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The Physical Vacuum Models with Intrinsic Angular Momentum: From Vorticity of Maxwell's Luminiferous Ether to Pseudomagnetism

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ABSTRACT

In this work, the main milestones of the development of physical vacuum model with intrinsic angular momentum were considered. J. C. Maxwell was the first researcher who introduced this property in the physical vacuum for the mathematical description of electromagnetic oscillations and results of Faraday's experiments with magnetic fields. The milestones of the development of Maxwell's model are the following: the introduction by Planck, Einstein and Stern of atomic oscillators with so-called zero-point energy; the introduction by Feynman of virtual particles created by quantum objects; the introduction of pseudomagnetic interaction between spins by Abragam et al. The enriching of our knowledge about the physical vacuum characterized by intrinsic angular momentum lets us to explain the wave and inertial properties of quantum objects, to create a theory alternative to Special Relativity, to determine the conditions of generation of a process having superluminal speed (spin supercurrent), to determine the conditions of obtaining energy from the spin system of physical vacuum. In some cases, without taking into account this energy (based only on Newton's laws) the violation of the principles of energy conservation takes place.

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1. Introduction

In 1861-1873 James Clerk Maxwell describing the light's properties and results of Faraday's experiments with magnetic fields supposed the existence in luminiferous ether of vortices and the process transferring angular moment between the vortices as well [1]. The further investigations of many researchers specified the properties both of the vortices and of the process transferring angular moment.

In 1913, Einstein and Stern proposed the model of physical vacuum as a medium consisting of so-called quantum oscillators having energy $h\nu/2$ which they classified as "residual energy" (later "residual energy" was called "zero-point energy") which all atomic oscillators have at absolute zero [2]. The proposition is based on the formula derived by Planck for the energy ε_o of the atomic oscillator vibrating with frequency ν [3]:

$$\varepsilon_o = h\nu/2 + h\nu/\left(exp\left(h\nu/(kT)\right) - 1\right), \qquad (1)$$

where h is Planck's constant, k is the Boltzmann constant, T is temperature: at $T=0K$ $\varepsilon_o = h\nu/2$.

The existence of those quantum oscillators "saves" the principle of conservation of angular momentum in the following phenomena: 1) the atom emission of a photon having spin and so-called orbital angular momentum, though the atom transfers to photon only the orbital angular momentum in most atomic transitions; 2) the Cherenkov effect, where the production of a photon by an electron with saving its own spin takes place [4-6].

In 1949, R. Feynman developed the diagram of force fields in which any force interaction is performed by the virtual particles created by interacting objects; for example, electric and magnetic interactions are accomplished by so-called virtual photons consisting of a pair of electric oppositely charged virtual particles [7]. The properties of virtual photons were similar to those of photons performing the propagation of the electromagnetic oscillations as well. The introduction of virtual particles lets us to explain the wave and inertial properties of quantum objects and to create a theory alternative to Special Relativity [8-10].

In 1970, L.I. Sedov pointed out the complete analogy between the structures of formulas describing the magnetic interactions of current-carrying wires and the structures of formulas describing the interactions of vortices in an ideal incompressible liquid with positive density and negative pressure (characterized by "omniradial tensions") [11]. It is shown in this work that, first, the physical vacuum consisting of quantum oscillators can be characterized by the properties of liquid with above mentioned features, and secondly, the moving electrically charged quantum objects, due to creating by them of virtual photons, can make vortex lines in the vacuum.

In 1975, A. Abragam with a group of researchers published the results of experiments demonstrating the existence of an interaction depending on electric charges and mutual direction of spins of interacting objects. The character of a pseudomagnetic interaction is, in some aspects, analogous to that of magnetic interaction; in particular, this interaction includes a force and moment (spin supercurrent [12-14]). However, the energy of this interaction is a thousand times greater than the energy of a magnetic interaction and a magnetic field does not influence it [15,16]. The action of force associated with pseudomagnetic interaction results in existence of electric dipole moments of virtual photon and electric component of photon. The action of spin supercurrent determines cavity structure effects, many processes in ecology and medicine, and the possibility of energy generation using electromagnetic oscillations (for example, Tesla's generators [8, 17-20]).

Let us analyze the above listed milestones of development of the physical vacuum model with intrinsic angular momentum in detail.

2. The Maxwell's Model of the Luminiferous Ether as a Two-Phase Medium with Vorticity

Maxwell developed the model of the luminiferous ether as a two-phase medium, the first phase consists of vortices and has the following features (citations from Maxwell's work are given in italic) [1].

1) It has the properties "*of ordinary matter*" ([1]: 345), described by Newton's equations.
2) The translational motion of the vortices is friction-free which can be interpreted in terms of classical mechanics as the absence of shear viscosity.
3) The vortices "*roll without sliding*" ([1]: 285) which is essentially the rotational viscosity.
4) The circumference velocity of vortices constituting the first phase is *"proportional to the intensity of the magnetic force*" ([1]: 282), and further: "*…the lines of fluid motion are arranged according to the same laws as the lines of magnetic force*" *(*[1]: 348).
5) "*The angular velocity (of vorticies- L.B.) must be the same throughout each vortex*" and "*are maintained for an indefinite time without any expenditure of energy*" ([1]: 346).

Thus, Maxwell supposed the existence of a dissipation-free process accomplishing the transfer of angular momentum between vortices of the first phase. Maxwell presented an equation characterizing the speed $\mathbf{Y}_t$ of process of transfer of angular momentum in the form:

$$\mathbf{Y}_\mathrm{t} = \mathbf{Y}_1 - \mathbf{Y}_2, \quad (2)$$

where $\mathbf{Y}_1$ and $\mathbf{Y}_2$ are the circumferential velocities of two vortices between which the process of transfer of angular momentum emerges.

Note: Maxwell supposed that the process transferring angular momentum and electric oscillations constituting electromagnetic process emerge in the second phase of the medium, which "*in what way it differs from matter*" ([1]: 282). Processes in this phase are determined by difference of the proper potentials.

3. The Model of Physical Vacuum Consisting of Quantum Oscillators Having "Zero-Point Energy"

3.1. The Characteristics of Quantum Oscillator

In 1913 Einstein and Stern basing on the Planck's formula (1) supposed that the physical vacuum free from magnetic and electric fields (without taking into account the gravitational energy) became defined not as an empty space but as the ground state of a field that consists of the oscillators with zero-point energy $\varepsilon_o = h\nu/2$ [21]. These oscillators have no generally accepted name but they can be called quantum oscillators.

