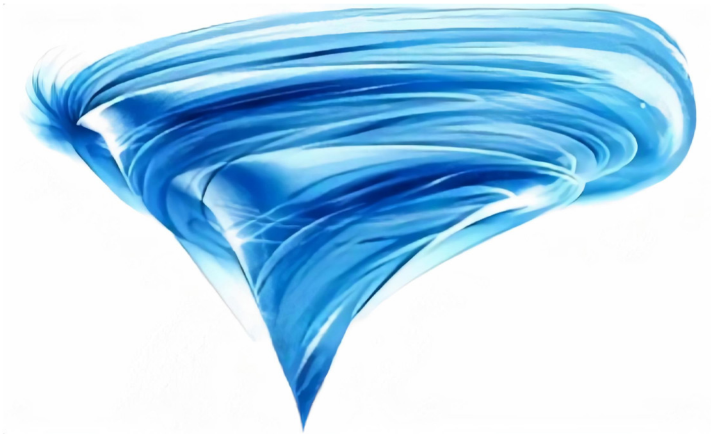

A THEORY OF SPIN VORTICES IN A PHYSICAL VACUUM CONSISTING OF QUANTUM OSCILLATORS

Liudmila Borisovna Boldyreva

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“Only they who see the unifying principle
in all the diversity of the Universe
possess the truth, only they, only they.”
Ancient Greek adage

The book is intended for people who are interested in scientific literature and/or specialize in areas, such as physics (matter waves, quantum correlation, electromagnetism, superconductivity, ball lightning, and the effect of cavity structures), astronomy (dark energy, dark matter, and cosmic microwave backgrounds), biophysics (the effect of biologically active substances in ultra-low doses and low-intensity physical factors on biological systems), and parapsychology.

This book does not contain lots of complicated mathematical formulas and special terms; it is intended for readers who are educated to college level.

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INTRODUCTION

The genesis of the theory of spin vortices in the physical vacuum is essentially the history of wave concepts of matter starting from Louis de Broglie's works.

Studying the nature of an X-ray emission that exerted both wave and corpuscular properties led him to create a theory connecting corpuscular and wave properties of matter (de Broglie 1924). De Broglie put forward a hypothesis that a wave is associated with every particle of non-zero rest mass and its characteristics are similar to the photon's analogous characteristics. Over the following decades, efforts were focused on searching for a "physical" wave that could accompany the particle, the so-called pilot wave (Wichmann 1971, Sinha et al. 1986). These efforts were unsuccessful and M. Born's proposal (Born 1954) has now been accepted; its main idea states that only the square of the absolute value of the wave function, which describes the state of the particle, has physical meaning because it determines the density of probability for finding the particle at a point in space.

In 1927, W. Heisenberg (Heisenberg 1927) introduced inequalities that took particles' wave properties into account and their interpretation was possible from a corpuscular point of view. The first inequality, $\Delta x \geq \hbar / \Delta p_x$ ($\hbar$ is the Planck constant), determines uncertainty Δx in the definition of coordinate x of the particle having uncertainty Δp_x in the definition of a component p_x of its momentum, **p**. This inequality is in accordance with the expression determining the wave function wavelength $\lambdabar$ for particles: $\lambdabar = \hbar / p$. The second inequality $\Delta t \geq \hbar / \Delta \varepsilon$ connects the lifetime Δt of a particle whose energy ε is defined with uncertainty $\Delta\varepsilon$; this inequality is in accordance with the expression determining the wave function frequency ω of the particle (Wichmann 1971): $1/\omega = \hbar/\varepsilon$. In general, the components of ε depend on the type of wave function; for example, in the Schrodinger wave function, ε is a particle's energy without taking into account the energy contained in its rest mass; and, in the de Broglie wave function, ε is the total energy of a particle (this function also describes the photon's wave properties). In quantum mechanics, any object whose state is described by the wave function is known as a quantum object.

In 1949, R. Feynman introduced virtual particles created by quantum objects for the denotation of force fields in his diagrams (Feynman 1949). The properties of the virtual particles depended on the interaction in which they were involved. For example, electric and magnetic interactions are accomplished by so-called virtual photons consisting of two oppositely charged virtual particles with spin (Mandl and Shaw 1984/2002). The introduction of virtual particles ascribed some physical meaning to the variables introduced by Heisenberg for the quantum objects; the variables characterized the properties of virtual particles created by these quantum objects. The value Δx determined the size of the virtual particles and Δt determined their lifetime; thus, the wave properties of quantum objects were connected with the virtual particles created by the quantum object.

Over time, the concept of virtual particles came to be applied to a number of physical effects, such as the spontaneous emission of photons, the Casimir effect, the Van der Waals force, the Lamb shift, and others. The question arises: if virtual particles are taken into account in the explanations for many experimentally observed physical effects, then why are virtual particles not "transformed" in real ones in the concepts of contemporary quantum mechanics? The answer to this question is that, in classical physics, a free object (which is not subjected to external forces and thus moves uniformly and rectilinearly) cannot emit or absorb another particle since in these processes the principles of conservation would not hold. In quantum physics, if one was to accept Heisenberg's inequalities, the principles of the conservation of energy and momentum are not violated since the energy and momentum of a particle living for a short time Δt in the area Δx are determined with uncertainties $(\Delta\varepsilon)$ and (Δp), respectively. However, Heisenberg's inequalities do not include a variation in the determination of the virtual particles' spin; therefore, the creation of a virtual photon (that has spin) by a quantum object (which is not subjected to external forces), without changing the value of its own spin violates the principle of conservation of angular momentum.

However, there will be no violation of the principle of conservation of angular momentum if the interaction of the quantum object with the physical vacuum that has an intrinsic degree of freedom (i.e., spin) takes place. The existence of this interaction also "saves" the principle of conservation of angular momentum in the following phenomena: 1) the emission of a photon with spin and so-called orbital angular momentum from an atom (Barnett 2010, Kidd 1989), though the photon acquires only the orbital angular momentum in most atomic transitions; and 2) the P. Cherenkov effect (Cherenkov 1937), where the production of photon by an electron (moving at a superluminal speed in a medium) having only spin takes place.

A group of physicists, including M. Planck, A. Einstein, and O. Stern, in Germany made the first step towards the physical vacuum having intrinsic degrees of freedom. In 1913, using the formula derived by Planck (Planck 1912) for the energy ε_o of the atomic oscillator vibrating with frequency ν: $\varepsilon_o = h\nu/2 + h\nu/\left(\exp\left(h\nu/\left(kT\right)\right)-1\right)$, Einstein and Stern published a paper (Einstein and Stern 1913) in which they classified $h\nu/2$ as "residual energy" (later, "residual energy" was called zero-point energy) that all atomic oscillators have at absolute zero. In quantum field theory, a physical vacuum free from magnetic and electric fields (without regard to gravitational energy) became defined not as an empty space but as the ground state of a field that consists of some oscillators with zero-point energy (Puthoff 1989). These oscillators have no generally accepted name but, in this work, they are called quantum oscillators (from now on the abbreviation QO will be used).

However, when ascribing physical properties to a physical vacuum, the following difficulty emerges. If in the above-mentioned Cherenkov's effect and at the emission of the photon by the atom, the photon spin is determined by the intrinsic degrees of freedom of the physical vacuum consisting of QOs with zero-point energy, then light is spreading in this physical vacuum as a process. However, this conclusion contradicts special relativity (SR), according to which there is no dedicated frame of reference (in particular, a luminiferous medium) (Einstein 1905). SR explains a lot of experimental data and consequently, in order to discard SR it is necessary to create an alternative theory. This theory must describe all of the experimental phenomena, which are also described by SR, using the Galilean law of adding velocities. This theory has been suggested by L. Boldyreva (Boldyreva 2017c). In this theory, the experimentally observed equalization of the speed of light in inertial systems was explained by the interaction of photons with the virtual photons created by the quantum objects that constitute the inertial system. In addition, an expression was proposed for the transformation of photon energy from $\hbar\omega_{ph}$ to $\hbar\omega_d$ when the photon passes from one inertial system to another moving relative to the first one at velocity **v**: $\hbar\omega_d = \hbar\omega_{ph}(\mathbf{c}+\mathbf{v})^2/\left(2c^2\right)+\hbar\omega_{ph}/2$ (c is the speed of light). This expression was deduced by two methods, one was based on the photon's properties (Boldyreva 2017c) and the other on the principles of conservation (the latter in collaboration with Dr. N. Sotina [Boldyreva and Sotina 2003]).

