar wave trajectory, which is perpendicular to such a plane. Nonzero item in (2.16) is only the second one, which is partial derivative of $\mathbf{B}$ with respect to time. One gets equality to (2.15) if multiplier ω/c multiplies vector amplitude in square brackets because $\frac{\omega}{p^2 c^2} = \frac{1}{\omega}$. Equality (2.11) is verified in the same way.

Longitudinal and transverse oscillations take place in traveling wave defined by the first items in (2.12) and (2.13). This wave is null if electron is in rest ($\mathbf{v} = 0$).

Standing wave defined by the second items in (2.12) and (2.13) depends only on spatial coordinates. It does not move with any velocity in space but exists eternally. Just this item originates Coulomb interaction. Therefore one can say that Coulomb force is a long-range one in contrast to interactions connected with charges' movement, which spreads with velocity of electron. Waves (2.12) and (2.13) as a whole are essentially threedimensional and cannot be described by plane monochromatic wave.

3.Photon.

Fundamental distinction between photon and electron is lack of electric charge in photon. Let us consider experiments on electron- positron annihilation in order to imagine photon visually. It was assumed above that electron and positron differ with their meridional rotation with respect to equatorial one. They both move along normal to their equatorial planes. Contacts of the following kinds are possible for them:

1. Their equatorial rotation directions coincide, i.e. their spins are antiparallel. When they turn to be in contact toruses must be broken because of opposite direction of their meridional rotations. Number of new created cylinders (particles) in such collisions are to increase with collision energy increasing.
2. Electron and positron equatorial rotation directions are opposite. Toruses are torn because of oppositely directed equatorial rotations in the contact point. Two cylinders rotating around their axes are created.

One gets for photon spin instead of (1.2)

$$\mathbf{S} = m\mathbf{R} \times (\boldsymbol{\omega} \times \mathbf{R}) = \boldsymbol{\omega} m R^2 = \hbar$$

So we are compelled to accept as a photon model a cylinder rotating around its axis and oscillating along it. Let us stress that this model is not more than a visual image, which proposes only a certain "visual hook" for the reader. Formal mathematical apparatus to which description we are passing works independently of this image, for instance if photon is a torus without equatorial rotation. I believe that adequate model may be constructed only in terms of complex functions or even quaternions.

This is photon's content description. Let us describe it mathematically. It does not possess electric charge. Therefore its initial conditions (divergent equalities) should be null.

$$div\mathbf{E} = 0 \qquad (3.1)$$

$$rot\mathbf{E} = -\frac{d\mathbf{B}}{dt} \qquad (3.2)$$

$$div\mathbf{B} = 0 \qquad (3.3)$$

$$c^2 rot\mathbf{B} = \frac{d\mathbf{E}}{dt} \qquad (3.4)$$

One can verify by direct substitution as it was done in the previous section that these system solutions are the functions

$$\mathbf{E} = \omega \exp\{i(\mathbf{p}\cdot\mathbf{r} - \omega t)\}\left[\frac{\mathbf{p}\times\mathbf{c}}{p^2 c} + \frac{\mathbf{c}}{\omega}\right] \qquad (3.5)$$

$$\mathbf{B} = \frac{\omega}{c}\exp\{i(\mathbf{p}\cdot\mathbf{r} - \omega t)\}\left[\frac{\mathbf{p}\times\mathbf{c}}{p^2 c} - \frac{\mathbf{c}}{\omega}\right] \qquad (3.6)$$

Bold $\mathbf{c}$ here means photon's vector speed. Only traveling wave is preserved in (3.5)-(3.6) functions in comparison with electron wave. It defines torsion oscillations in the plane perpendicular velocity and longitudinal oscillations along it just as it takes place in (2.12) and (2.13) waves. One can imagine it visually as cylinder-photon rotation around its axis and longitudinal oscillations along it. Cylinder axis is directed along velocity.

Certainly photons are originated not only in the process of charges' annihilation. Photons' origination necessary and sufficient conditions should be found in future. Some sufficient conditions are found in [6]. In general one can assert that photons are ether vortexes, which appears on many different causes. Therefore different masses from ether are drawn into vortexes and created photons posses different sizes and frequencies. Let us try to understand how these parameters should look in order to satisfy well known experimental facts. First of all the following equality should hold

$$\frac{m}{p^2}\boldsymbol{\omega} = \hbar \qquad (3.7)$$

Here m is photon mass drawn into the vortex when it was created in ether, $\mathbf{p}$ is normal vector directed from cylinder axis perpendicular velocity, $\boldsymbol{\omega}$ is angular velocity (frequency), $\hbar$ is vector or to be accurate pseudovector Planck constant. We accept equality (3.7) as nondeductive fact justified by experiments.

When (3.7) is scalarly multiplied by $\boldsymbol{\omega}$ one gets.

$$\frac{m\omega^2}{P^2} = mc^2 = \hbar \cdot \boldsymbol{\omega} \qquad (3.8)$$

We can come to this result starting from (3.5) and (3.6) fields. Let us find work produced by these fields. This work defines photon energy (3.8) got from (3.7).

Let $\mathbf{E}^*$ be function complex conjugate to $\mathbf{E}$. Then

$$\mathbf{E}\mathbf{E}^* = \omega^2\left[\frac{\mathbf{p}\times\mathbf{c}}{p^2c} + \frac{\mathbf{c}}{\omega}\right]^2 = 2c^2 \qquad (3.9)$$

Kinetic energy of electric field

$$K = \frac{1}{2}m\mathbf{E}\mathbf{E}^* = mc^2 \qquad (3.10)$$

Magnetic field energy should be summed with it. Or to be accurate energy originated by magnetic field projection on $\mathbf{E}$ should be added to (3.10) because force perpendicular to $\mathbf{E}$ does not produce work.

(3.5) and (3.6) look as they are collinear. Let us verify this supposition. Scalar production of vector amplitudes in (3.5) and (3.6) is

$$\left[\frac{\mathbf{p}\times\mathbf{c}}{p^2c} + \frac{\mathbf{c}}{\omega}\right]\cdot\left[\frac{\mathbf{p}\times\mathbf{c}}{p^2c} - \frac{\mathbf{c}}{\omega}\right] = \left[\frac{(\mathbf{p}\times\mathbf{c})^2}{p^4c^2} - \frac{c^2}{\omega^2}\right] = \left[\frac{1}{p^2} - \frac{1}{p^2}\right] = 0$$

i.e. $\mathbf{E}\perp\mathbf{B}$ and force created by $\mathbf{B}$ does not produce work and does not manifest itself in experiments. In other terms photon's energy is defined by formula (3.10).