The expression for energy of quantum oscillation, $h\nu/2$, is analogous to expression for energy of so-called "motion-less" photon (**v**+**c**=0 in Eq. (19)). Thus, value $h\nu/2$ can be interpreted as the energy of object having spin $\mathbf{S}_{qo} = \hbar$ precessing with frequency $2\pi\nu$, and kinetic mass m_{qo} determined by the well-known connection between energy and mass: $m_{qo} = h\nu/(2c^2)$.

The electrical polarization of physical vacuum in electric field indicates that a quantum oscillator is an electric dipole in electric field, that is, it is characterized by electric dipole moment d_{qo}.

Thus, the considered model endows the physical vacuum with the following properties:
1) Positive density,
2) The possibility of electric polarization,
3) The existence of internal angular momentum (spin).

The last properties provide the fulfillment of the principle of conservation of angular momentum in some phenomena. For example, a photon has a spin angular momentum and so-called orbital angular momentum, at the same time, in the photon's emission by an atom only the orbital angular momentum is transferred to the photon in most atomic transitions [4,5]. Another example, in the photon's emission by a free-moving electron with the speed higher than the speed of light (the Cherenkov effect) the electron conserves its own spin [6].

4. The Virtual Particles in the Physical Vacuum

In 1949, R. Feynman developing diagrams of force fields advanced a hypothesis that electric and magnetic interactions between quantum objects are accomplished by so-called virtual photons (consisting of two unlike charged virtual particles) created by the objects [7]. According to Feynman's model, the properties of virtual photon are similar to properties of photon performing the propagation of the electromagnetic oscillations as well. Let us consider these properties.

4.1. The Size of Virtual Photon

In accordance with Feynman's definition, wavelength λ_q of the wave function of the quantum object determines the size δ_v of virtual photon created by the object; it will be shown in Section 4.5 (Eq.(10)) that the value of δ_v may be equal to the size of virtual photon as an electric dipole. According to postulate of quantum mechanics, $ƛ_q$ is determined by momentum of the quantum object p_q, consequently, the following is valid for δ_v [22]:

$$\delta_v \approx ƛ_q = \hbar/p_q. \quad (3)$$

4.2. The Spin of Virtual Photon

According to Feynman's hypothesis, the characteristics of virtual photon's spin are similar to characteristics of photon's spin. Let us consider some characteristics of photon's spin. In accordance with experiments by Weber and Kelvin the spin is located in a plane normal to photon's speed, that is:

$$\mathbf{S}_{ph} \perp \mathbf{c}. \quad (4)$$

Thus, in a circular-polarized photon the spin performs precession motion with frequency of photon $\boldsymbol{\omega}_{ph}$. The frequency $\boldsymbol{\omega}_{ph}$ is oriented along photon's velocity **c**, $\boldsymbol{\omega}_{ph} \parallel \mathbf{c}$.

Due to analogy between the properties of virtual photon and those of photon, it can be assumed that virtual photon's spin precessing with frequency $\boldsymbol{\omega}_v$ oriented along its velocity **u**, $\boldsymbol{\omega}_v \parallel \mathbf{u}$, as well. As, according to Feynman's definition, the virtual photon has electric dipole moment $\mathbf{d}_v$, the electric charge of quantum object producing the virtual photon influences the mutual orientation of $\boldsymbol{\omega}_v$ and **u,** and the latter condition can be expressed as follows:

$$\boldsymbol{\omega}_v \uparrow\uparrow \eta\mathbf{u}, \quad (5)$$

where $\eta = 1$ for positively charged quantum object and $\eta = -1$ for negatively charged quantum object. The validity of equation (5) is proven in work [8]. Spin of virtual photon is assumed to be equal to $\hbar$, similar to spin of photon,

$$\mathbf{S}_v = \hbar. \quad (6)$$

4.3. The Wave-Particle Dualism

According to De Broglie's hypothesis, the characteristics of wave associated with every quantum object of non-zero rest mass are similar to the photon's analogous characteristics (frequency, phase, size), but does not having magnetic or electric component [23, 24]. According to Feynman's hypothesis, the characteristics of virtual photon are similar to characteristics of photon. It follows from both hypotheses that the wave properties of quantum object are similar to properties of virtual photon. The virtual photon is characterized by only one wave process of non-magnetic and non-electric nature – the precession motion of its spin. Consequently, the characteristics of precession of virtual photon's spin are equal to the respective characteristics of wave function of quantum objects creating this virtual photon. That is, the precession frequency ω_v of virtual photon's spin equals the frequency ω_q of the wave function of quantum object: $\omega_v = \omega_q$. According to Schrodinger's wave function describing the wave properties of quantum objects in a non-relativistic approach, the frequency ω_q of the wave function of quantum object is determined by its energy U_q, consequently [22]:

$$\omega_v = \omega_q = U_q/\hbar. \quad (7)$$

The angle of precession α_v of spin $\mathbf{S}_\mathrm{V}$ equals the phase of wave function of quantum object creating the virtual photon.

Consequently, Schrodinger's wave function of quantum object, essentially, describes the precession of spin $\mathbf{S}_v$ of virtual photon created by the object.

Note: As the characteristic "quantum" means that the object's properties are determined by wave equation, the phrase "quantum object which participates in electric or/and magnetic interactions creates a virtual photon" is slightly redundant as the word "quantum" already means that this object creates the virtual photon.

4.4. Mass of Virtual Photon

Similar to photon's kinetic mass, virtual photon's mass m_V is determined by its frequency ω_v: $m_v = \hbar\omega_v/c^2$. Using in expression for m_v equation Eq. (7) and taking into account that in this equation (non-relativistic approach) energy U_q equals the kinetic energy of quantum object (with mass m_q):

$$U_q = m_q u^2/2, \quad (8)$$

we obtain the following expression for m_v:

$$m_v = m_q u^2/(2c^2). \quad (9)$$

The mass m_V determined by Eq. (9) is equal (up to u^2/c^2) to relativistic addition to mass in Lorentz transformation of quantum object's total mass M_t in Special Relativity [25]:

$$M_t = m_q/\sqrt{1-u^2/c^2} = m_q\left(1 + u^2/(2c^2) + o(u^2/c^2)\right),$$

where $o(u^2/c^2)$ denotes the terms of a lower order of magnitude than u^2/c^2.