Based on the alternative theory to SR, the reality of virtual photons may be accepted and it may be supposed that they, as well as photons, are spin vortices (objects with spin precession) in the physical vacuum consisting of QOs with zero-point energy. The frequency and angle (phase) of the precession of spin and the size of the spin vortex (as an electric dipole) are, respectively, equal to the frequency, phase, and wavelength of the wave function of the quantum object that created this spin vortex (Boldyreva 2014b and 2014c). Note that the concept of creating spin vortices by moving quantum objects in the physical vacuum, which is a quantum medium with intrinsic degrees of freedom (the medium consists of QOs), is in accordance with the results of experiments with quantum media conducted by Chinese researchers (Li H. et al. 2020). They observed quantized superfluid vortex filaments induced by the axial flow effect.)

An important characteristic of spin vortices is the possibility of their interaction by means of a spin supercurrent. Y. Bunkov, V. Dmitriev, and I. Fomin were awarded the Fritz London Memorial Prize in 2008 for their studies into spin supercurrents in superfluid ^{3}He-B (Borovic-Romanov et al. 1989, Bunkov 2009, Dmitriev and Fomin 2009). The spin supercurrent equalizes the respective angles of precession and deflection of the precessing spins of spin vortices: that is, it transfers the angular momentum between spin vortices. Since a spin supercurrent is a process that equalizes the spin part of the order parameter in quantum liquid, which is described by a single wave function (in particular, in superfluid ^{3}He-B), the spin supercurrent must be a dissipation-free process. Thus, spin supercurrent may be considered to be a process not accompanied by emergence of kinetic mass, that is, to be an inertia-free process. Consequently, it may propagate at a speed exceeding that of light, which does not contradict the experimental data that only demonstrate the speed limit for an inertial process.

In this work, it has been shown that the concept of matter waves as a real physical process (the spin precession in spin vortices created by quantum objects in a physical vacuum consisting of QOs) and the possibility of interaction between the vortices through spin supercurrents allow one to explain many physical phenomena. Some of these phenomena have no physical explanation as yet, in particular, the superluminal propagation of electromagnetic field near an antenna (an oscillating electric dipole) (Walker 1999 and 2000, Boldyreva 2019b); quantum correlations between any quantum entities of both zero rest mass (photons) and non-zero rest mass (Klyshko 1994, Boldyreva 2014b and 2019b); the action of biologically active substances in ultra-low doses on biological systems (Boldyreva 2011); the effect of cavity structures (Boldyreva 2013b); and the potency of some magic rites (Boldyreva 2018e). It should be noted that with respect to the difficulty of explaining quantum correlations A. Einstein, B. Podolsky, and N. Rosen wrote (Einstein et al. 1935): “the description of reality given by the wave function in quantum mechanics is not complete”. Hopefully, the representation of matter waves by the precession motion of a spin in the spin vortices created by quantum objects in a physical vacuum consisting of QOs may eliminate this incompleteness.

A detailed list of the phenomena explained by the concept of spin vortices created by quantum objects in a physical vacuum consisting of QOs is given in the Conclusion.

Note. Two types of spin vortices are considered: 1) photons that are quanta of electromagnetic oscillations; 2) virtual photons (that consist of pairs of virtual particles) created by quantum objects which take part in electric and magnetic interactions (electric charges, magnetic and/or electric dipoles).

Abbreviations and Comments on the Text

QO: Quantum Oscillator
BS: Biological System
BAS: Biologically Active Substance
ULD: Ultra-Low Dose
NP: Nanoparticle
Eq.: equation
Eqs: equations
Fig.: figure
Figs: figures

The structure of the equation number – the number of the Chapter, point, and the number of the equation in the Chapter.

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CHAPTER ONE

THE PROPERTIES OF SPIN VORTICES IN A PHYSICAL VACUUM CONSISTING OF QUANTUM OSCILLATORS

This chapter examines two types of spin vortices (objects with precessing spin) that arise in a physical vacuum consisting of quantum oscillators (QOs). The spin vortices considered are those that constitute photons and those that constitute the virtual photons created by quantum objects with non-zero rest mass. (The spin vortex created by a quantum object has the following characteristics of its spin: the single values of precession frequency, angle of precession, and angle of deflection. The value of that spin is unchanged as well as the value of photon's spin.)

The properties of a physical vacuum will be considered in Section 4.1.

1.1. The Properties of Spin Vortices that Constitute Photons

1.1.1. Matter Waves

According to the principles of quantum mechanics, the quantum object is an object whose state is described by the wave function (Wichmann 1971). The state of a quantum object with zero rest mass (photon) is described by the de Broglie wave function.

The de Broglie wave function $\boldsymbol{\psi}_B(\mathbf{x},t)$ for a photon may be written in the following form (here the amplitude equals one):

$$\boldsymbol{\psi}_B(\mathbf{x},t) = \exp\left(i\mathbf{x}\mathbf{p}_{ph}/\hbar - itU_{ph}/\hbar\right), \qquad (1.1)$$

where $\mathbf{p}_{ph}$ is the photon momentum, U_{ph} is the photon energy, t is time, $\hbar$ is the Planck constant, and $\mathbf{x}$ is the axis along which the motion takes place. Here, the term $U_{ph}/\hbar$ is the frequency of the wave function for the photon and it equals the frequency ω_{ph} of the photon.

Momentum and energy are characteristics of the so-called M-photon—a hypothetical elementary particle from the light field, which generates a pulse at the output of a photodetector (Klyshko 1994). Note that the first corpuscular models of a light field consisting of elementary particles, the quanta, were developed after A. Compton's experiments on X-ray scattering (Compton 1923). The observed change in the frequency of the scattered radiation could be explained by the elastic collision of an electron and a particle possessing energy,

$$U_{ph} = \hbar\omega_{ph} \qquad (1.2)$$

and momentum

$$p_{ph} = \hbar\omega_{ph}/c, \qquad (1.3)$$

where c is the speed of light. That is, Eq. (1.1) describes the wave connected with the photon as a particle. The question arises: what wave process may be associated with a photon as a particle? To answer this question, let us consider some properties of the photon's spin.

The data of the three-photon annihilation of electron and positron with a total spin equal to one (orthopositronium) (Weber and Lynn 2000) suggest that the spin $\mathbf{S}_{ph}$ of any photon is directed transverse to the light velocity $\mathbf{c}$: that is,

$$\mathbf{S}_{ph} \perp \mathbf{c}\,. \tag{1.4}$$

A photon in a pure state is a circular-polarized photon (Wichmann 1971). This means that the electric component $\mathbf{E}_{ph}$ of the photon performs a precession motion with the frequency of the photon, $\boldsymbol{\omega}_{ph}$. Depending on the type of photon's circular polarization we have, for the left-hand one, $\boldsymbol{\omega}_{ph} \uparrow\downarrow \mathbf{c}$ and, for the right-hand one, $\boldsymbol{\omega}_{ph} \uparrow\uparrow \mathbf{c}$: that is, in general,

$$\boldsymbol{\omega}_{ph} \| \mathbf{c}. \tag{1.5}$$

Since the photon has the transverse electric polarization, that is, $\mathbf{E}_{ph} \perp \mathbf{c}$, then taking Condition (1.4) into account, we may assume (and further studies into the properties of spin vortices support the validity of this assumption) that there is the following relationship between electric component $\mathbf{E}_{ph}$ and the spin $\mathbf{S}_{ph}$ of the photon:

$$\mathbf{S}_{ph} \uparrow\downarrow \mathbf{E}_{ph}\,. \tag{1.6}$$

Then spin $\mathbf{S}_{ph}$, as well as $\mathbf{E}_{ph}$, performs a precession motion with a frequency of $\boldsymbol{\omega}_{ph}$. The following equations describe the precession of the spin of the photon moving along axis **x** with frequency $\boldsymbol{\omega}_{ph}$ and momentum $\mathbf{p}_{ph}$.

$$\left.\begin{aligned} \left(S_{ph}\right)_y &= \left(S_{ph}\right)_0 \exp(i\omega_{ph}t - i\mathbf{x}\mathbf{p}_{ph}/\hbar) \\ \left(S_{ph}\right)_z &= ni\left(S_{ph}\right)_0 \exp(i\omega_{ph}t - i\mathbf{x}\mathbf{p}_{ph}/\hbar) \end{aligned}\right\}, \tag{1.7}$$

where **x**. **y**, and **z** are Cartesian coordinates, n=1 at $\boldsymbol{\omega}_{ph} \uparrow\uparrow \mathbf{c}$ and n=-1 at $\boldsymbol{\omega}_{ph} \uparrow\downarrow \mathbf{c}$.

$$\left|\left(\mathbf{S}_{ph}\right)_0\right| = \hbar\,. \tag{1.8}$$

The angle of the precession, $\alpha = \omega_{ph} t$, of the spin is responsible for the phase of the photon. The angle of the deflection β of the precessing spin (see Fig. 1-1), according to Conditions (1.4)–(1.5), is determined to be

$$\beta = \pi / 2 . \tag{1.9}$$

Thus, the wave properties of the photon are connected not only to its electric and magnetic oscillations but also with precession of its spin. As it is spin that characterizes the photon as a particle, we may suppose that the wave properties of the photon as a particle are connected with the precession motion of its spin (Boldyreva 2014b and 2014c).