Certainly we could begin from magnetic field energy computing.

$$c^2\mathbf{B}\cdot\mathbf{B}^* = \omega^2\left[\frac{\mathbf{p}\times\mathbf{c}}{p^2c} - \frac{\mathbf{c}}{\omega}\right]^2 = 2c^2$$

Here already electric field energy turns to be not revealed. Again we come to formula (3.10). Its physical meaning is also clear: photon's kinetic energy is doubled because of its oscillations in two perpendicular dimensions. If one takes a voluntary direction in the plane defined by vectors $\mathbf{E}$ and $\mathbf{B}$ and adds the work produced by their projection on This direction one comes to the same result again. Let us compare it with electron's energy. One gets using (2.12) formula for electron's electric field:

$$\mathbf{E}\mathbf{E}^* = \omega^2\left[\frac{\mathbf{p}\times\mathbf{v}}{p^2c} + \frac{\mathbf{v}}{\omega}\right]^2 + \frac{\omega^2}{p^2} = 2v^2 + c^2 \qquad (3.11)$$

Kinetic energy of electron's electric field is

$$K = \frac{1}{2}m\mathbf{E}\mathbf{E}^* = mv^2 + \frac{1}{2}mc^2 \qquad (3.12)$$

But electron's electric and magnetic fields (2.12) and (2.13) contain a collinear part in addition: stable magnetic field directed along $\mathbf{p}$ which should be added to electric field energy. This magnetic field component is

$$\mathbf{B}_{11} = \frac{\omega}{c}\exp\{i(\mathbf{p}\cdot\mathbf{r})\}\frac{\mathbf{p}}{p^2}$$

$$c^2\mathbf{B}_{11}\cdot\mathbf{B}_{11}^* = \frac{\omega^2}{p^2} = c^2$$

Its kinetic energy is

$$K = \frac{1}{2}m\mathbf{B}_{11}\cdot\mathbf{B}_{11}^* = \frac{1}{2}mc^2 \qquad (3.13)$$

When (3.12) and (3.13) are summed one gets for electron as a whole

$$K = mv^2 + mc^2 \qquad (3.14)$$

We could begin not with electric field but with magnetic one and we would come to the same result just as in the case of photon. The first item in (3.14) defines electron's movement contribution into its energy. It is originated by electron's velocity. This result is in good accord with De-Broglie concept about matter waves. Let us consider these approaches in greater details. De-Broglie formula for electron's energy is

$$K = mc^2 + \frac{1}{2}mv^2 + P,$$

where P is a potential energy which is not defined explicitly. One can say that (3.13) defines potential energy in explicit form: it is equal to kinetic energy.

The second item in (3.14) is electron's energy at rest. Numerically it is equal to energy of photon with electron mass. But their physical essence is different. In the case of electron this is energy of two fields oscillating in one dimension. Photon's energy mc^2 corresponds to electron energy mv^2. Equality holds just because $v = c$ for the case. But photon possesses no energy of rest in contrast to electron.

The reader may feel certain unsatisfaction: why one field in traveling wave does not deposit into total energy. The answer is: imaginary part was essentially included into all our computations. We should not get accord with experiment if we took into account only real parts of fields. This means that imaginary part should be essentially included into fields' characteristics and nowadays it is completely ignored by physicists. One can call imaginary part of a field potential or nonrevealed one. In other terms (3.10) may be understood as kinetic and potential energy sum. Let us note that potential energy notion is very vaguely defined in modern physics.

Although the received results lead to new question sometimes nevertheless they solve some problems of modern physics such as electron's "electrodynamic mass", electron's electric field energy infinity, electron's self action, etc.

All these problems are solved because electron is understood as rotation of a certain mass and electric field is understood as a special case of gravity, as it is defined in [2]. Let us consider one additional point.

Photon polarization is naturally defined by left of right screw its rotation constitutes with velocity. Linear polarization corresponds to oscillations along $\mathbf{p}\times\mathbf{v}$ vector in a fixed plane.

Linearly polarized photon beam was used for allegedly experimental proof of longitudinal oscillations lack in photons: when analyzer letting through photons polarized only in one plane is turned for $\pi/2$ angle the light disappears. The reason is: if photon had longitudinal oscillations the light wouldn't disappear. But waves (3.5) and (3.6) are similar to waves on boundary surface of two different mediums: longitudinal and transverse oscillations in such waves are connected. One type oscillations suppression means immediate suppression of the other type oscillations. The very idea that electromagnetic waves must be similar to boundary surface waves was proposed first by P.D. Proosov in his monograph [5].

Let us compare function (3.5) and (3.6) with the waves traditionally considered in electrodynamics. Traditional form of Maxwell equations for light is

$$div\mathbf{E} = 0 \qquad (3.15)$$

$$rot\mathbf{E} = -\frac{\partial\mathbf{B}}{\partial t} \qquad (3.16)$$

$$div\mathbf{B} = 0 \qquad (3.17)$$

$$c^2 rot\mathbf{B} = \frac{\partial\mathbf{E}}{\partial t} \qquad (3.18)$$

The following functions are usually considered as solutions of this system

$$\mathbf{E} = \mathbf{E}_0 \exp\{i(\mathbf{k}\cdot\mathbf{r} - \omega t)\} \qquad (3.19)$$

$$\mathbf{B} = \mathbf{B}_0 \exp\{i(\mathbf{k}\cdot\mathbf{r} - \omega t)\} \qquad (3.20)$$

Let us remind that wave vector $\mathbf{k}$ is modulo equal to our normal vector $\mathbf{p}$ but is directed along speed vector in contrast to $\mathbf{p}$ which is directed perpendicular to speed vector.

Convective derivative of (3.5) and (3.6) functions is null. Therefore they are also solutions of (3.15)-(3.18) system and not only (3.1)-(3.4) system. Thus they could be considered as electrodynamic waves description already for a long time. Apparently tradition of wave description in habitual mediums made scientists consider only function (3.19) and (3.20) as (3.15)-(3.18) system solutions. But plane waves description (3.19)-(3.20) does not take into account torsion character of electromagnetic waves. Mathematically this is manifested in the fact that waves (3.19), (3.20) does not satisfy generalized Maxwell equations (3.1)-(3.4). Plane waves describe electromagnetic ones not adequately. And this is manifested in well-known paradoxes of quantum mechanics.

4.Interaction energy, momentum and force for two photons.

It was shown in [1] that energy and momentum of interaction should be preliminary found in order to calculate interaction force for elementary particles. Let us begin with two photons.

Let

$$\mathbf{E}_1 = \omega_1 \exp\{i((\mathbf{p}_1\cdot\mathbf{r}) - \omega_1 t)\}\left[\frac{\mathbf{p}_1\times\mathbf{c}_1}{p_1^2 c} + \frac{\mathbf{c}_1}{\omega_1}\right] \qquad (4.1)$$

$$\mathbf{B}_1 = \frac{\omega_1}{c} \exp\{i((\mathbf{p}_1\cdot\mathbf{r}) - \omega_1 t)\}\left[\frac{\mathbf{p}_1\times\mathbf{c}_1}{p_1^2 c} - \frac{\mathbf{c}_1}{\omega_1}\right] \qquad (4.2)$$

be electric and magnetic fields for photon 1. $\mathbf{c}_1$ here is photon's 1 vector speed, $|\mathbf{c}_1| = c$, where c is scalar light speed.