4.5. The Electric Properties of Virtual Photon

As, according to Feynman's definition, a virtual photon consists of a pair of electric oppositely charged virtual particles, it is electric dipole. Its electric dipole moment $\mathbf{d}_v$ is determined by expression:

$$d_v = q_v\delta_v, \quad (10)$$

where q_v is electric charge of virtual particle. Based on the results of experiments conducted by W. Kaufmann [26] on the deflection of the beta-rays emitted by radium, which showed that the mass m_e of the electron is purely of an electromagnetic nature, we assume that the specific charge $2q_v/m_v$ of the virtual particles equals the specific electron charge q_e/m_e (q_e is the electron's electric charge), that is: $e/m_e = 2q_v/m_v$. Using the latter expression, Eq. (3) and Eqs. (8)-(9) in Eq. (10), the value of $\mathbf{d}_v$ can be expressed as:

$$d_v = \mu_B u/(2c), \quad (11)$$

where $\mu_B = \hbar e/(2m_e c)$ is the Bohr magneton.

The existence of electric dipole moment $\mathbf{d}_v$ means that in electric field $\mathbf{E}_n$ a moment $\mathbf{M} = \mathbf{d}_v \times \mathbf{E}_n$ acts on the virtual photon. For an example, the expression for moment **M** acting on the virtual photon produced by electron in a hydrogen atom at condition:

$$\mathbf{d}_v \uparrow\uparrow \mathbf{u} \qquad (12)$$

is analogous to expression for the maximum value of energy of the spin-orbit interaction of the electron in the atom: $(U_{s-o})_{max} = |\mu_B(\boldsymbol{u} \times \boldsymbol{E}_n)/(2c)|$ which was derived by L. Thomas based on the general requirements of relativistic invariance [27]. As the mutual orientation of electric dipole moment $\mathbf{d}_v$ of virtual photon and its velocity **u** must depend on the electrical sign of quantum object creating the virtual photon, in general case condition (12) for an electron must transform into the following condition:

$$\mathbf{d}_v \uparrow\downarrow \eta\mathbf{u}, \qquad (13)$$

where $\eta = 1$ for positively charged quantum object and $\eta = -1$ for negatively charged quantum object.
It should be noted that in a hydrogen atom the speed u of electron is much less than the speed of light c, that is, Eqs (12) and (13) are written for the following case:

$$u \ll c. \qquad (14)$$

As the virtual photon created by the object is a gyroscope, the virtual photon's spin $\mathbf{S}_v$ performs a precession motion with the frequency $\boldsymbol{\omega}_v$ determined by expression $\mathbf{M}_v = \boldsymbol{\omega}_v \times \mathbf{S}_v$ [11]. Then, taking into account Eqs (5) and (12) the following holds:

$$\mathbf{S}_v \uparrow\uparrow \mathbf{d}_v. \qquad (15)$$

4.6. The Angle of Deflection of Virtual Photon's Spin
Both virtual photon and photon are spin vortices (objects with precessing spins) in the physical vacuum consisting of quantum oscillators. Let us determine the expression for angle of deflection β -- the angle between spin ($\mathbf{S}_v$) and direction opposite to precession frequency ($-\boldsymbol{\omega}_v$) of spin vortex.

If speed u of spin vortex equals c (for photon) then, according to Eq. (4) $\beta = \pi/2$; if $u \ll c$ (condition (14) for virtual photon) then, according to Eqs (5), (13) and (15), $\beta = 0$. In general case the angle of deflection $\beta$of spin vortex is defined by expression:

$$\sin\beta = u/c. \qquad (16)$$

It follows from Eqs (5) and (16) that projection of spin $\mathbf{S}_v$ on the direction of its velocity **u**, $(\mathbf{S}_v)_{\boldsymbol{u}}$, is determined as:

$$(\mathbf{S}_v)_{\mathbf{u}} = -\eta S_v \cos\beta = -\eta S_v\sqrt{1 - u^2/c^2}, \qquad (17)$$

where $\eta = 1$ for positively charged quantum object and $\eta = -1$ for negatively charged quantum object.

The equation (17) is analogous to Lorentz transformation of quantum object length L in direction of motion **u** [25]: $L = L_0\sqrt{1 - u^2/c^2}$, where L_0 is the length of quantum object at u=0.

The characteristics of virtual photons produced by positively charged and negatively charged quantum objects considered in previous sections are shown in Figure 1.

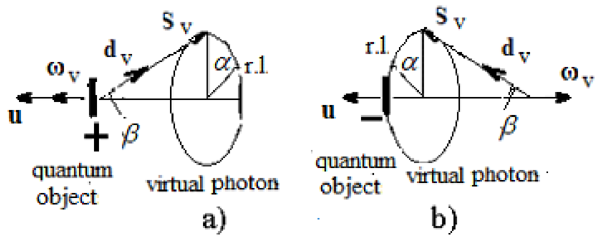

Figure 1: Schematic images of virtual photons produced by positively charged quantum objects - variant (a); and by negatively charged quantum object - variant (b). $\boldsymbol{\omega}_v$ is the precession frequency of spins $\mathbf{S}_v$; $\mathbf{d}_v$ are electric dipole moments; α is a precession angle determined from reference line r.l.; β is a deflection angle; **u** is a velocity of quantum object.

4.7. The Connection of the Force of Inertia with Virtual Photon's Spin
It follows from Eqs (5), (16) and (17) that any change in quantum object's velocity **u** results in a change in orientation of spin $\mathbf{S}_v$. Taking into account the gyroscopic properties of spin, it can be assumed that any change in **u** results in the emergence of force acting on the quantum object and it can be supposed that it is the force of inertia $\mathbf{F}_{in}$ [11]. There are possible the two variants of changes in velocity **u**: the change in the value and the change in the direction. Let us consider the first variant.

The change in value of **u,** according to Eq. (17), results in a change in magnitude $(\mathbf{S}_v)_\mathbf{u}$. Let us determine the force of inertia $\mathbf{F}_{in}$ in the form: $F_{in} = \gamma_{in}\partial(S_v)_{\boldsymbol{u}}/\partial t$ where $\gamma_{in} > 0$ is a factor of proportionality. Then, taking into account Eq. (17), $\mathbf{F}_{in}$ is determined to be:
$\mathbf{F}_{in} = -\gamma_{in}\hbar\mathbf{u}/\left(c^2\sqrt{1 - u^2/c^2}\right) \cdot \partial\mathbf{u}/\partial t$. That is, the force of inertia $\mathbf{F}_{in}$ is directed along the velocity of moving quantum object that is an accordance with experimental observation.