1.1.2. Electric Properties

In the nucleus' eletrical field (Wichmann 1971), the decay of the photon into unlike-charged particles with equal masses and charges may take place. This allows one to suppose that the photon consists of two unlike charged particles (with charge q_{ph}), and electric component $\mathbf{E}_{ph}$ is an electric field between these particles. Consequently, we may introduce the electric dipole moment $\mathbf{d}_{ph}$ of the photon. As the direction of the electric field inside an electric dipole is oriented oppositely to the direction of the electric dipole moment of this electric dipole (Purcell 1965), it holds that $\mathbf{E}_{ph} \uparrow\downarrow \mathbf{d}_{ph}$. Thus, from Condition (1.6) it follows that

$$\mathbf{S}_{ph} \uparrow\uparrow \mathbf{d}_{ph} . \tag{1.10}$$

If one assumes that the distance between the unlike-charged particles that constitute the photon equals the photon's wavelength $\lambda\!\!\!^{-}_{ph}$, then the photon's electric dipole moment d_{ph} may be determined to be

$$d_{ph} = q_{ph} \lambda\!\!\!^{-}_{ph} . \tag{1.11}$$

Based on the results of experiments conducted by W. Kaufmann (Kaufmann 1902) on the deflection of the beta-rays emitted by radium, which showed that the mass of the electron is purely of an electromagnetic nature, we assume that the specific charge of the particles that constitute the photon is proportional to the specific electron charge: that is, the following holds:

$$e / m_e = 2 q_{ph} / m_{ph}, \tag{1.12}$$

where e and m_e are the electric charge and mass of electron, respectively. Taking into account that the photon's kinetic mass m_{ph} is connected with its energy U_{ph} (Born 1962),

$$m_{ph} = U_{ph} / c^2, \tag{1.13}$$

and, taking into account that

$$\lambda\!\!\!^{-}_{ph} = \hbar / p_{ph}, \tag{1.14}$$

we obtain the following from Eqs (1.2)–(1.3) and (1.11)–(1.14):

$$d_{ph} = \mu_B, \tag{1.15}$$

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

1.1.3. Angular Momentum Associated with Kinetic Mass

The photon kinetic mass m_{ph} is revealed in experiments on a photon's decay in external electric fields into a pair of charged particles with equal masses $m_{ph} / 2$ (Wichmann 1971).

The precession motion of $\mathbf{E}_{ph}$ of the circularly polarized photon means that the charged particles constituting the photon and which create this electric component $\mathbf{E}_{ph}$ perform a circular motion at the photon's frequency $\boldsymbol{\omega}_{ph}$.

Then every charged particle, positive or negative, has the following characteristics: angular momentum $\left(\mathbf{J}_{ph}\right)_+$ or $\left(\mathbf{J}_{ph}\right)_-$ and the radius of circular motion $\left(r_{ph}\right)_+$ or $\left(r_{ph}\right)_-$. Based on the hypothesis that these particles are point-like from Eq. (1.11) it follows that $\left|\left(r_{ph}\right)_- - \left(r_{ph}\right)_+\right| = ƛ_{ph}$ (the sign of difference $\left(r_{ph}\right)_- - \left(r_{ph}\right)_+$ defines the orientation of the electric field $\mathbf{E}_{ph}$). All of the characteristics mentioned for the right-hand photon are given in Fig. 1-1.

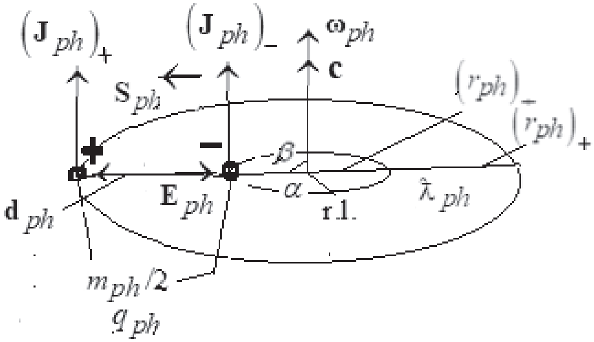


Fig. 1-1. The characteristics of the right-hand photon. $\boldsymbol{\omega}_{ph}$ is the frequency of the precession of spin $\mathbf{S}_{ph}$; $\mathbf{d}_{ph}$ is the electric dipole moment; $\mathbf{E}_{ph}$ is the electric component; **c** is the photon's velocity; $ƛ_{ph}$ is the photon's wavelength; $\left(\mathbf{J}_{ph}\right)_+$ and $\left(r_{ph}\right)_+$ are the angular momentum and the radius of the circle of motion of the positively charged particle, respectively; $\left(\mathbf{J}_{ph}\right)_-$ and $\left(r_{ph}\right)_-$ are the angular momentum and the radius of the circle of motion of the negatively charged particle, respectively; q_{ph} and $m_{ph}/2$ are the charge and the mass of every particle that constitutes the

photon, respectively; β is the angle of deflection; α is the angle of precession; and r.l. is a reference line.

According to the definition of angular momentum (Sedov 1971–1972), the latter expression for radii may be rewritten as $\left|\sqrt{\frac{2\cdot(J_{ph})_+}{m_{ph}\cdot\omega_{ph}}}-\sqrt{\frac{2\cdot(J_{ph})_-}{m_{ph}\cdot\omega_{ph}}}\right|=\lambdabar_{ph}$, or, using Eqs (1.2)–(1.3) and (1.13)–(1.14), we obtain

$$\left|\sqrt{\left(J_{ph}\right)_+}-\sqrt{\left(J_{ph}\right)_-}\right|=\sqrt{\hbar/2}\,. \qquad (1.16)$$

The angular momentum $\mathbf{J}_{ph}$ connected with the circular motion of photon's mass is determined to be

$$\mathbf{J}_{ph}=\left(\mathbf{J}_{ph}\right)_+ + \left(\mathbf{J}_{ph}\right)_-\,, \qquad (1.17)$$

and, according to the definition of angular momentum,

$$\mathbf{J}_{ph}\uparrow\uparrow\boldsymbol{\omega}_{ph}\,. \qquad (1.18)$$

Thus, the total angular momentum $\left(\mathbf{J}_{ph}\right)_t$ of the photon has two components: $\mathbf{J}_{ph}$ and spin $\mathbf{S}_{ph}$. $\left(\mathbf{J}_{ph}\right)_t=\mathbf{S}_{ph}+\mathbf{J}_{ph}$, which is in accordance with works by S.M. Barnett (Barnett S.M. 2010) and Kidd et al. (Kidd et al. 1989). In a photon's decay, for example into an electron and positron, every emerging particle gains two types of angular momentum: the electron $\mathbf{S}_{ph}/2$ and $\left(\mathbf{J}_{ph}\right)_-$; and the positron $\mathbf{S}_{ph}/2$ and $\left(\mathbf{J}_{ph}\right)_+$. It will be shown in Section 1.1.4 that $J_{ph}=\hbar$ (Eq. [1.20]); it then follows from Eqs (1.16)–(1.17) that $\left(J_{ph}\right)_-=\hbar\left(1/2-\sqrt{3}/4\right)$, $\left(J_{ph}\right)_+=\hbar\left(1/2+\sqrt{3}/4\right)$.

1.1.4. Energy

A photon's energy may be associated with its mass or with its spin. The energy associated with mass m_{ph} contains two terms. The first term is the kinetic energy $m_{ph}c^2/2$ of the translational motion of the center of mass, in which all the mass m_{ph} is assumed to be contained. The second term is the energy of circular motion, which is determined to be $J_{ph}\omega_{ph}/2$ (Sedov 1971–1972).