One has for the second photon

$$\mathbf{E}_2^* = \omega_2 \exp\{-i((\mathbf{p}_2\cdot\mathbf{r}) - \omega_2 t)\}\left[\frac{\mathbf{p}_2\times\mathbf{c}_2}{p_2^2 c} + \frac{\mathbf{c}_2}{\omega_2}\right] \qquad (4.3)$$

$$\mathbf{B}_2^* = \frac{\omega_2}{c} \exp\{-i((\mathbf{p}_2\cdot\mathbf{r}) - \omega_2 t)\}\left[\frac{\mathbf{p}_2\times\mathbf{c}_2}{p_2^2 c} - \frac{\mathbf{c}_2}{\omega_2}\right] \qquad (4.4)$$

$\mathbf{E}_2^*$ and $\mathbf{B}_2^*$ here are complex conjugate electric and magnetic fields for photon 2.

Interaction energy of two photons is defined by formula (2.7) modified for two photons. Let us calculate the following function preliminary

$$K_{21} = c\mathbf{E}_1\cdot\mathbf{B}_2^* = \omega_1\omega_2 \exp\{i((\mathbf{p}_1 - \mathbf{p}_2)\cdot\mathbf{r} - (\omega_1 - \omega_2))t\}\cdot$$
$$\cdot\left[\frac{(\mathbf{p}_1\times\mathbf{c}_1)\cdot(\mathbf{p}_2\times\mathbf{c}_2)}{p_1^2 p_2^2 c^2} + \frac{\mathbf{c}_1\cdot(\mathbf{p}_2\times\mathbf{c}_2)}{\omega_1 p_1^2 c} - \frac{\mathbf{c}_2\cdot(\mathbf{p}_1\times\mathbf{c}_1)}{\omega_2 p_2^2 c} - \frac{\mathbf{c}_1\cdot\mathbf{c}_2}{\omega_1\omega_2}\right] \qquad (4.5)$$

(4.5) defines energy oscillations. The reader remembers that unique photon energy is constant. But interaction energy oscillates and behaves like wave.

Function

$$L_{21} = \frac{m_1\cdot m_2}{\varepsilon_0} K_{21} \qquad (4.6)$$

is called integral or simply interaction energy if misunderstanding is impossible. It has dimension of energy multiplied by a volume. Here m_1 and m_2 are photons' masses and ε_0 is electric constant physical meaning of which is mass density of free ether. Certainly exponent index in (4.5) should contain not $(\mathbf{p}_1 - \mathbf{p}_2)\cdot\mathbf{r}$ but $(\mathbf{p}_1\cdot\mathbf{r}_1 - \mathbf{p}_2\cdot\mathbf{r}_2)$. Photon 1 and photon 2 radius-vectors $\mathbf{r}_1$ and $\mathbf{r}_2$ do not coinside. But here we speak about energy interaction in a certain interaction volume. Therefore one can define this volume radius- vector

$$\mathbf{r} = (\mathbf{r}_1 + \mathbf{r}_2)/2 \qquad (4.7)$$

$$-gradL_{21} = -\frac{im_1 m_2 \omega_1 \omega_2}{\varepsilon_0} \Delta\mathbf{p} \exp\{i(\Delta\mathbf{p}\cdot\mathbf{r} - \Delta\omega t)\}\cdot$$
$$\cdot\left[\frac{(\mathbf{p}_1 \times \mathbf{c}_1)\cdot(\mathbf{p}_2 \times \mathbf{c}_2)}{p_1^2 p_2^2 c^2} + \frac{\mathbf{c}_1\cdot(\mathbf{p}_2 \times \mathbf{c}_2)}{\omega_1 p_1^2 c} - \frac{\mathbf{c}_2\cdot(\mathbf{p}_1 \times \mathbf{c}_1)}{\omega_2 p_2^2 c} - \frac{\mathbf{c}_1\cdot\mathbf{c}_2}{\omega_1\omega_2}\right] \qquad (4.8)$$

Here $\Delta\mathbf{p} = (\mathbf{p}_1 - \mathbf{p}_2)$, $\Delta\omega = (\omega_1 - \omega_2)$.

(4.8) has dimension of force multiplied by a volume. This is force integrated with respect to volume. In a certain aspect it is symmetric to the concept of force density which is force derivative with respect to volume. (4.8) will be called integral or simply interaction force. It describes integral action of photon 2 on photon 1 as energy gradient.

Let us consider physical meaning of functions (4.6) and (4.8) in some special cases.

Let $\mathbf{c}_1 = \mathbf{c}_2$, i.e. photons' velocities are codirected and $|\omega_1| = |\omega_2|$.

Let $\omega = \pm|\omega_1|$.

The case $\omega = \omega_1$ corresponds the situation with codirected spins and the case $\omega = -\omega_1$ corresponds the case of antidirected spins.

1. $\omega = \omega_1$, i.e. photons are coherent.

If $\mathbf{c}_1 = \mathbf{c}_2$ then vectors $\mathbf{p}_1$ and $\mathbf{p}_2$ are complanar. But generally speaking they are not collinear. The angle between them is difined by photons' polarization difference. $\Delta\mathbf{p}$ is analogous to phase remainder for transverse waves and means photons' polarization difference.

If in addition to the accepted assumption $\mathbf{p}_1 = \mathbf{p}_2$, i.e. photons' polarization coincide in addition to their coherentness, then $\Delta\mathbf{p} = 0$ and the whole force (4.8) is null. Interaction energy (4.6) is null as well.

$$L_{21} = 0 \qquad (4.9)$$

Let now $\mathbf{p}_1 = -\mathbf{p}_2$, i.e. photons are antipolarized.

Then $\Delta\mathbf{p} = 2\mathbf{p}_1$.

Spatial oscillation period is maximal

$$L_{21} = -\frac{m^2 c^2}{\varepsilon_0} \exp\{i(2\mathbf{p}_1\cdot\mathbf{r})\} \qquad (4.10)$$

$$\mathbf{F}_{21}^1 = \frac{2im^2c^2}{\varepsilon_0} \exp\{i(2\mathbf{p}_1\cdot\mathbf{r})\}\mathbf{p}_1 \qquad (4.11)$$

Interferation picture is stable for the considered cases. In general when general formulas (4.6) and (4.8) are valid this picture becomes function of space coordinates and time.

Two force definitions are considered equivalent in modern physics: force as momentum derivative with respect to time and force as energy gradient. Let us verify this assertion. Let $m\mathbf{v}$ be a body momentum and $\frac{1}{2}mv^2$ be its kinetic energy

$$\frac{d}{dt}(m\mathbf{v}) = m(\mathbf{v}\cdot grad)\mathbf{v} + \mathbf{v}(\mathbf{v}\cdot grad\ m) + \frac{\partial m}{\partial t}\mathbf{v} + m\frac{\partial \mathbf{v}}{\partial t} \qquad (4.12)$$

$$grad\left(\frac{1}{2}mv^2\right) = m(\mathbf{v}\cdot grad)\mathbf{v} + \frac{1}{2}v^2 grad\ m \qquad (4.13)$$

Only the first item coincides in the right hand parts of these equalities. One can see that (4.12) and (4.13) coincide only if $m = const$ and $\mathbf{v}$ does not depend explicitly on time. Just this case is usually considered in textbooks. When interaction force is defined this coincidence is also absent: the first item in (4.12) turns to be dependent on photons' velocities and the first one in (4.13) depends on photons' velocities vector difference.