4.8. The Energy of Virtual Photon
The energy of virtual photon associated with mass m_v contains two terms. The first term is the kinetic energy $m_v u^2/2$ of the translational motion of the center of mass, in which all the mass m_v is assumed to be contained. The second term is the energy of circular motion, which is determined to be $J_v\omega_v/2$ where J_v is the angular momentum connected with m_v (see Figure 4) [11]. Thus, the total energy U_v associated with mass m_v equals:

$$U_v = m_v u^2/2 + J_v \omega_v/2. \quad (18)$$

Equalizing energy U_v to energy connected with spin precession frequency, Eq. (7), we obtain: $\hbar\omega_v = \hbar\omega_v u^2/(2c^2) + J_v\omega_v/2$. It follows from the latter expression:

$$J_v = \hbar(2 - u^2/c^2). \quad (19)$$

At $u \to c$ the transformation of virtual photon into "real" photon (for example in the Cherenkov effect) takes place. In this case, according to Eqs (18)-(19), the expression for photon's energy U_{ph} is: $U_{ph} = m_{ph}c^2/2 + \hbar\omega_{ph}/2$ (ω_{ph} and $m_{ph} = \hbar\omega_{ph}/c^2$ are respectively the frequency and mass of photon).

Note: If source of photon with frequency ω_{ph} moves at velocity $\boldsymbol{\upsilon}$ relative to its detector, the expression for the detected photon's frequency ω_d is the following:

$$\hbar\omega_d = \hbar\omega_{ph}(\mathbf{c} + \boldsymbol{\upsilon})^2/(2c^2) + \hbar\omega_{ph}/2 \quad (20)$$

It is shown in [8, 28] that using of expression (20) allows one to obtain the expression describing the transverse Doppler's effect described earlier only by Special Relativity [25].

4.9. The Electric Current as the Vortex Line Consisting of Virtual Photons

In 1970, L.I. Sedov pointed out the complete analogy between the structures of formulas describing the magnetic interactions of current-carrying wires and the structures of formulas describing the interactions of vortices in an ideal incompressible liquid with positive density and negative pressure (characterized by "omniradial tensions") [11]. That is, magnetic phenomena might be due to the motion of a medium described at the stationary case (without regard to gravitational forces) by the following equation:

$$\rho v^2 / 2 - p = \text{const}, \quad (21)$$

where ρ, v, and p are, respectively, the density, speed, and pressure, of the medium.

Based on the above-mentioned (Section 3.1) characteristics of quantum oscillators the following assumption can be made: a physical vacuum consisting of quantum oscillators with zero-point energy could be actually such a medium:

- According to Eq. (9), the mass of quantum oscillators can create positive density ρ of the physical vacuum.
- From the dissipation-free motion of celestial bodies, such as the solar system's planets, it follows that the shear viscosity in a physical vacuum can be negligible.
- The birth of particles in the physical vacuum [22] and "phase slipping" at the action of spin supercurrent (in detail see Section 5.2.1, property 3, Figure 5) indicate the possibility of "omniradial tensions" in the physical vacuum consisting of quantum oscillators.

Due to production of virtual photons by electrically charged quantum objects from Eq. (5) it follows that electric current **I** is a vortex line in the physical vacuum producing the motion in it. The velocity $\boldsymbol{\upsilon}$ of the motion, according to Eq. (21), is described by the equation of the type of Biot-Savart law which defines the magnetic induction **B** generated by a loop of current **I.** In the CGS system of units it is presented as: $\mathbf{B} = \frac{I}{c}\int_{L'} \frac{d\mathbf{l}\times\mathbf{r}}{r^3}$, where L' is the length of the loop, and $d\boldsymbol{l}$ is an infinitesimal wire element of the vortex line, oriented along **I** at the wire element location**, r** is the vector from d**l** towards the point of measurement **B** [29].

Having solved the simultaneous Eq. (21) and the above-mentioned expression for B, we obtain an equation relating the magnetic induction **B** to the velocity $\boldsymbol{\upsilon}$ of the motion of the physical vacuum (in detail see [8, 28]):

$$\mathbf{B} = \boldsymbol{\upsilon}\sqrt{4\pi\rho}. \quad (22)$$

It should be noted that the velocity $\boldsymbol{\upsilon}$ and electric current **I** are determined relative to the same reference frame.

Figure 2 contains the characteristics of vortex lines consisting of virtual photons created by positively charged current-carriers (upper) and negatively charged current-carriers (below) forming current **I:** velocities of current-carriers **u**, spins $\mathbf{S}_v$, the frequencies of precession $\boldsymbol{\omega}_v$, electric components $\mathbf{E}_v$, magnetic components $\mathbf{B}_v$. The magnetic induction **B** created by electric current in the physical vacuum is formed by magnetic components $\mathbf{B}_v$ of virtual photons are produced by current-carriers.

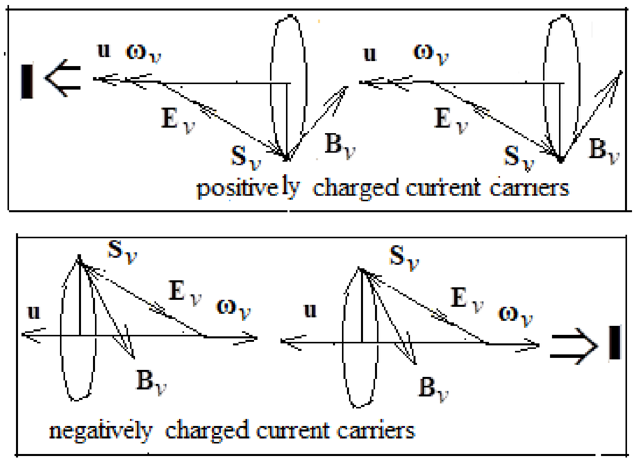

Figure 2: The characteristics of vortex lines consisting of virtual photons created by positively charged current-carriers (upper) and negatively charged current-carriers (below) forming current **I:** velocities **u**, spins $\mathbf{S}_v$, frequencies of precession $\boldsymbol{\omega}_v$, electric components $\mathbf{E}_v$, magnetic components $\mathbf{B}_v$.