The energy associated with mass equals experimentally obtained energy U_{ph}. Consequently, we have

$$U_{ph} = m_{ph}c^2/2 + J_{ph}\omega_{ph}/2. \qquad (1.19)$$

Then, from Eqs (1.2), (1.13), and (1.19), it follows that

$$J_{ph} = \hbar. \qquad (1.20)$$

From Eqs (1.19)–(1.20), we obtain the following expression for a photon's energy:

$$U_{ph} = m_{ph}c^2/2 + \hbar\omega_{ph}/2. \qquad (1.21)$$

Let us now consider the energy associated with a photon's spin $\mathbf{S}_{ph}$. Similar to the energy of mass, it contains two terms:

$$U_{ph} = W_{St} + \left(W_{ph}\right)_{S\omega}. \qquad (1.22)$$

The first term W_{St} is the energy of the translational motion of spin. The second term $\left(W_{ph}\right)_{S\omega}$ is the energy of the precession motion of spin. According to (Sedov 1971–1972), under Conditions (1.4)–(1.5) and taking into account equality (1.8): $\left(W_{ph}\right)_{Sw} = \hbar\omega_{ph}$. Then from Eqs (1.2) and (1.22), it follows that

$$W_{St} = 0. \quad (1.23)$$

Thus, the translational motion of spin as angular momentum is a dissipation-free motion.

1.1.5. Magnetic Properties

The magnetic component of a photon

As it will be shown in Section 4.3 (Eq. 4.9) the magnetic component of a photon $\mathbf{B}_{ph}$ may be determined by the velocity $\boldsymbol{\upsilon}_{ph}$ of the circular motion of the center of the photon mass m_{ph}, in which all the mass is assumed to be contained: $\mathbf{B}_{ph} = \boldsymbol{\upsilon}_{ph}\sqrt{4\pi\rho}$, where ρ is the density of a physical vacuum consisting of QOs. The speed υ_{ph} may be determined from the definition of the angular momentum of the photon J_{ph}: $J_{ph} = m_{ph}\upsilon_{ph}^2 / \omega_{ph}$. Then it follows from the latter expression that

$$\upsilon_{ph} = \sqrt{J_{ph}\omega_{ph} / m_{ph}}. \quad (1.24)$$

Using Eqs (1.2), (1.13), and (1.20) in (1.24), we obtain $\upsilon_{ph} = c$, and then the value of the magnetic induction B_{ph} is determined by the following expression: $B_{ph} = c\sqrt{4\pi\rho}$.

The magnetic dipole moment of a photon (see also Boldyreva 2017a)

The fact that the electrically unlike-charged particles that constitute a photon are not annihilated suggests that between them not only the Coulomb attractive force $\left(F_q\right)_{ph}$ exists but also a repulsive force $\left(F_c\right)_{ph}$ that compensates force

$\left(F_q\right)_{ph}$. That is, for either particle that constitutes a photon it holds true that

$$\left(\mathbf{F}_q\right)_{ph} = -\left(\mathbf{F}_c\right)_{ph}. \qquad (1.25)$$

Taking into account Eq. (1.11), using the CGS system of units (Purcell 1965), the force $\left(F_q\right)_{ph}$ is determined to be

$$\left(F_q\right)_{ph} = \frac{q_{ph}^2}{\varepsilon_{ph} ƛ_{ph}^2}, \qquad (1.26)$$

where ε_{ph} is the permittivity of the physical vacuum at the location of the photon. Simultaneously solving Eqs (1.12)–(1.13) and (1.25)–(1.26), we obtain the following expression for $\left(F_c\right)_{ph}$: $\left(F_c\right)_{ph} = \dfrac{e^2 U_{ph}^2}{4\varepsilon_{ph} c^4 m_e^2 ƛ_{ph}^2}$. Using this expression for $\left(F_c\right)_{ph}$, the Eqs (1.2)–(1.3) and (1.14), and the expression for the Bohr magneton $\mu_B = e\hbar/\left(2m_e c\right)$, we obtain

$$\left(F_c\right)_{ph} = \frac{1}{\varepsilon_{ph}} \cdot \frac{\mu_B^2}{\cdot ƛ_{ph}^4}. \qquad (1.27)$$

The structure of Eq. (1.27) is similar to the structure of equations determining the force of the magnetic interaction of the two magnetic dipoles that have magnetic moments equal to μ_B and separated by distance $ƛ_{ph}$. Indeed, the expression for the force of the magnetic interaction of particles that constitute the photon, provided every particle has magnetic moment μ_B, must be determined in the CGS system as:

$$\left(F_m\right)_{ph} = \gamma \cdot \mu_{ph} \cdot \frac{\mu_B^2}{\lambda_{ph}^4}, \qquad (1.28)$$

where μ_{ph} is the magnetic permeability of the physical vacuum at the location of the pair of particles that constitute the photon, and γ is the factor of proportionality that depends on the mutual orientation of magnetic moments of these particles (Purcell 1965). The repulsive force acts between the magnetic dipoles if the magnetic moments of these dipoles are oriented oppositely along one line connecting the magnetic dipoles ($\leftarrow\rightarrow$ or $\rightarrow\leftarrow$) or parallel to each other ($\uparrow\uparrow$). Since in experiments the photon does not exhibit the properties of magnetic dipole whose magnetic dipole moment is $2\mu_B$, we may assume that the magnetic moment $\left(\mathbf{m}_{mag}\right)_{ph}^{+}$ of the positively charged particle and magnetic moment $\left(\mathbf{m}_{mag}\right)_{ph}^{-}$ of the negatively charged particle that constitute the photon are oriented oppositely; this means that two cases are possible: $\left(\mathbf{m}_{mag}\right)_{ph}^{+} \leftarrow\rightarrow \left(\mathbf{m}_{mag}\right)_{ph}^{-}$ or $\left(\mathbf{m}_{mag}\right)_{ph}^{+} \rightarrow\leftarrow \left(\mathbf{m}_{mag}\right)_{ph}^{-}$. The pair of oppositely charged particles that constitutes the photon is an electric dipole whose electric dipole moment $\mathbf{d}_{ph}$ is directed from the negative particle to the positive one. Taking into account Condition (1.10) at $\left(\mathbf{m}_{mag}\right)_{ph}^{+} \leftarrow\rightarrow \left(\mathbf{m}_{mag}\right)_{ph}^{-}$, we have

$$\left(\mathbf{m}_{mag}\right)_{ph}^{+} \uparrow\uparrow \mathbf{S}_{ph}, \quad \left(\mathbf{m}_{mag}\right)_{ph}^{-} \uparrow\downarrow \mathbf{S}_{ph}. \qquad (1.29)$$

In this case the mutual orientation of the magnetic moment $\left(\mathbf{m}_{mag}\right)_{ph}^{+}$ and the photon spin $\mathbf{S}_{ph}$, and also that of the magnetic moment $\left(\mathbf{m}_{mag}\right)_{ph}^{-}$ and the photon spin $\mathbf{S}_{ph}$, are appropriate to the mutual orientation of the spin magnetic moment and the spin of the positron and the electron, respectively.

Due to the similarity of expressions (1.27) and (1.28) and the correspondence of Condition (1.29) to the properties of the positron and electron, we may suppose that the particles that constitute the photon are magnetic dipoles, with the magnetic moment of either being equal to μ_B (the moment does not depend on the photon energy): that is,

$$\left(m_{mag}\right)_{ph}^{+} = \left(m_{mag}\right)_{ph}^{-} = \mu_B. \qquad (1.30)$$

Thus not only spin $S_{ph}/2$, mass $m_{ph}/2$, charge q_{ph}, and angular momentum ($\left(\mathbf{J}_{ph}\right)_{-}$ or $\left(\mathbf{J}_{ph}\right)_{+}$ depend on the particle sign, see Eq. [1.17]), but the magnetic moment μ_B should also belong to the characteristics of the particles that constitute a photon. During the decay of a photon into an electron-positron pair, all of the characteristics of the particles that constitute the photon are "transferred" to the emerging electron and positron. However, according to Eqs (1.29)–(1.30), the total magnetic moment of the photon equals zero.