Therefore generalized Lorentz force (2.7) contains two items: interaction energy gradient and interaction momentum derivative. We have found the first item. Now let us find the second one.

Interaction momentum in free ether is

$$\mathbf{P}_{21} = \frac{cm_1 m_2}{\varepsilon_0}\left[\mathbf{B}_1 \times \mathbf{B}_2^*\right] \tag{4.14}$$

One gets substituting fields from (4.2) and (4.4):

$$\mathbf{P}_{21} = \frac{m_1 m_2 \omega_1 \omega_2}{\varepsilon_0 c}\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r} - \Delta\omega t)\}\cdot$$
$$\cdot\left[\begin{array}{l}\frac{(\mathbf{p}_1 \times \mathbf{c}_1)\times(\mathbf{p}_2 \times \mathbf{c}_2)}{p_1^2 p_2^2 c^2} + \frac{\mathbf{c}_2 \times (\mathbf{p}_1 \times \mathbf{c}_1)}{p_1^2 \omega_2 c} - \\ - \frac{\mathbf{c}_1 \times (\mathbf{p}_2 \times \mathbf{c}_2)}{p_2^2 \omega_1 c} + \frac{\mathbf{c}_1 \times \mathbf{c}_2}{\omega_1 \omega_2}\end{array}\right] \tag{4.15}$$

$$\frac{d}{dt}\mathbf{P}_{21} = (\Delta\mathbf{v}\cdot grad)\mathbf{P}_{21} + \frac{\partial \mathbf{P}_{21}}{\partial t} \tag{4.16}$$

$$\Delta\mathbf{v} = \mathbf{v}_1 - \mathbf{v}_2 .$$

One gets taking into account (4.15):

$$\frac{d}{dt}\mathbf{P}_{21} \equiv \mathbf{F}_{21}^2 = \frac{i m_1 m_2 \omega_1 \omega_2}{\varepsilon_0 c}(\Delta\mathbf{v}\cdot\Delta\mathbf{p} - \Delta\omega)\cdot$$
$$\cdot\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r} - \Delta\omega t)\}\cdot \tag{4.17}$$
$$\cdot\left[\begin{array}{l}\frac{(\mathbf{p}_1 \times \mathbf{c}_1)\times(\mathbf{p}_2 \times \mathbf{c}_2)}{p_1^2 p_2^2 c^2} + \frac{\mathbf{c}_2 \times (\mathbf{p}_1 \times \mathbf{c}_1)}{p_1^2 \omega_2 c} - \\ - \frac{\mathbf{c}_1 \times (\mathbf{p}_2 \times \mathbf{c}_2)}{p_2^2 \omega_1 c} + \frac{\mathbf{c}_1 \times \mathbf{c}_2}{\omega_1 \omega_2}\end{array}\right]$$

$$\Delta\mathbf{v}\cdot\Delta\mathbf{p} = (\mathbf{v}_1 - \mathbf{v}_2)\cdot(\mathbf{p}_1 - \mathbf{p}_2) = \mathbf{v}_1\mathbf{p}_1 - \mathbf{p}_1\mathbf{v}_2 - \mathbf{p}_2\mathbf{v}_1 + \mathbf{v}_2\mathbf{p}_2 \tag{4.18}$$

The extreme items here are null by definition. But the middle ones are not null generally speaking. Hence

$$\Delta\mathbf{v}\Delta\mathbf{p} = -(\mathbf{p}_1\mathbf{v}_2 + \mathbf{p}_2\mathbf{v}_1) \tag{4.19}$$

$$(\mathbf{p}_1 \times \mathbf{c}_1)\times(\mathbf{p}_2 \times \mathbf{c}_2) = \mathbf{p}_2(\mathbf{c}_2\cdot(\mathbf{p}_1 \times \mathbf{c}_1)) - \mathbf{c}_2(\mathbf{p}_2\cdot(\mathbf{p}_1 \times \mathbf{c}_1)) \tag{4.20}$$

Let us consider some explaining examples:

1. $\mathbf{c}_1 = \pm\mathbf{c}_2$

   The square brackets are null for this case. Hence momentum (4.15) and force (4.17) is null.
2. $\Delta\mathbf{p}\cdot\Delta\mathbf{v} - \Delta\omega = 0$

   The parentheses are null for this case and force (4.17) is null but momentum (4.15) is not null, it is stable.

In general (4.15) and (4.17) are not null and describe a certain wave or to be strict a certain torsional oscillation carrying mass or an oscillating vortex moving with light velocity in ether.

The last property attaches particle quality to photon. The following interaction force appears between two photons

$$\mathbf{F}_{21} = \mathbf{F}_{21}^1 + \mathbf{F}_{21}^2 \tag{4.21}$$

where items are defined by (4.8) and (4.17).

If this force is null then 2 photons move “not hindering each other” (coherent photons with coinciding normal vectors $\mathbf{p}_1$ and $\mathbf{p}_2$ is the case). If the force (4.21) is not null an interaction force directed to the velocity at certain angle appears. $\mathbf{F}_{21}^1$ is directed along $\Delta\mathbf{p}$ and $\mathbf{F}_{21}^2$ is directed along vector in square brackets in (4.17). As a result a photons beam becomes cone shaped.

5.Interaction energy, momentum and force for two electrons.

The formulas we are going to consider are similar to the ones we got in the previous chapter but additional items appear because oscillations along normal vector $\mathbf{p}$ takes place. Let us consider two electrons' interaction.

Let

$$\mathbf{E}_1 = \omega_1 \exp\{i(\mathbf{p}_1 \cdot \mathbf{r} - \omega_1 t)\}\left[\frac{\mathbf{p}_1 \times \mathbf{v}_1}{p^2 c} + \frac{\mathbf{v}_1}{\omega_1}\right] + \\ + \omega_1 \exp\{i(\mathbf{p}_1 \cdot \mathbf{r})\}\frac{\mathbf{p}_1}{p^2} \tag{5.1}$$

$$\mathbf{B}_1 = \frac{\omega_1}{c} \exp\{i(\mathbf{p}_1 \cdot \mathbf{r} - \omega_1 t)\}\left[\frac{\mathbf{p}_1 \times \mathbf{v}_1}{p^2 c} - \frac{\mathbf{v}_1}{\omega_1}\right] + \\ + \frac{\omega_1}{c} \exp\{i(\mathbf{p}_1 \cdot \mathbf{r})\}\frac{\mathbf{p}_1}{p^2} \tag{5.2}$$

be electric and magnetic fields of the first electron. $p_1^2 = p_2^2 = p^2$.