Conclusion to Section 4

1. The electric properties of virtual photon determine the spin-orbit interaction of quantum object in the atom.
2. The properties of virtual photon determine the wave properties of quantum object creating this photon: the precession frequency and precession angle of virtual photon's spin equal respectively to the frequency and phase of wave function of the quantum object; the size of virtual photon as an electric dipole equals the wave function wavelength of the quantum object.
3. The properties of virtual photon determine Lorentz transformations (in Special Relativity): the mass of virtual photon equals relativistic addition to mass of the object; the change in the projection of virtual photon's spin on the direction of its velocity can be interpreted as a change in the object's size along its velocity.
4. The influence of a change in the virtual photon's speed (value or/and orientation) on the orientation of its spin determines the first law of Newton - law of inertia.
5. Based on the properties of virtual photon, the formula for transformation of energy of photon during its transition from one inertial system to another was deduced. If the source of photon with frequency ω_{ph} moves at velocity $\mathbf{\upsilon}$ relative to its detector, the expression for the detected photon's frequency ω_d is the following: $\hbar\omega_d = \hbar\omega_{ph}(\mathbf{c}+\mathbf{\upsilon})^2/(2c^2) + \hbar\omega_{ph}/2$. Using this expression allows one to obtain the expression describing the transverse Doppler's effect derived earlier only in Special Relativity.
6. The interaction of photons with an inertial system can be performed due to their interaction with virtual photons created by quantum objects of the inertial system. (It cannot be excluded that this interaction fulfills the equalization of the speed of light to c in any inertial system.)
7. The virtual photons produced by charged current-carries create vortex line in the physical vacuum consisting of quantum oscillators. The interaction of the vortex lines can determine the magnetic interaction of electric currents creating these vortex lines.

5. Pseudomagnetism

As shown in Section 2.2, the intrinsic angular momentum in the physical vacuum consisting of quantum oscillators is associated with the spins of these quantum oscillators. An important property of the physical vacuum is a possibility of interaction of quantum oscillators' spins. This interaction is of nonmagnetic nature, can manifest itself as a force or a moment and called by pseudomagnetic interaction.

5.1. The Forces in Pseudomagnetism

5.1.1. Ferromagnetism

Ferromagnetism is due to the formation of domains with spins of electrons oriented in one direction. That is, the attractive force exists between like charged particles (electrons) with uniformly oriented spins. The force is a thousand times greater than the magnetic force between the electrons and is of nonmagnetic nature. Studies have shown that the ordered orientation of spins in domains can be fulfilled by pseudomagnetic interaction [16].

5.1.2. The forming of mass and electric dipole moment in a virtual photon

As photons and virtual photons are spin vortices in the physical vacuum consisting of quantum oscillators, the characteristics of these spin vortices are determined by characteristics of the quantum oscillators. As concerns the virtual photon, it means that, first, its mass, m_v, consists of masses m_{qo} of the quantum oscillators constituting the virtual photon; secondly, its electric dipole moment d_v is determined by the possibility of separation of masses m_{qo} into positive and negative electrically charged parts (the electric polarization of physical vacuum in electric field testifies in favor of this possibility).

Thus, the existence of mass and electric dipole moment of virtual photon is a result of two processes: collapse of the electrically like charged particles and separation of the unlike charged particles of quantum oscillators constituting the virtual photon. Both these processes are possible if there exists a force depending on the electric sign of interacting electric charges and mutual orientation of their spins. The force acting in this case (pseudomagnetic force), F_{pm}, can be determined as:

$$F_{pm} = K_{pm}|\phi_{pm}| \cdot q_1.q_2/|q_1.q_2| \qquad (23)$$

where ϕ_{pm} is a function of values of electric charges (q_1, q_2) and of directions of spins ($(\mathbf{S}_{qo}/2)_1$, $(\mathbf{S}_{qo}/2)_2$) of interacting particles and can be represented as: $\phi_{pm}\left(\left(\left((\mathbf{S}_{qo})_1/2\right).\left((\mathbf{S}_{qo})_2/2\right)\right), q_1, q_2\right)$.

The factor of proportionality K_{pm} is determined as:

$$K_{pm} = \begin{cases} 1, if\left(\mathbf{S}_{qo}/2\right)_1 \rightarrow\rightarrow \left(\mathbf{S}_{qo}/2\right)_2 \\ -1, if\left(\mathbf{S}_{qo}/2\right)_1 \leftarrow\rightarrow \left(\mathbf{S}_{qo}/2\right)_2 \end{cases} \qquad (24)$$

If $F_{pm} > 0$, it is an attractive force, if $F_{pm} < 0$, it is a repulsive force.

The structure of virtual photon with indication of Coulomb forces $\mathbf{F}_{Cqo}$ and pseudomagnetic forces $\mathbf{F}_{pm}$ between the charged parts of virtual photon (virtual particles) and charged particles of quantum oscillators constituting the virtual photon is given in Figure 3: m_{qo}, $\mathbf{S}_{qo}$ and q_{qo} are respectively mass, spin and charge determining the electric dipole moment of quantum oscillator constituting the virtual photon; $\mathbf{S}_{\text{v}}$, $\mathbf{d}_v$ and m_v are respectively spin, electric dipole moment and mass of virtual photon. The condition of existence of virtual photon: $\mathbf{F}_{pm} = \mathbf{F}_{Cqo}$.

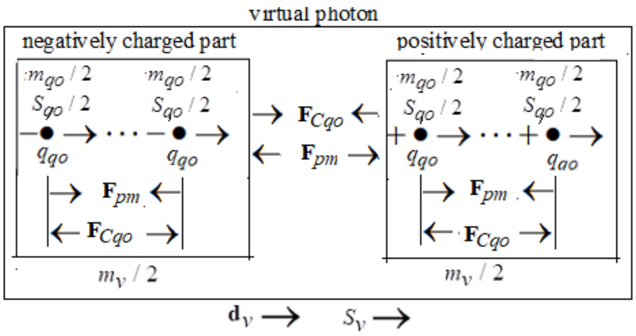

Figure 3: The structure of virtual photon: m_v, $\mathbf{S}_v$ and $\mathbf{d}_v$ are respectively mass, spin and electric dipole moment of virtual photon; m_{qo}, $\mathbf{S}_{qo}$ and q_{qo} are respectively mass, spin and charge determining the electric dipole moment of the quantum oscillators constituting the virtual photon; $\mathbf{F}_{Cqo}$ is a Coulomb force; $\mathbf{F}_{pm}$ is a pseudomagnetic force.