1.2. The Properties of Spin Vortices that Constitute the Virtual Photons Created by Quantum Objects with Non-Zero Rest Mass

1.2.1. Matter Waves

The state of a quantum object with non-zero rest mass at $u \ll c$ (u is the speed of quantum object; c is the speed of light) may be described by the de Broglie wave function, or Schrodinger's wave function. Since in calculations of the spectrum of hydrogen atom, for example, the Schrodinger wave function is used (Schrödinger 1926), this work also uses the characteristics of the Schrodinger wave function.

The Schrodinger wave function for a free-moving (in the absence of external forces) quantum object possessing momentum $\mathbf{p}_q$ and energy U_q (the energy contained in the mass of the quantum object is not taken into account) may be written in the following form:

$$\boldsymbol{\psi}_{Sh}(\mathbf{x},t) = \exp\left(i\mathbf{x}\mathbf{p}_q / \hbar - itU_q / \hbar\right). \tag{1.31}$$

The Schrodinger wave function frequency ω_{Sh} is determined to be

$$\omega_{Sh} = U_q / \hbar . \tag{1.32}$$

Like in the case of the photon, the question arises: what wave process may be associated with the particle? According to the postulates of quantum mechanics, a quantum object which is a singularity in electric or magnetic fields (electric charge or/and magnetic dipole) creates a pair of oppositely charged electric particles, so-called virtual particles (Feynman 1949, Mandl and Shaw 2002). This pair is also called a "virtual photon" since it is, like a photon, transferring electric and magnetic interactions. The virtual photon has a precessing spin like a photon, and an electric component. This similarity particularly manifests itself in the Cherenkov effect

(Cherenkov 1937): the emission of a photon by a quantum object moving at a speed exceeding the speed of light. This effect may be a consequence of the fact that, when the speed of a virtual photon is equal to the speed of light, the characteristics of the virtual photon become identical to those of the photon (in particular, according to Eq. [1.9], such a characteristic is the angle of the deflection of the precessing spin).

Thus, it may be supposed that the wave function of a quantum object with nonzero rest mass, as well as the wave function of a photon, describes the precession motion of spin; in this case that of spin $\mathbf{S}_v$ of the virtual photon created by this object. This means that the frequency ω_v of the precession of the virtual photon spin $\mathbf{S}_v$ equals the frequency of the wave function of the quantum object creating this virtual photon:

$$\omega_v = \omega_{Sh}. \qquad (1.33)$$

Then, using (1.32) and (1.33), one may describe the precession of the spin S_v of the virtual photon created by a quantum object moving along axis **x** and having momentum $\mathbf{p}_v$ by the following equations:

$$\left.\begin{aligned}\left(S_v \sin\beta\right)_y &= \left(S_v \sin\beta\right)_0 \exp\left(i\omega_v t - i\mathbf{x}\mathbf{p}_v / (2\hbar)\right)\\ \left(S_v \sin\beta\right)_z &= in\left(S_v \sin\beta\right)_0 \exp\left(i\omega_v t - i\mathbf{x}\mathbf{p}_v / (2\hbar)\right)\end{aligned}\right\}, \qquad (1.34)$$

where **x**. **y**, **z** are Cartesian coordinates; n=1 at $\boldsymbol{\omega}_v \uparrow\uparrow \mathbf{u}$; $n=-1$ at $\boldsymbol{\omega}_v \uparrow\downarrow \mathbf{u}$; and β is the angle of deflection (see Fig. 1-2). The angle of the precession of spin, $\alpha = \omega_v t$, is responsible for the phase of the wave function of the quantum object. According to the postulates of quantum mechanics, the wave function wavelength $\lambda\!\!\!^{-}_q$ of the quantum object determines the size l_{vp} of the region where the quantum object creates a virtual photon: that is,

$$l_{vp} = \lambdabar_q , \quad (1.35)$$

where, according to postulates of quantum mechanics (Wichmann 1971),

$$\lambdabar_q = \hbar / p_q . \quad (1.36)$$

1.2.2. Mass

Let us assume that the mass m_v of a virtual photon is determined through the precession frequency ω_v of the spin of a virtual photon analogous to determining the kinetic mass m_{ph} of a photon through the precession frequency ω_{ph} of its spin (Eqs [1.2] and [1.13]); that is, $m_v = \hbar\omega_v / c^2$, or using Eqs (1.32)–(1.33):

$$m_v = U_q / c^2 . \quad (1.37)$$

The total mass M of the quantum object, which takes account of the mass m_v of the virtual photon created by the object, is determined to be

$$M = m_0 + m_v , \quad (1.38)$$

where m_0 is the rest mass of the quantum object. Let us consider the case where the energy U_q of the quantum object equals its kinetic energy: that is,

$$U_q = m_0 u^2 / 2 , \quad (1.39)$$

where u is the quantum object's speed. Then, using Eqs (1.37)–(1.39), we have $M = m_0 + m_0 u^2 / \left(2c^2\right)$. This expression for M at $u << c$ accurate to u^2 / c^2 coincides with the Lorentz transformation (Born 1962):

$$M = \frac{m_0}{\sqrt{1 - u^2 / c^2}} = m_0\left(1 + \frac{u^2}{2c^2} + o\left(\frac{u^2}{c^2}\right)\right),$$

where $o\left(u^2 / c^2\right)$ are the summands of a lower order of magnitude than u^2 / c^2.

Inertial properties of quantum object

Let us consider the summands in Eq. (1.38), which determine the total mass of a quantum object in more detail. The first summand m_0 is essentially half the kinetic mass of a photon whose decay results in the emergence of this quantum object; and the second summand is the mass m_v of the virtual photon created by this quantum object. According to Eqs (1.2) and (1.13), m_0 is determined by the frequency $\left(\omega_{ph}\right)_{m_o}$ of the decayed photon as $m_0 = \hbar\left(\omega_{ph}\right)_{m_0} / \left(2 \cdot c^2\right)$ (two quantum objects are created at the photon's decay). According to Eqs (1.32)–(1.33) and (1.37), $m_v = \hbar\omega_v / c^2$. Thus, according to Eq. (1.38), the quantum object's mass M may be determined through the precession frequencies of the spin vortices (of the photon and the virtual photon) which created this mass: $M = \hbar\left(\left(\omega_{ph}\right)_{m_0} + 2\omega_v\right) / \left(2 \cdot c^2\right)$. It is possible that this "gyroscopic" origin of the mass may determine the inertial properties of the quantum object and, consequently, the inertial properties of matter.

1.2.3. Electric Properties

Since a virtual photon consists of unlike-charged virtual particles, the virtual photon is an electric dipole. Consequently, the virtual photon has an electric component, namely an electric field $\mathbf{E}_v$ inside the electric dipole. As with the case of the photon (Condition [1.6]), one may suppose (and the further study of the properties of spin vortices supports this supposition) the following condition between the electric component $\mathbf{E}_v$ and the spin $\mathbf{S}_v$ of the virtual photon:

$$\mathbf{S}_v \uparrow\downarrow \mathbf{E}_v . \tag{1.40}$$

As the direction of electric field inside an electric dipole is oriented oppositely to the direction of the electric dipole moment of this electric dipole (Purcell 1965), it holds that $\mathbf{E}_v \uparrow\downarrow \mathbf{d}_v$. Then it follows from (1.40) that

$$\mathbf{S}_v \uparrow\uparrow \mathbf{d}_v . \tag{1.41}$$

Assuming the size of the virtual particle to be point-like, and taking into account that the size of the virtual photon l_{vp} is determined by Eq. (1.35), d_v may be determined to be

$$d_v = q_v \lambda\!\!\!^{-}_q . \tag{1.42}$$

As an example, let us consider the electric dipole moment $\mathbf{d}_v$ of the virtual photon created by the electron. By analogy with the definition of q_{ph} (see Eq. [1.12]), q_v is determined to be

$$e / m_e = 2q_v / m_v . \tag{1.43}$$

Using Eq. (1.37) and the expression for the Bohr magneton $\mu_B = e \cdot \hbar / \left(2m_e c\right)$, from (1.43) we obtain the expression for q_v:

$$q_v = \frac{\mu_B U_q}{c\hbar} . \tag{1.44}$$

Using Eqs (1.36) and (1.44) in Eq. (1.42), for electric dipole moment d_v, we obtain

$$d_v = \frac{\mu_B U_q}{c\, p_q}. \tag{1.45}$$

If energy U_q equals kinetic energy, that is, equalities (1.39) and $p_q = 2U_q / u$ take place, then expression (1.45) is transformed into following expression:

$$d_v = \frac{\mu_B u}{2c}. \tag{1.46}$$

It should be noted that the expression (1.45) for the electric dipole moment of the virtual photon d_v may be rewritten, in accordance with Eqs (1.32)–(1.33) and (1.36), in terms of the wave function of the quantum object (the frequency and wavelength) as $d_v = \mu_B \omega_{Sh} \lambda_q / c$.