Let

$$\mathbf{E}_2^* = \omega_2 \exp\{-i(\mathbf{p}_2 \cdot \mathbf{r} - \omega_2 t)\}\left[\frac{\mathbf{p}_2 \times \mathbf{v}_2}{p^2 c} + \frac{\mathbf{v}_2}{\omega_2}\right] + \\ + \omega_2 \exp\{-i(\mathbf{p}_2 \cdot \mathbf{r})\}\frac{\mathbf{p}_2}{p^2} \tag{5.3}$$

$$\mathbf{B}_2^* = \frac{\omega_2}{c} \exp\{-i(\mathbf{p}_2 \cdot \mathbf{r} - \omega_2 t)\}\left[\frac{\mathbf{p}_2 \times \mathbf{v}_2}{p^2 c} - \frac{\mathbf{v}_2}{\omega_2}\right] + \\ + \frac{\omega_2}{c} \exp\{-i(\mathbf{p}_2 \cdot \mathbf{r})\}\frac{\mathbf{p}_2}{p^2} \tag{5.4}$$

be complex conjugate electric and magnetic fields of the second electron.

Integral interaction energy for these two electrons is

$$L_{21} = \frac{m_1 m_2 \omega_1 \omega_2}{\varepsilon_0}\left\{\begin{array}{l} \exp\{i((\mathbf{p}_1 - \mathbf{p}_2)\cdot \mathbf{r} - (\omega_1 - \omega_2)t)\}\cdot \\ \cdot\left[\begin{array}{l}\frac{(\mathbf{p}_1 \times \mathbf{v}_1)\cdot(\mathbf{p}_2 \times \mathbf{v}_2)}{p^4 c^2} + \frac{\mathbf{v}_1 \cdot (\mathbf{p}_2 \times \mathbf{v}_2)}{\omega_1 p^2 c} - \\ - \frac{\mathbf{v}_2 \cdot (\mathbf{p}_1 \times \mathbf{v}_1)}{\omega_2 p_1^2 c} - \frac{\mathbf{v}_1 \cdot \mathbf{v}_2}{\omega_1 \omega_2}\end{array}\right] + \\ + \exp\{i((\mathbf{p}_1 - \mathbf{p}_2)\cdot \mathbf{r} + \omega_2 t)\}\cdot \\ \cdot\left[\frac{\mathbf{p}_1 \cdot (\mathbf{p}_2 \times \mathbf{v}_2)}{p^4 c} - \frac{\mathbf{p}_1 \cdot \mathbf{v}_2}{p^2 c}\right] + \\ + \exp\{i((\mathbf{p}_1 - \mathbf{p}_2)\cdot \mathbf{r} - \omega_1 t)\}\cdot \\ \cdot\left[\frac{\mathbf{p}_2 \cdot (\mathbf{p}_1 \times \mathbf{v}_1)}{p^4 c} - \frac{\mathbf{p}_2 \cdot \mathbf{v}_1}{p^2 c}\right] + \\ + \exp\{i((\mathbf{p}_1 - \mathbf{p}_2)\cdot \mathbf{r})\}\cdot \frac{\mathbf{p}_1 \cdot \mathbf{p}_2}{p^4} \end{array}\right\} \tag{5.5}$$

Let us explain (5.5) with the help of rather a special but very important example. Let

$$\mathbf{v}_1 = \mathbf{v}_2 = 0,\ \mathbf{p}_1 = \mathbf{p}_2,\ \omega_1 = \omega_2 \tag{5.6}$$

Condition (5.6) means that all the items in (5.5) are null except the last one and the last item does not oscillate. One has: integral energy of two electrons at rest is

$$L_{21} = \frac{m_1 \omega_1 m_2 \omega_2}{\varepsilon_0 p^2} \quad (5.7)$$

The reader certainly remembers that $m_1 \omega_1 = q_1$, $m_2 \omega_2 = q_2$ are charges which signs are defined by ω_1 and ω_2 signs, $1/p^2 = R^2$, where R is radius of the greater circumference defining torus and $\rho = 1/2R$ is the smaller circumference radius.

Condition before the last one in (5.6) yields that equatorial planes of the charges (tori) are parallel. Function (5.7) is integral energy acting in volume between equatorial section of the tori and redoubled radius of the smaller circumference. Let us find it. Torus equatorial section square is

$$S = \pi\left[\left(\frac{3}{2}R\right)^2 - \left(\frac{1}{2}R\right)^2\right] = 2\pi R^2 \quad (5.8)$$

Interaction volume is

$$V = S \cdot R = 2\pi R^3 \quad (5.9)$$

Inside this volume energy (5.7) is constant hence interaction force is null. We'd like to understand how the charges interact at a distance $r > R$. Interaction energy for the case is

$$V = 2\pi R^2 \cdot r \quad (5.10)$$

Interaction energy formula also changes. It was shown above that in touch interaction energy is redoubled. When remote charges are under consideration we must use classic formula for kinetic energy. In other terms we must divide integral energy (5.7) by volume (5.10) and by 2 in addition. One finally gets for the case: already habitual but not integral energy is

$$E_{21} = \frac{q_1 q_2}{4\pi\varepsilon_0 r} \quad (5.11)$$

One gets calculating minus gradient of this energy: already habitual and not integral interaction force is

$$\mathbf{f}_{21} = \frac{q_1 q_2}{4\pi\varepsilon_0 r^3}\mathbf{r}_{21} \quad (5.12)$$

where $\mathbf{r}_{21}$ is radius- vector from charge 2 to charge 1. We have received habitual Coulomb potential (5.11) and Coulomb force (5.12)

Let us weaken the first condition in (5.6), i.e.

$$\mathbf{v}_1 = \mathbf{v}_2 = \mathbf{v},\ \mathbf{p}_1 = \mathbf{p}_2,\ \omega_1 = \omega_2 \quad (5.13)$$

In other terms the charges move “side by side” with equal velocities.

One gets taking into account that $\omega^2/p^2 = c^2$

$$E_{21} = \frac{q_1 q_2}{4\pi\varepsilon_0 r}\left[1 - \frac{v^2}{c^2}\right] \quad (5.14)$$

$$\mathbf{f}_{21} = \frac{q_1 q_2}{4\pi\varepsilon_0 r^3}\left[1 - \frac{v^2}{c^2}\right]\mathbf{r}_{21} \quad (5.15)$$

The second item in square brockets is traditional Lorentz force. It weakens Coulomb repulsion between two parallel beams of electrons and displays as attractive force between two neutral conductors with parallel currents.

$$\mathbf{v}_1 \cdot \mathbf{v}_2 = v^2 \cos\varphi \quad (5.16)$$

$\cos\varphi = 1$ for parallel currents and $\cos\varphi = -1$ for antiparallel currents. Therefore for

$$\mathbf{v}_1 = -\mathbf{v}_2\,,\ \mathbf{p}_1 = \mathbf{p}_2\,,\ \omega_1 = \omega_2 \tag{5.17}$$

the second item in square brackets changes its sign.