5.1.3. Wave-vortex-spin (electro-magneto-spin) process

In 1915 Einstein and De Haas discovered a rotation of ferromagnetic during its remagnetization [30]. Ferromagnetic contains an ensemble of free electrons that allows one to consider this ensemble as a medium with intrinsic angular momentum (spins). As the physical vacuum consists of quantum oscillators having spins, the effect of Einstein - De Haas can take place in the vacuum as well, that is the following equation holds:

$$k_s \partial \mathbf{S}/\partial t = -curl\boldsymbol{\upsilon}, \tag{25}$$

where t is time, $\mathbf{S}$ is the total spin (of quantum oscillators) of the unit volume of physical vacuum, k_s is a factor of proportionality, $k_s > 0$.

Below it will be shown that the following equation holds, as well, in the physical vacuum with considered properties:

$$k_\upsilon \partial \boldsymbol{\upsilon}/\partial t = curl\mathbf{S}, \tag{26}$$

where k_υ is a factor of proportionality, $k_\upsilon > 0$.

According to Eq. (16), the change in velocity $\mathbf{u}$ of motion of virtual photons: $\partial \mathbf{u}/\partial t \neq 0$ results in a change in virtual photons' angle of deflection β ($\partial\beta/\partial t$), that is, results in a change in virtual photons spins' orientation: $\partial \mathbf{S}_v/\partial t \neq 0$. The change in orientation of spin $\mathbf{S}_v$, according to the principle of conservation of angular momentum, results in emergence of inequality $curl\mathbf{S}_v \neq 0$ [11]. As photons and virtual photons are spin vortices in the physical vacuum consisting of quantum oscillators, the characteristics of the spin vortices are determined by characteristics of these quantum oscillators. Consequently, the Eq. (26) may be used for description of motion (with velocity $\boldsymbol{\upsilon}$) of quantum oscillators constituting the unit volume of physical vacuum.

Let us introduce factor χ measured in the same units as speed: $\chi = \sqrt{k_\upsilon/k_s}$. Then Eqs (25)-(26) can be written in the form:

$$\partial(\chi k_S \cdot \mathbf{S})/\partial t = -\chi curl\boldsymbol{\upsilon}, \tag{27}$$

$$\partial \boldsymbol{\upsilon}/\partial t = \chi curl(\chi k_S \cdot \mathbf{S}). \tag{28}$$

The system of Eqs (27)-(28) describes a wave-vortex-spin process spreading with the speed χ in the physical vacuum consisting of quantum oscillators. The coefficient $\chi k_s S$ measured in the same units as speed; and thus Eqs (27)-(28) describe the transformation in the physical vacuum of velocity $\boldsymbol{\upsilon}$ to velocity $\chi k_s \mathbf{S}$.

That this velocity is determined by spins $\mathbf{S}$ of quantum oscillators indicates that this motion can be caused by pseudomagnetic force $\mathbf{F}_{pm}$. According to Eqs (23)-(24), the action of this force can cause electric polarization of unit volume of physical vacuum due to mutual motion of oppositely charged parts of quantum oscillators constituting this vacuum (similar to action of force $\mathbf{F}_{pm}$ in virtual photon, see Section 5.1.2). Consequently, the specific kinetic energy connected with velocity $\chi k_s \mathbf{S}$ must be equal to specific energy of electric field $\mathbf{E}$ emerging as a result of this motion:

$$\rho(\chi k_s \mathbf{S})^2/2 = (\boldsymbol{E})^2/(8\pi). \tag{29}$$

According to Condition (15) and connection between electric dipole moment $\mathbf{d}$ and its electric field $\mathbf{E}$ ($\mathbf{d} \uparrow\downarrow \mathbf{E}$), the following is valid: $\mathbf{S} \uparrow\downarrow \mathbf{E}$. Then assuming $\chi = c$ and using Eqs (22) and (29), the system of Eqs (27)-(29) can be presented as:

$$\mathbf{E} = -c \cdot k_S\sqrt{4\pi\rho} \cdot \mathbf{S}, \tag{30}$$

$$\partial \mathbf{E}/\partial t = c \cdot curl\mathbf{B}, \tag{31}$$

$$\partial \mathbf{B}/\partial t = -c \cdot curl\mathbf{E}, \tag{32}$$

This system of Eqs (30)-(32) describes electro-magneto-spin oscillations. Eqs (31)–(32) are coincident with the equations derived by J. Maxwell. These equations are in accordance with the properties of photon having electric, magnetic and spin components. The components ($\mathbf{E}$, $\mathbf{S}$, $\mathbf{B}$, $\boldsymbol{\upsilon}$) of the wave-vortex-spin (electro-magnetic-spin) process are given in Figure 4, $\mathbf{J}_{ph}$ is an angular momentum connected with circular motion of photon's mass m_{ph} (see Section 4.7 and Eq. (19)).

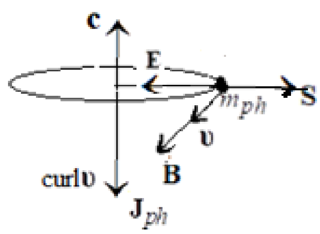

Figure 4: The schema of characteristics of a vortex arising in wave-vortex-spin (electro-magneto-spin) process: $\mathbf{c}$ is the velocity; $\mathbf{B}$ is the magnetic induction; $\mathbf{S}$ is spin; $\boldsymbol{\upsilon}$ is the velocity of a physical vacuum consisting of quantum oscillators; $\mathbf{E}$ is an electric component; m_{ph} is a kinetic mass of photon.

Note: It follows from Eqs (27)-(28) that wave-vortex-spin (electro-magneto-spin) process could not propagate in the region for which the following equality is valid:

$$\partial \boldsymbol{S}/\partial t = 0. \tag{33}$$

The equality (33) can take place in the following cases:
- at the rotation of the physical vacuum consisting of quantum oscillators (due to the Barnett effect [4]);
- as a result of emergence of significant spin supercurrent equalizing the direction of the spins of quantum oscillators (see Section 5.2.1).

It cannot be excluded that Dark Matter exists in those regions of Cosmos where the Condition (33) is fulfilled [8,31].

5.2. The Moment in Pseudomagnetism

The pseudomagnetic interaction includes not only a force but a moment as well. There are examples of it.

1) In a substance with the polarized spins of nuclei, the spins of moving protons and neutrons perform precession motion relative to the direction of the polarization. A similar phenomenon takes place in a substance with polarized spins of substance's electrons in the motion of external electrons in it. These phenomena have nonmagnetic origin [16]. The interacting quantum objects are of the same "nature": for example, all of them are either nucleons or leptons.