Let us prove the validity of the expression (1.46) for $\mathbf{d}_v$, using the electric dipole moment of the virtual photon created by the electron of hydrogen atom as an example. As the energy of an electron in a hydrogen atom equals its kinetic energy, Eq. (1.46) may be used. In the electric field $\mathbf{E}_n$ of the nucleus a moment $\mathbf{M}$ will act on the virtual photon as on an electric dipole:

$$\mathbf{M} = \mathbf{d}_v \times \mathbf{E}_n. \tag{1.47}$$

The speed of an electron in a hydrogen atom is two orders of magnitude less than the speed of light: that is,

$$u \ll c. \tag{1.48}$$

If, in this case, condition

$$(\mathbf{d}_v)_e \uparrow\uparrow \mathbf{u} \tag{1.49}$$

holds for the electric dipole moment $(\mathbf{d}_v)_e$ of the electron then, from Eqs (1.46)–(1.49), it follows that the moment acting on the virtual photon created by the electron of hydrogen atom is determined to be $\left|\mathbf{M}\right| = \left|\mu_B\left(\mathbf{u}\times\mathbf{E}_n\right)/\left(2c\right)\right|$. The expression for **M** is the same as for the value of the spin-orbit interaction energy U_{s-o} of the electron in a hydrogen atom: $U_{s-o} = \left|\mu_B\left(\mathbf{u}\times\mathbf{E}_n\right)/\left(2c\right)\right|$, which was derived by L. Thomas based on the general requirements of relativistic invariance (Thomas L. 1927). One may consider this coincidence as a proof of the validity of expressions (1.46) and (1.49) under Condition (1.48).

Note. The spin-orbit interaction not only exists for an electron in an atom but this interaction is also the case for nucleons that are scattered by the atom's nucleus. In the latter case, the spin-orbit interaction is also connected with the moment acting in the electric field of atom nucleus on the electric dipole moment of the virtual photon (spin vortex) created by a nucleon.

The mutual orientation of $\mathbf{d}_v$ and **u** may be determined by the action of the electric field of the quantum object creating the virtual photon on this virtual photon as an electric dipole. Then, taking into account Condition (1.49), generally, the following must take place under Condition (1.48):

$$\mathbf{d}_v \uparrow\downarrow \eta\mathbf{u}\,, \tag{1. 50}$$

where

$$\eta = \begin{cases} 1, & for\,positively\ charged\,quantum\,object \\ -1, & for\,negatively\,charged\,quantum\,object \end{cases}. \tag{1.51}$$

The mutial orientation of **u** and $\boldsymbol{\omega}_v$ determined by Conditions (1.41) and (1.50) means the existence of moment:

$$\mathbf{M}_v = k_v\eta\left(\mathbf{S}_v\times\mathbf{u}\right) \tag{1.52}$$

($k_v < 1$ is a factor of proportionality) that acts on the quantum object moving at velocity **u.** 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 (Sedov 1971-1972): $\mathbf{M}_v = \boldsymbol{\omega}_v \times \mathbf{S}_v$. Then, taking into account Eq. (1.52) the following holds:

$$\boldsymbol{\omega}_v \uparrow\uparrow \eta \mathbf{u} \quad (1.53)$$

According to Conditions (1.41), (1.50)–(1.51) and (1.53) the angle of deflection β (the angle between vectors $\boldsymbol{\omega}_v$ and $\mathbf{S}_v$; see Fig. 1-2) of the precessing spin of the virtual photon created by the quantum object moving at a speed much lower than the speed of light (Condition [1.48] holds) equals π. Taking that the angle of the deflection β of the photon equals $\pi/2$ (Eq. [1.9]) into account, one may suppose that, generally, for the precessing spin of a spin vortex (of a photon or virtual photon) the following may be taken:

$$|\sin\beta| = u/c. \quad (1.54)$$

Consequently, according to Eqs (1.53)-(1.54), the projection of spin $\mathbf{S}_v$ on the velocity of quantum object **u**, $(S_v)_u$, is determined to be

$$(S_v)_u = S_v|\cos\beta| = S_v\sqrt{1-u^2/c^2}. \quad (1.55)$$

Thus, this may mean a contraction of the spin vortex created by the quantum object, with the contraction taking place in the direction of the quantum object's motion. This is in accordance with the Lorentz transformation (Born 1962).

1.2.4. Angular Momentum Associated with Mass and the Circulation of the Mass Velocity

As the spin $\mathbf{S}_v$ of the virtual photon performs a precession motion with a frequency of $\boldsymbol{\omega}_v$, then the mass m_v of the virtual photon performs the circular motion characterized by angular momentum $\mathbf{J}_{\nu}$. (Here, we consider mass m_{ν} without taking into account that it consists of two oppositely charged virtual particles). Besides, circulation Γ_{ν} is associated with the velocity $\boldsymbol{\upsilon}_{\nu}$ of the circular motion of mass (Sedov 1971–1972), in case if trajectory of motion is circle then: $\Gamma_{\nu} = J_{\nu} 2\pi / m_{\nu}$.

The characteristics of the virtual photon created by a negatively charged quantum object, moving with velocity **u**, are given in Fig. 1-2. This figure shows the precession angle (phase) relative to the reference line (r.l.), α; the deflection angle between the precession frequency $\boldsymbol{\omega}_{\nu}$ and spin $\mathbf{S}_{\nu}$, β; the electric component of the virtual photon, $\mathbf{E}_{\nu}$; and the magnetic induction created by the virtual photon at the location of the virtual photon mass m_{ν}, $\mathbf{B}_{\nu}$. The mutial orientation of $\boldsymbol{\upsilon}_{\nu}$ and $\mathbf{B}_{\nu}$ is determined by Eq. (4.9) (see Section 4.3). The mutual orientation of **u** and $\boldsymbol{\omega}_{\nu}$ is determined by Conditions (1.53) and (1.51). For electron $\boldsymbol{\omega}_{\nu} \uparrow\downarrow \mathbf{u}$.

The motion of charged quantum objects in one direction forms an electric current. Let us consider circulation Γ_{I}, which is created in the physical vacuum by electric current **I**. We assume that all the current carriers move in one direction with the same velocity **u** and energy U_{q}. Then, according to Eqs (1.32)–(1.33), (1.39), and (1.53)–(1.54), the virtual photons (spin vortices) created by these current carriers will have the same value and direction of precession frequencies $\boldsymbol{\omega}_{\nu}$ and the same angles of deflection β. In this case, the spin supercurrent (see Section 2.2.2) arising between the spin vortices equalizes the precession angles (phases), α, of the spins of the spin vortices. Thus, the electric current is accompanied by the emergence of a vortex line in the physical vacuum. It follows from Fig. 1.2: $\Gamma > 0$ and

$$\mathbf{J}_{\nu} = \mathbf{I}\frac{\Gamma m_{\nu}}{2\pi I}. \tag{1.56}$$

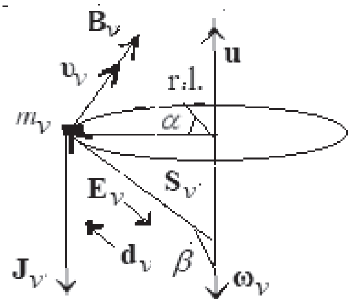


Fig. 1-2. The characteristics of a virtual photon created by a negatively charged quantum object: m_{ν} is the mass; $\mathbf{d}_{\nu}$ is the electric dipole moment; $\mathbf{J}_{\nu}$ is the angular momentum associated with m_{ν}; α is the precession angle (phase) relative to the reference line (r.l.); β is the deflection angle between the precession frequency $\mathbf{\omega}_{\nu}$ and spin $\mathbf{S}_{\nu}$; $\mathbf{\upsilon}_{\nu}$ is velocity of the circular motion; $\mathbf{E}_{\nu}$ is the electric component; and $\mathbf{B}_{\nu}$ is the magnetic induction created by the virtual photon at the location of the virtual photon mass m_{ν}; **u** is the speed of electron.