Let us find gradient part of interaction force between two charges.

$$\begin{aligned}
- gradL_{21} &= -\frac{im_1m_2\omega_1\omega_2}{\varepsilon_0}\Delta\mathbf{p}\{\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r}-\Delta\omega t)\}\cdot \\
&\cdot\left[\begin{array}{l}\frac{(\mathbf{p}_1\times\mathbf{v}_1)\cdot(\mathbf{p}_2\times\mathbf{v}_2)}{p^4c^2}+\frac{\mathbf{v}_1\cdot(\mathbf{p}_2\times\mathbf{v}_2)}{\omega_1p^2c}- \\ -\frac{\mathbf{v}_2\cdot(\mathbf{p}_1\times\mathbf{v}_1)}{\omega_2p_1^2c}-\frac{\mathbf{v}_1\cdot\mathbf{v}_2}{\omega_1\omega_2}\end{array}\right]+ \\
&+\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r}-\omega_1t)\}\cdot\left[\frac{(\mathbf{p}_1\times\mathbf{v}_1)\cdot\mathbf{p}_2}{p^4c}-\frac{\mathbf{p}_2\cdot\mathbf{v}_1}{p^2c}\right]+ \\
&+\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r}+\omega_2t)\}\cdot\left[\frac{\mathbf{p}_1\cdot(\mathbf{p}_2\times\mathbf{v}_2)}{p^4c}-\frac{\mathbf{p}_1\cdot\mathbf{v}_2}{p^2c}\right]+ \\
&+\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r})\}\cdot\frac{\mathbf{p}_1\cdot\mathbf{p}_2}{p^4}\}
\end{aligned} \tag{5.18}$$

This force depends on absolute electrons velocities with respect to ether.

It was shown above that interaction force as momentum total derivative with respect to time should be added to it. Let us find it.

$$\begin{aligned}
(\mathbf{B}_1\times\mathbf{B}_2^*) &= -\frac{\omega_1\omega_2}{c^2}\{\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r}-\Delta\omega t)\}\cdot \\
&\cdot\left[\begin{array}{l}\frac{(\mathbf{p}_1\times\mathbf{v}_1)\cdot(\mathbf{p}_2\times\mathbf{v}_2)}{p^4c^2}- \\ -\frac{\mathbf{v}_2\times(\mathbf{p}_1\times\mathbf{v}_1)}{p_1^2c\omega_2}- \\ -\frac{\mathbf{v}_1\times(\mathbf{p}_2\times\mathbf{v}_2)}{p^2c\omega_1}+\frac{\mathbf{v}_1\times\mathbf{v}_2}{\omega_1\omega_2}\end{array}\right]+\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r}-\omega_1t)\}\cdot \\
&\cdot\left[\frac{(\mathbf{p}_1\times\mathbf{v}_1)\times\mathbf{p}_2}{p^4c}-\frac{\mathbf{p}_2\times\mathbf{v}_1}{p^2\omega_1}\right]+\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r}+\omega_2t)\}\cdot \\
&\left[\frac{\mathbf{p}_1\times(\mathbf{p}_2\times\mathbf{v}_2)}{p^4c}-\frac{\mathbf{p}_1\times\mathbf{v}_2}{p^2\omega_2}\right]+\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r})\}\cdot\frac{\mathbf{p}_1\cdot\mathbf{p}_2}{p^4}\}
\end{aligned} \tag{5.19}$$

Let $\Delta\mathbf{v} = \mathbf{v}_1 - \mathbf{v}_2$ be electrons' velocities difference.

$$\frac{d}{dt}\left[\frac{m_1 m_2 c}{\varepsilon_0}\left(\mathbf{B}_1 \times \mathbf{B}_2^*\right)\right] = -\frac{i m_1 m_2 \omega_1 \omega_2}{\varepsilon_0 c}\left(\Delta\mathbf{v}\cdot\Delta\mathbf{p}\right)\cdot\{\exp\left\{i\begin{pmatrix}\Delta\mathbf{p}\cdot\mathbf{r} - \\ -\Delta\omega t\end{pmatrix}\right\}\cdot$$
$$\cdot\left[\frac{(\mathbf{p}_1\times\mathbf{v}_1)\times(\mathbf{p}_2\times\mathbf{v}_2)}{p^4c^2} + \frac{\mathbf{v}_2\times(\mathbf{p}_1\times\mathbf{v}_1)}{p_1^2 c\omega_2} - \frac{\mathbf{v}_1\times(\mathbf{p}_2\times\mathbf{v}_2)}{p^2 c\omega_1} + \frac{\mathbf{v}_1\times\mathbf{v}_2}{\omega_1\omega_2}\right] +$$
$$+\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r} - \omega_1 t)\}\cdot\left[\frac{(\mathbf{p}_1\times\mathbf{v}_1)\times\mathbf{p}_2}{p^4 c} + \frac{\mathbf{p}_2\times\mathbf{v}_1}{p^2\omega_1}\right] +$$
$$+\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r} + \omega_2 t)\}\cdot\left[\frac{\mathbf{p}_1\times(\mathbf{p}_2\times\mathbf{v}_2)}{p^4 c} - \frac{\mathbf{p}_1\times\mathbf{v}_2}{p^2\omega_2}\right] +$$
$$+\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r})\}\cdot\frac{\mathbf{p}_1\cdot\mathbf{p}_2}{p^4}\} - \frac{i m_1 m_2 \omega_1 \omega_2 \Delta\omega}{\varepsilon_0 c}\{\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r} - \Delta\omega t)\}\cdot$$
$$\cdot\left[\frac{(\mathbf{p}_1\times\mathbf{v}_1)\times(\mathbf{p}_2\times\mathbf{v}_2)}{p^4c^2} + \frac{\mathbf{v}_2\times(\mathbf{p}_1\times\mathbf{v}_1)}{p_1^2 c\omega_2} - \frac{\mathbf{v}_1\times(\mathbf{p}_2\times\mathbf{v}_2)}{p^2 c\omega_1} + \frac{\mathbf{v}_1\times\mathbf{v}_2}{\omega_1\omega_2}\right]\} -$$
$$-\frac{i m_1 m_2 \omega_1 \omega_2}{\varepsilon_0 c}\{\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r} - \omega_1 t)\}\cdot\left[\frac{(\mathbf{p}_1\times\mathbf{v}_1)\times\mathbf{p}_2}{p^4 c} + \frac{\mathbf{p}_2\times\mathbf{v}_1}{p^2\omega_1}\right]\} +$$
$$+\frac{i m_1 m_2 \omega_1 \omega_2}{\varepsilon_0 c}\{\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r} + \omega_2 t)\}\cdot\left[\frac{\mathbf{p}_1\times(\mathbf{p}_2\times\mathbf{v}_2)}{p^4 c} - \frac{\mathbf{p}_1\times\mathbf{v}_2}{p^2\omega_2}\right]\} \qquad (5.20)$$

The item in the first braces here is convective derivative. It is null if only velocities coincide ($\Delta\mathbf{v} = 0$) or polarizations are equal ($\Delta\mathbf{p} = 0$). The items in the second the third and the fourth braces are partial derivatives with respect to time. The second item depends on frequencies' difference $(\omega_1 - \omega_2)$ and the third and the fourth ones depend on production of $(\omega_1 \cdot \omega_2)$ on ω_1 and ω_2 correspondingly. These forces' amplitudes are defined by vectors in square brackets attached to exponents.