2) The Faraday effect [32]. The light polarization twisting while passing light through a magnetized medium (that is, through a medium with oriented electrons' spins). In this case, in contrast to natural optical activity, the sign of the rotation angle does not depend on the direction of the propagation of light (along the magnetization or against it).

3) In 1976, Vuorio observed a long transport of spin polarization [33]. In the following years the phenomena were studied in experiments with superfluid ^{3}He-B by Borovic-Romanov, Bunkov, Dmitriev, Fomin, et al. [12-14]. In these experiments this long transport of spin polarization occurred between regions with identically oriented and coherently precessing spins of ^{3}He atoms and was called spin supercurrent.

The spin supercurrent is the most studied process among above citied processes. Let us consider some its features.

5.2.1. The properties of spin supercurrent

1) The definition of spin supercurrent

As the spin supercurrent transfers angular momentum between spins, its value is a function of difference in angles of precession α and angles of nutation β of those spins. The spin supercurrent $(I_{ss})_z$ in the direction of the orientation (axis z) of the precession frequencies of the interacting spins is determined to be

$$(I_{ss})_z = -g_1 \partial\alpha/\partial z - g_2 \partial\beta/\partial z, \tag{34}$$

where g_1 and g_2 are coefficients depending on β. As the action of spin supercurrent towards on equalization of characteristics of precessing spins: the following expressions are hold as a result of its action: $\partial\alpha/\partial z \to 0$ and

$$\partial\beta/\partial z \to 0. \tag{35}$$

Note: The expression (34) is similar to expression (1) introduced by Maxwell for describing the process of angular momentum's transfer. According to the Maxwell model of the luminiferous ether as a two-phase medium [1], the processes which are described by the difference in potential (not by Newton laws) exist in the second phase of the ether and these processes are inertia-free, that is they are not accompanied by the emergence of kinetic mass. Maxwell classified electrical and gravitational interaction, and transferring of angular momentum as processes of this type [1,34].

2) Speed of spin supercurrent

Since a spin supercurrent can be a process that equalizes the spin part of the order parameter in the quantum liquid described by a single wave function (for example, in superfluid ^{3}He-B), the spin supercurrent must be a dissipation-free process (analogous to the property of process of angular momentum's transfer introduced by Maxwell) and consequently (due to connection between energy and mass) an inertia-free process, that is not accompanied by the creation of a spin vortex in the physical vacuum with quantum oscillators. Thus, spin supercurrent does not interact (as the spin vortex could interact) with spin vortices created by quantum objects of inertial systems. Consequently, the speed of spin supercurrent can be greater than the speed of light and this does not contradict the postulate of Theory of Relativity about light speed limit, as it is valid only for inertial systems.

3) The slippage of precession angle.

The precession angle (phase) slippage (drop) by value $k\pi$ (k=1,2…) can take place at a definite difference $\Delta\alpha_c$ in the precession angles of the interacting objects' spins. The critical spin supercurrent $(I_{ss})_z^c$ corresponds to the value $\Delta\alpha_c$. Figure 5 shows an example of dependence of the spin supercurrent between virtual photons on the hypothetical difference in their precession angles $\Delta\omega$,

$$\Delta\varphi = \Delta\omega \cdot t, \tag{36}$$

where $\Delta\omega$ is a difference in the frequencies of spin's precession of the interacting virtual photons. It follows from the Eq. (36) that the slippage of precession angle can be missing if $\Delta\omega \to 0$, or, due to Eq. (7), if the interacting objects have the same energies.

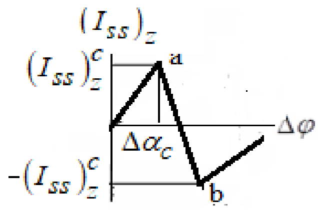

Figure 5: The dependence of the spin supercurrent $(I_{ss})_z$ on the hypothetical difference in precession angles $\Delta\varphi$. $(I_{ss})_z^c$ is the critical spin supercurrent. $\Delta\alpha_c$ is the phase difference at which the phase slippage (line *a–b*) emerges.

4) The generation of energy by spin supercurrent.

The spin supercurrent determined by Eq. (34) tends to equalize the respective characteristics of spins of virtual photons created by interacting quantum objects. The equalization of the spin's characteristics results in changes in energy connected with these spins. As an example, let us consider the case where the action of spin supercurrent results in the equalization of spin's angles of deflection (to values β_3) of two virtual photons: the angle of deflection of one virtual photon changes as $\beta_3 - \beta_1$, of another virtual photon changes as $\beta_3 - \beta_2$. In this case the change in the total projection of the spins of interacting virtual photons, $\Delta \mathbf{S}_u$, on the direction of their velocity $\mathbf{u}$ (the objects with equal velocity are considered), is determined, according to Eq. (16), as:

$$\Delta S_u = -|S_v(\cos\beta_1 + \cos\beta_2 - 2\cos\beta_3)|. \qquad (37)$$

If the energies of the quantum objects (with mass m_q) creating the considered virtual photons equal kinetic energy, then from Eq. (16) it follows that the changes in kinetic energies of these objects (respectively ΔU_{q1} and ΔU_{q2}). are determined to be $\Delta U_{q1} = c^2 m_q(\sin^2\beta_3 - \sin^2\beta_1)/2$ and $\Delta U_{q2} = c^2 m_q(\sin^2\beta_3 - \sin^2\beta_2)/2$. The total change in kinetic energy, $\Delta U = \Delta U_{q1} + \Delta U_{q2}$, of these quantum objects as a result of the action of spin supercurrent is determined to be:

$$\Delta U = c^2 m_q(\cos^2\beta_1 + \cos^2\beta_2 - 2\cos^2\beta_3)/2. \qquad (38)$$

Let us consider the most probable case:

$$\beta_3 - \beta_1 = -(\beta_3 - \beta_2). \qquad (39)$$

Taking into account inequalities $\partial(\sin\beta)/\partial\beta > 0$ and $\partial^2(\sin\beta)/\partial\beta^2 < 0$, from Eqs (38)-(39) it follows: $\Delta U > 0$. (Note that the angles of deflection of virtual photon's spin are less than $\pi/2$ as at $\pi/2$ the virtual photon transforms into a photon.) It follows from Eqs (37)-(39) the expression:

$$\Delta U/\Delta S_u < 0. \qquad (40)$$

Consequently, in this case at non-dissipativeness of spin supercurrent the principle of energy conservation is fulfilled only with taking into account the spin system of the physical vacuum.