1.2.5. Magnetic Properties

The magnetic component of a virtual photon

Like in the case of the photon, the circular velocity $\mathbf{\upsilon}_{\nu}$ (Fig. 1-2) determines the magnetic induction $\mathbf{B}_{\nu}$ created by the virtual photon at the location of the virtual photon mass m_{ν} (see Section 4.3, Eq. [4.9]): $\mathbf{B}_{\nu} = \mathbf{\upsilon}_{\nu}\sqrt{4\pi\rho}$.

***The magnetic dipole moment of a virtual photon* (Boldyreva 2017a).**

Like in the case of the photon, the attractive Coulomb force $\left(F_q\right)_v$ between the oppositely charged virtual particles that constitute the virtual photon is compensated by a repulsive force $\left(F_c\right)_v$: for either virtual particle it holds true that

$$\left(\mathbf{F}_q\right)_v = -\left(\mathbf{F}_c\right)_v . \tag{1.57}$$

According to equality (1.42), the distance between the unlike charged virtual particles that constitute the virtual photon equals $\bar{\lambda}_q$. Then the force $\left(F_q\right)_v$ can be determined in the CGS system (Purcell 1965) as

$$\left(F_q\right)_v = \frac{q_v^2}{\varepsilon_{vph} \bar{\lambda}_q^2}, \tag{1.58}$$

where ε_{vph} is the permittivity of the physical vacuum at the location of the virtual photon.

Let us transform the expression (1.58) for the case where the virtual photon is created by an electron. Using Eq. (1.44), $\left(F_q\right)_v$ can be expressed as $\left(F_q\right)_v = \dfrac{\mu_B^2 U_q^2}{\varepsilon_{vph} c^2 p_q^2 \bar{\lambda}_q^4}$. If the latter expression for $\left(F_q\right)_v$ and Eq. (1.39) in Eq. (1.57) are used, the expression for $\left(F_c\right)_v$ may be written in the following form:

$$\left(F_c\right)_v = \frac{1}{\varepsilon_{vph} \bar{\lambda}_q^4} \left(\frac{\mu_B u}{2c} \right)^2 . \tag{1.59}$$

The structure of Eq. (1.59) is similar to the structure of the following equation:

$$\left(F_m\right)_v = \frac{\gamma\,\mu_{vph}}{\lambdabar_q^4}\left(\frac{\mu_B\,u}{2c}\right)^2, \qquad (1.60)$$

which determines (in the CGS system) the force of the magnetic interaction of the two particles separated by distance $\lambdabar_q$ and which have magnetic moment $\mu_B u/(2c)$; μ_{vph} is the magnetic permeability of the physical vacuum at the location of the virtual photon.

In Fig. 1-3, there is a diagram of the relative orientation of the respective characteristics of an electron and the virtual particles that constitute the virtual photon created by the free-moving electron. When determining the orientation, the following should be taken into account: the action of the electron's electric field on the virtual photon as on the electric dipole; the action of the electron's magnetic field on the virtual particles as on magnetic dipoles; Condition (1.41); and the fact that force $\left(F_m\right)_v$ (Eq. [1.60]) acting between the magnetic dipoles must be a repulsive force. The mutual direction of the velocity **u** of the electron and its electric dipole moment $\left(\mathbf{d}_v\right)_e$ is in accordance with Condition (1.49).

By analogy with determining the magnetic dipole moment of charged particles that constitute a photon (Condition [1.29]) the following must hold true:

$$\left(\mathbf{m}_{mag}\right)_v^+ \uparrow\uparrow \mathbf{S}_v \text{ and } \left(\mathbf{m}_{mag}\right)_v^- \uparrow\downarrow \mathbf{S}_v, \qquad (1.61)$$

where $\left(\mathbf{m}_{mag}\right)_v^+$ and $\left(\mathbf{m}_{mag}\right)_v^-$ are the magnetic moments of positively and negatively charged virtual particle, respectively, that constitute the virtual photon created by the electron.

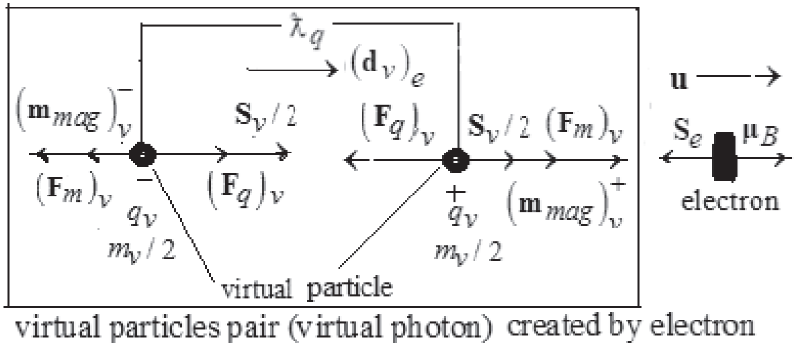


Fig. 1-3. The characteristics of the virtual particles pair (virtual photon) created by the free-moving electron: m_v is the mass; $\mathbf{S}_v$ is the spin; q_v is the charge of the virtual particle; $\left(\mathbf{F}_q\right)_v$ and $\left(\mathbf{F}_c\right)_v$ are the force of electric interaction and force of magnetic interaction of virtual particles, respectively; $\left(\mathbf{m}_{mag}\right)_v^+$ and $\left(\mathbf{m}_{mag}\right)_v^-$ are the magnetic moments of the positively and the negatively charged virtual particle, respectively; $\left(\mathbf{d}_v\right)_e$ is the electric dipole moment of the virtual particles pair created by the electron; λ_q is the distance between the virtual particles; $\mathbf{\mu}_B$ is the spin magnetic moment of the electron without taking into account the magnetic moment of the virtual photon created by this electron; $\mathbf{S}_e$ is spin of the electron; and $\mathbf{u}$ is the velocity of the electron.

Due to the similarity between expressions (1.59) and (1.60), and the correspondence of Condition (1.61) to the properties of the positron and electron, we may suppose that the virtual particles that constitute the virtual photon created by the electron are magnetic dipoles, with magnetic moment of either being equal to $\mu_B u/(2c)$: that is,

$$\left(m_{mag}\right)_v^+ = \left(m_{mag}\right)_v^- = \mu_B u/(2c). \qquad (1.62)$$

The total magnetic moment $\left(m_{mag}\right)_v^t$ of the pair equals zero at the distance from the virtual particles pair much greater than its size, $\lambdabar_q$.

However, in a region whose size is of the same order of magnitude as $\lambdabar_q$, $\left(m_{mag}\right)_v^t \neq 0$. As follows from Fig. 1-3, in this case the value $\left(m_{mag}\right)_v^t$ can be expressed as

$$\left(m_{mag}\right)_v^t = k_1\left(m_{mag}\right)_v^+ - k_2\left(m_{mag}\right)_v^-, \qquad (1.63)$$

where k_1 is a proportionality factor determining the proportion of the magnetic moment $\left(\mathbf{m}_{mag}\right)_v^+$ of the positively charged virtual particle in $\left(m_{mag}\right)_v^t$, $0 < k_1 < 1$; and k_2 is a proportionality factor determining the proportion of the magnetic moment $\left(\mathbf{m}_{mag}\right)_v^-$ of the negatively charged virtual particle in $\left(m_{mag}\right)_v^t$, $0 < k_2 < 1$. According to the relative orientation of magnetic moments $\left(\mathbf{m}_{mag}\right)_v^+$, $\left(\mathbf{m}_{mag}\right)_v^-$ and the electron magnetic moment which equals

μ_B (see Fig. 1-3), $k_1 > k_2$. Then, according to Eqs (1.62)–(1.63), we have

$$\left(m_{mag}\right)_v^t < \mu_B u / (2c). \qquad (1.64)$$

Thus, the total spin magnetic moment $\left(m_{mag}\right)_e$ of the electron is equal to the sum of two summands:
1) the first summand is the magnetic moment acquired by the electron at its emergence from the photon and, according to Eq. (1.30), it equals μ_B;

2) the second summand $\left(m_{mag}\right)_v^t$ is the magnetic moment of the virtual photon (a pair of virtual particles) created by this electron, which is measured at the location of electron,

$$\left(m_{mag}\right)_e = \mu_B + \left(m_{mag}\right)_v^t. \qquad (1.65)$$

For example, for the electron in a hydrogen atom in the ground state $(U_e = m_e u^2 / 2 = 13.59\,\text{eV})$ according to Eq. (1.64) we have

$$\left(m_{mag}\right)_v^t < \mu_B \cdot 0.003643972.... \qquad (1.66)$$

Then, using Eq. (1.65),

$$\left(m_{mag}\right)_e < \mu_B + \mu_B \cdot 0.003643972... \qquad (1.67)$$

The expression for $\left(m_{mag}\right)_e$ obtained in experiments with sodium and gallium in $2S_{1/2}$, $2P_{1/2}$, and $2P_{3/2}$ states (Foley and Kusch 1948), and in experiments determining the hyperfine splitting of the ground state of atomic hydrogen (Lamb and Retherford 1947) is

$$\left(m_{mag}\right)_e = \mu_B + \mu_B \cdot 0.001159652180(76), \qquad (1.68)$$

which is in accordance with inequality (1.67).