Momentum forces amplitudes are vectors in contrast to gradient forces which oscillation directions are defined by polarization difference $\Delta\mathbf{p}$.

Interaction momentum between photon and electron is a special case of (5.19). Let us investigate this case separately because it is connected with famous Compton experiment.

Let $\mathbf{B}_1$ be photon's magnetic field defined by (4.2) and $\mathbf{B}_2^*$ be complex conjugate magnetic field of an electron defined by (5.4).

$$c\left(\mathbf{B}_1\times\mathbf{B}_2^*\right) = -\frac{\omega_1\omega_2}{c}\{\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r} - \Delta\omega t)\}\cdot$$
$$\cdot\begin{bmatrix}\frac{(\mathbf{p}_1\times\mathbf{c}_1)\cdot(\mathbf{p}_2\times\mathbf{v}_2)}{p_1^2 p_2^2 c^2} + \frac{\mathbf{v}_2\times(\mathbf{p}_1\times\mathbf{c}_1)}{p_1^2 c\omega_2} - \\ -\frac{\mathbf{c}_1\times(\mathbf{p}_2\times\mathbf{v}_2)}{p_2^2 c\omega_1} + \frac{\mathbf{c}_1\times\mathbf{v}_2}{\omega_1\omega_2}\end{bmatrix} + \qquad (5.21)$$
$$+\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r} - \omega_1 t)\}\cdot\left[\frac{(\mathbf{p}_1\times\mathbf{c}_1)\times\mathbf{p}_2}{p_1^2 p_2^2 c} - \frac{\mathbf{p}_2\times\mathbf{c}_1}{p_2^2\omega_1}\right]\}$$

One gets when triple vector products are revealed.

$$c\left(\mathbf{B}_1 \times \mathbf{B}_2^*\right) = -\frac{\omega_1\omega_2}{c}\{\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r} - \Delta\omega t)\}\cdot$$

$$\cdot\begin{bmatrix} \frac{\mathbf{p}_2(\mathbf{v}_2\cdot(\mathbf{p}_1\times\mathbf{c}_1)) - \mathbf{v}_2(\mathbf{p}_2\cdot(\mathbf{p}_1\times\mathbf{c}_1))}{p_1^2 p_2^2 c^2} + \\ + \frac{\mathbf{p}_1(\mathbf{c}_1\cdot\mathbf{v}_2) - \mathbf{c}_1(\mathbf{p}_1\cdot\mathbf{v}_2)}{p_1^2 c\omega_2} - \\ - \frac{\mathbf{p}_2(\mathbf{c}_1\cdot\mathbf{v}_2) - \mathbf{v}_2(\mathbf{p}_2\cdot\mathbf{v}_1)}{p_2^2 c\omega_1} + \frac{\mathbf{c}_1\times\mathbf{v}_2}{\omega_1\omega_2} \end{bmatrix} - \tag{5.22}$$

$$-\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r} - \omega_1 t)\}\cdot\begin{bmatrix} \frac{-\mathbf{p}_1(\mathbf{p}_2\cdot\mathbf{c}_1) + \mathbf{c}_1(\mathbf{p}_1\cdot\mathbf{p}_2)}{p_1^2 p_2^2 c} - \\ - \frac{\mathbf{p}_2\times\mathbf{c}_1}{p_2^2\omega_1} \end{bmatrix}\}$$

When formulas (5.21) and (5.22) are multiplied by $(m_1 \cdot m_2)/\varepsilon_0$, where m_1 is photon mass, m_2 is electron mass, ε_0 is ether density they define momentum increase which electron transfers to the photon.

$$\mathbf{p}_1 \perp \mathbf{c}_1,\ \mathbf{p}_2 \perp \mathbf{v}_2 \tag{5.23}$$

because of photon and electron construction.
Let us assume in addition that

$$\mathbf{p}_1 // \mathbf{p}_2,\ \mathbf{v}_2 \perp \mathbf{c}_1 \tag{5.24}$$

Hence and from (5.23) condition one gets

$$\mathbf{p}_1 \perp \mathbf{v}_2,\ \mathbf{p}_2 \perp \mathbf{c}_1 \tag{5.25}$$

One gets taking into account (5.23)-(5.25) in (5.22): the first square brackets in the right hand part

$$[\ ]_1 = \left[\mathbf{p}_2\frac{|\mathbf{v}_2||\mathbf{p}_1|\cos\varphi}{p_1^2 p_2^2 c} + \mathbf{p}_1\frac{|\mathbf{v}_2|}{p_1^2\omega_2} - \mathbf{p}_2\frac{|\mathbf{v}_2|}{p_2^2\omega_1} + \frac{\mathbf{c}_1\times\mathbf{v}_2}{\omega_1\omega_2}\right] \tag{5.26}$$

where φ is angle between $\mathbf{v}_2$ and $(\mathbf{p}_1 \times \mathbf{c}_1)$. The second the third and the fourth items here are constant vectors independent with respect to collision angle φ. Only the first item depends on it. When vectors $\mathbf{v}_2$ and $(\mathbf{p}_1 \times \mathbf{c}_1)$ are perpendicular this item is null. All the items depend on photon's characteristics $\mathbf{p}_1$ and $\boldsymbol{\omega}_1$. Let us introduce an additional velocity vector for photon:

$$\mathbf{v}_1 = \frac{\omega_1\mathbf{p}_1}{p_1^2},\ |\mathbf{v}_1| = c \tag{5.27}$$

This is oscillation velocity for linearly polarized photon along normal vector $\mathbf{p}_1$. $\mathbf{v}_1$ designation is introduced in order to distinguish this velocity from electron translational movement speed $\mathbf{c}_1$.

Let us multiply the square brackets (5.26) by $\omega_1\omega_2/c$ factor standing before braces. One gets

$$[\ ]_1 = \left[-\mathbf{p}_2\frac{|\mathbf{v}_2|\omega_2}{p_2^2 c}(1-\cos\varphi) + \mathbf{v}_1\frac{|\mathbf{v}_2|}{c} + \frac{\mathbf{c}_1\times\mathbf{v}_2}{c}\right] \tag{5.28}$$

Coefficient attached to parentheses is proportional to Compton's wavelength of electron $|\mathbf{R}| = |\mathbf{p}_2/p_2^2|$ and electron's frequency ω_2. Just this item appears in textbooks when Compton's experiment is explained. (5.28) formula contains two additional vectors. They define a certain drift in reflected photons' distribution, i.e. certain asymmetry in their spatial distribution. This drift is not taken into account when Compton's experiment is described in textbooks as rigid balls' collision.