If the equalization of precession angles of spins of virtual photons created by quantum objects of a substance is impossible, then, according to Eq. (34), spin supercurrent will exist constantly in the substance, and the generation of energy is possible in it. In particular, according to Eq. (34). it can take place if spins' precession frequencies of interacting virtual photons cannot be oriented in the same direction. According to Eq. (5), the orientation of these precession frequencies is determined by the orientation of velocities of quantum objects creating those virtual photons. If the quantum objects constitute an atom, their velocities are the object's orbital velocities and consequently can be determined by atoms configuration. In particular, as it is shown in Figure 6, this can be a ring configuration: the directions of precession frequencies ($\boldsymbol{\omega}_1$, $\boldsymbol{\omega}_p$, $\boldsymbol{\omega}_q$, …,$\boldsymbol{\omega}_r$) of the spins of virtual photons are tangential to a ring. According to Eq. (34), a spin supercurrent $(I_{ss})_{pq}$ between the arbitrary p and q virtual photons will never be zero in this configuration, that is,

$$(I_{ss})_{pq} \neq 0. \qquad (41)$$

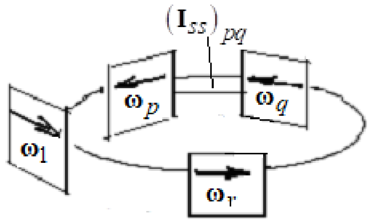

Figure 6: The example of ring configuration of virtual photons with respective precession frequencies $\boldsymbol{\omega}_1$, $\boldsymbol{\omega}_p$, $\boldsymbol{\omega}_q$, …,$\boldsymbol{\omega}_r$. $(I_{ss})_{pq}$ is a spin supercurrent.

Thus, according to Eq. (41), the space inside the ring will be constantly "filled" with spin supercurrent and the energy associated with it. The similar configurations can emerge in a substance forming a cavity structure and there are examples of generation of energy in cavity structures.

-In 1952, Czech researcher K. Drbal was granted a patent for the discovery of the possibility without an auxiliary source of energy, of "maintaining razor blades and straight razors sharp" in pyramid [35].

-In 1977–1987, area (called "bubble") that had the property of shielding various fields was discovered near pyramids by Parr [36].

More detail about the energy of cavity structure sees in works [8,17-19].

According to Eqs (30)-(32), the electromagnetic field contains a spin component. Consequently, the continuous generation of electromagnetic oscillations means continuous generation of spin component and spin supercurrent connected with it. The similar generator of continuous spin supercurrent may be a generator of energy. It is possible that Tesla's generators of energy are based on these physical principles [20].

6. Discussion

The Compounds of the Total Spin of Quantum Object

Pseudomagnetism is an interaction of spins. In the Faraday effect (Section 5.2) and in the emergence of mass and electric dipole moment of virtual photons (Sections 4.4-4.5) these spins are spins of quantum oscillators and virtual photons. But in many other phenomena the nature of spins is unclear as they can be the spins of quantum objects as well. Let us consider the compounds of the total spin of quantum object.

One of the ways of emergence of quantum object (electron, positron, proton, antiproton) is a decay of photon (with spin $\mathbf{S}_{ph}$) in electric field [22]. During the decay the emerging quantum object acquires the following characteristics: mass, angular momentum (may determine the character of motion of quantum object after the decay), spin $\mathbf{S}_{qo} = \mathbf{S}_{ph}/2$. Taking into account spin $\mathbf{S}_v$ of virtual photon created by emerging quantum object, the total spin of quantum object $\mathbf{S}_q$ is determined as: $\mathbf{S}_q = \mathbf{S}_{qo} + \mathbf{S}_v$. It is shown in [8] that $\mathbf{S}_{qo} \uparrow\downarrow \mathbf{S}_v$, consequently, according to Eq. (6), $\mathbf{S}_q = \mathbf{S}_v/2 = \hbar/2$. Thus, the spin of quantum object is, essentially, a spin of virtual photon. (However, the spin magnetic dipole moment of quantum object is probably connected with its spin $\mathbf{S}_{qo}$ [37]).

At u<<c, according to Eqs (13) and (15), $\mathbf{S}_v \parallel \mathbf{u}$, that is in accordance with the result of experiments by Gerlach and Stern [38]: the spin of the moving (with u<c) quantum object orients along or oppositely the velocity of motion.

7. Conclusion

In this work there were considered the following milestones of the physical vacuum model with intrinsic angular momentum and physical phenomena which they explain.

I. The Maxwell's Model of the Luminiferous Ether.
The model developed by Maxwell lets one: 1) to deduce the equation of spreading electromagnetic oscillations; 2) to introduce the process of angular momentum transfer.

II. The Model of Physical Vacuum with Quantum Oscillators Having "Zero-Point Energy".
The considered model endows the physical vacuum with the following properties: 1) positive density; 2) the possibility of emergence of wave-vortex-spin (electro-magneto-spin) process; 3) provides the fulfillment of the principle of conservation of angular momentum in the following phenomena: the photon's emission by an atom and in the Cherenkov effect.

III. The Creation in the Physical Vacuum of Virtual Photons (Consisting of Virtual Particles) by the Quantum Objects Taking Part in an Electric and Magnetic interaction.
The properties of virtual photons determine the following phenomena: 1) the spin-orbit interaction of a quantum object in the atom (due to existence of virtual photon's electric dipole moment); 2) the wave properties of quantum object: the precession frequency and precession angle of virtual photon's spin equal to the frequency and phase of the wave function of the quantum object, respectively; the size of virtual photon as an electric dipole equals the wave function wavelength of the quantum object; 3) the relativistic addition to mass of quantum object (due to existence of virtual photon's mass); 4) the contraction of quantum object's size along its velocity (due to a change in the size of virtual photon's spin along its velocity); 4) the possibility of the transformation of energy of photon during its transition from one inertial system to another moving relative to the first system; 5) the first law of Newton - law of inertia – (is due to the connection of speed of virtual photon with the size of projection virtual photon's spin on the direction of its motion).

IV. Pseudomagnetism.
Pseudomagnetic interaction of objects depends on their charges and mutual orientation of their spins. The force connected with pseudomagnetic interaction can determine the emergence of kinetic mass and electric dipole moment of photons and virtual photons. The moment connected with pseudomagnetic interaction (in particular, spin supercurrent) can transfer angular momentum and can initiate the generation of energy.

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