One has for the second square brackets

$$[\ ]_2 = \left[\mathbf{c}_1 + (\mathbf{c}_1 \times \mathbf{p}_2) \frac{\omega_2}{p_2^2 c} \right] \tag{5.29}$$

These brackets consist only of stable vectors dependent only on photon's movement direction and independent of its individual characteristics: polarization and frequency. One gets finally: additional momentum transferred by electron to photon under mentioned conditions is

$$\begin{aligned} \Delta\mathbf{P}_{21} &= \frac{c m_1 m_2}{\varepsilon_0} \left(\mathbf{B}_1 \times \mathbf{B}_2^* \right) = \frac{m_1 m_2}{\varepsilon_0} \{\exp\{ i(\Delta\mathbf{p}\cdot\mathbf{r} - \Delta\omega t)\} \cdot \\ &\cdot \left[\mathbf{p}_2 \frac{|\mathbf{v}_2|\omega_2}{p_2^2 c}(1-\cos\varphi) + \mathbf{v}_1 \frac{|\mathbf{v}_2|}{c} + \frac{\mathbf{c}_1 \times \mathbf{v}_2}{c} \right] - \\ &- \exp\{ i(\Delta\mathbf{p}\cdot\mathbf{r} - \omega_1 t)\} \cdot \left[\mathbf{c}_1 + (\mathbf{c}_1 \times \mathbf{p}_2) \frac{\omega_2}{p_2^2 c} \right] \end{aligned} \tag{5.30}$$

Normal vector drift whose modulus define wave length drift is got if (5.30) is divided by $\dfrac{m_1 m_2 |\mathbf{v}_1| \omega_2}{\varepsilon_0 c}$

$$\begin{aligned} \Delta\mathbf{P}_{21} &= \exp\{ i(\Delta\mathbf{p}\cdot\mathbf{r} - \Delta\omega t)\} \cdot \\ &\cdot \left[\frac{\mathbf{p}_2}{p_2^2}(1-\cos\varphi) + \frac{\mathbf{v}_1}{\omega_2} + \frac{\mathbf{c}_1 \times \mathbf{v}_2}{|\mathbf{v}_2|\omega_2} \right] - \\ &- \exp\{ i(\Delta\mathbf{p}\cdot\mathbf{r} - \omega_1 t)\} \cdot \left[\mathbf{c}_1 + (\mathbf{c}_1 \times \mathbf{p}_2) \frac{1}{p_2^2 |\mathbf{v}_2|} \right] \end{aligned} \tag{5.31}$$

Vectors in square brackets define oscillation amplitudes of the exponents attached to them. Physical meaning of the first brackets has been already discussed. The second oscillation is directed "forward" along photon's speed vector $\mathbf{c}_1$ and perpendicular to it. This interpretation is not accurate, because of simplification conditions (5.24) assumed above. In general case (5.22) "side oscillation" is weakened because $\mathbf{c}_1$ and $\mathbf{v}_2$, $\mathbf{c}_1$ and $\mathbf{p}_2$ are not perpendicular in general.

Conclusion.

Let us sum main results. Wave solution of the Generalized Maxwell equations led us to a concept of a wave originated by moving electron as an essentially threedimensional torsional oscillation. This oscillation takes place in longitudinal (along speed) and transverse (perpendicular) directions. This oscillation defines traveling wave which amplitudes in longitudinal and transverse directions are connected. Therefore in one direction oscillation suppression leads to other direction oscillation suppression.

In addition to this two dimensional oscillations electron's wave oscillates in the third dimension creating standing wave independent with respect to time and electron's own movement in contrast to the above mentioned traveling wave. This standing wave defines electron's charge and Coulomb interaction force with other charges.

Therefore Coulomb force turns to be a long-range one in contrast to Lorentz force which is defined by traveling wave and which moves with electron's velocity. Positron possesses similar standing wave with opposite sign. In electron and positron collision their standing waves are mutually annihilated which means charge disappearance.

These waves can appear only "have being repulsed by" each other. Therefore electric charges appear only in couple: positive and negative ones. A certain visual notion about electron as a massive torus rotating in equatorial and meridional planes is proposed. Charge magnitude is defined by electron's mass and angular velocity of its equatorial rotation. If it constitutes right hand screw with meridional angle velocity one gets charge of one sign and of opposite sign in visa-versa case. This screw also defines sign of the above mentioned standing wave.

Charge is vector modulo stable and directed along the greater circumference radius. It can be directed either in or out of the circumference. Therefore it can be described by scalar. Charge is inner characteristic of electron independent of its movement.

Electron's spin is also proportional to equatorial angular velocity. It is also vector taking only two values: along or against electron's speed because electron always moves perpendicular to its equatorial plane. Therefore to-day spin definition as vector with discrete projections on *any* direction in space looks nonrightful. Spin also characterizes electron but reveals only in movement. In other words spin is an external, dynamic characteristic of electron.

Photon does not possesses charge, i.e. it does not have equatorial rotation. It can be imagined as a cylinder moving along its axis and performing longitudinal and in general torsion oscillations along its directrix.

In particular (linearly polarized light) these torsion oscillations becomes transverse ones. Photon's movement is completely similar to electron's traveling wave. In other terms photon is two-dimensional object in contrast to electron. One can say that it is a longitudinally oscillating vortex carrying mass with light velocity. Photon's energy redoubling (mc^2 instead of $\frac{1}{2}mc^2$) becomes understandable: every oscillation longitudinal and torsion one add their half to the total sum.

Two-dimensional wave of a moving electron possesses mv^2 and not $\frac{1}{2}mv^2$ energy on the same reason. In the third direction oscillation gives redoubled energy mc^2 because magnetic and electric fields are parallel in this direction.

Elementary particles' oscillations are described with essential utilization of complex functions. Essential utilization means that if we limited ourselves to only real part we would not only complicate computations (as textbooks often assert) but we would not get correspondence to experiment. In other terms imaginary part of electric and magnetic fields brings its fee into elementary particles' energy and momentum. Therefore electron's and photon's model as torus and cylinder are conventional. We shall not get their adequate description if we don't take into consideration their rotation in complex plane or perhaps their movement in the space of quaternions.

The last chapters of the article are devoted to elementary particles' interaction. Such interaction turns to be wave like as well. Interaction and oscilations in particles' ensembles are null only between coherent photons with codirected spins. Such photons fly in parallel lines. In general photons' beams diverge because of such oscillations. Photons interfere and this is interpreted to-day as a wave quality of separate photon. Separate photon oscillates and possesses wave quality but not because photons' ensembles oscillate.

The received results naturally explain some difficult problems of modern quantum mechanics such as electron's self-action, its energy infinity, electromagnetic mass and etc.

In philosophical aspect the proposed approach is very close to Newtonian light corpuscular ideas, sometimes even in details.

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