Historically, the first summand of $\left(m_{mag}\right)_e$, which equals μ_B, was derived in a nonrelativistic approximation from the Dirac equation (Dirac 1939) for an electron in the external magnetic field. The existence of the second summand was explained (Efremov and Sharkov 2009) by the interaction of an electron with zero fluctuations of electromagnetic vacuum (the absorption and generation of virtual photons) that influenced the electron's characteristics (for example, its mass).

Notes

[1] The properties of a virtual photon determine not only the total magnetic moment of the quantum object that produced this virtual photon, but also the total spin of the object itself. It is possible that the results of the Stern-Gerlach experiment (Gerlach and Stern 1922) determining the origin of the postulate of the quantization of a quantum object's spin is a consequence of the definite mutual orientation between the virtual photon spin and the speed of the quantum object that produced this virtual photon.

[2] The following condition results from the diagram of the characteristics of free-moving electron shown in Fig 1-3: $\mathbf{S}_e \uparrow\downarrow \mathbf{S}_v$. It is obvious that the analogous diagram also applies to the characteristics of free-moving positron; consequently, we may rewrite the latter condition in a more common form:

$$\mathbf{S}_q \uparrow\downarrow \mathbf{S}_v, \tag{1.69}$$

where $\mathbf{S}_q$ is the spin of the quantum object.

[3] As shown in Fig 1-3, the virtual photon (spin vortex) follows the moving electron. According to Conditions (1.41), (1.50)-(1.51), (1.53), and (1.61), the same holds for a virtual photon (spin vortex) created by a positively charged quantum object. Consequently, virtual photons (spin vortices) follow the path of the electrically

charged quantum objects creating these spin vortices, which is analogous to how eddy water follows the path of a moving boat. The orientation of the spin of the spin vortex relative to the velocity of the quantum object is determined by the sign for the object's electric charge.

Chapter Two

Interactions of Spin Vortices

Since spin vortices possess the electric dipole moment (see Sections 1.1.2 and 1.2.3) and spin, two types of interaction may exist between them: electric dipole-dipole interaction and that by means of a spin supercurrent (gravitational interaction is not taken into account). The physical phenomena in which those interactions take place are considered below.

2.1. Electric Dipole-Dipole Interaction

2.1.1. The Change in the Size of a System of Electric Charges Set in Motion, with the System Being in an Equilibrium Under the Action of Electrostatic Forces Only

It was H. Lorentz who noticed that a system of electric charges when set in motion contracts in the direction of the motion, the system being in equilibrium under the action of electrostatic forces only. Note that the hypothesis of the length contraction in the direction of motion was first advanced by G. Fitzgerald in 1832 (Born 1962).

Let us discuss this phenomenon taking the electric dipole moment of the virtual photons (spin vortices) created by moving charged quantum objects into account (Section 1.2.3) (see also Boldyreva 2012b). For simplicity's sake, we shall consider a system of two electrically charged quantum objects, with the system moving at velocity **u.** Let us denote by q_1 and q_2 the charges of the first and the second quantum object, and by d_1 and d_2 the magnitudes of electric dipole moment of virtual photons created by the first and the second quantum object. The force of the interaction between the two quantum objects has two components: the force due to the interaction between them as electric charges, F_q, and the force due to the interaction between them as electric dipoles, F_d.

Let us consider two types of relative positions of the quantum objects: along the velocity **u** (Fig. 2-1a), and parallel to each other (Fig. 2-1b). The force F_q is determined (in the CGS system) to be

$$F_q = q_1 q_2 / r_q^2 , \tag{2.1}$$

where r_q is the distance between the charged quantum objects.

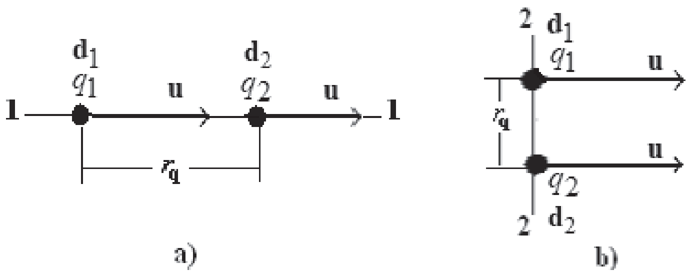


Fig. 2-1. Variants (a) and (b) of the relative position of two charged quantum objects with the following characteristics: q_1 and q_2 are charges; **u** is the velocity; $\mathbf{d}_1$ and $\mathbf{d}_2$ are electric dipole moments of virtual photons created by the quantum objects; and r_q is the distance between the quantum objects.

If Condition (1.48) holds, then, in accordance with Eqs (1.50)–(1.51), force F_d is expressed (Purcell 1965) as

$$F_d = \gamma d_1 d_2 / r_q^4 , \quad (2.2)$$

where γ is the factor of proportionality that depends on the mutual orientation of electric dipole moments $\mathbf{d}_1$ and $\mathbf{d}_2$.

Let us determine the resultant force between the two charges for the case of their relative position shown in Fig. 2-1*a*. As follows from Eqs (1.50)–(1.51) (under Condition [1.48]), *at any combination of signs of* q_1 *and* q_2, the forces F_q and F_d have mutually opposite directions, and they are aligned with the same straight line 1-1. Thus, the resultant force F_{11} acting on the charges, in accordance with Eqs (2.1)–(2.2) (in this case $\gamma = 6$), will be

$$F_{11} = \left| F_q - F_d \right| = \frac{q_1 q_2}{r_q^2} \left| 1 - \frac{6 d_1 d_2}{q_1 q_2 r_q^2} \right| . \quad (2.3)$$

Let us now determine the resultant force between the two charges for the variant of their relative position, as shown in Fig. 2-1b. As follows from Eqs (1.50)–(1.51) (under Condition [1.48]), *at any combination of signs of* q_1 *and* q_2, the forces F_q and F_d have the same direction, and they are aligned with the same straight line 2-2 which is perpendicular to velocity **u**. According to Eqs (2.1)–(2.2) (in this case $\gamma = 3$), the resultant force F_{22} acting on the charges normally to velocity **u** will be

$$F_{22} = \left| F_q + F_d \right| = \frac{q_1 q_2}{r_q^2} \left| 1 + \frac{3 d_1 d_2}{q_1 q_2 r_q^2} \right| . \quad (2.4)$$

Therefore, the motion of the electric charges of any sign results in a decrease of the electric force acting between the charges in the direction of motion, with a reduction factor, according to Eq. (2.3), of $1-6d_1d_2/\left(q_1q_2r_q^2\right)$, and in an increase of the force acting in the normal direction, with an amplification factor, according to Eq. (2.4), of $1+3d_1d_2/\left(q_1q_2r_q^2\right)$. If the moving charges are electrons and/or positrons ($q_1=q_2=e$) and the energies of the moving charges are equal to their kinetic energies, then, according to Eq. (1.46), the reduction factor is $1-\left(\frac{u}{c}\right)^2\frac{3\mu_B^2}{2r_q^2e^2}$ and amplification factor is $1+\left(\frac{u}{c}\right)^2\frac{3\mu_B^2}{4r_q^2e^2}$.

Thus, if there is a system of electric charges being in equilibrium only under the action of electrostatic forces between the charges and the system is set in motion, then the size of the system will be affected by the action of electric dipole-dipole forces.

Besides, the change in the size of system of moving charges may also take place as a result of change in the size of the spin projection of the virtual photons created by those charges, with the change occurring in the direction of motion **u** (see Eq. [1.55]).

2.1.2. The Interaction Between Two Parallel Uncharged Conducting Plates

A force exists between two parallel uncharged metal plates: the so-called Casimir effect and Casimir-Lifshitz effect. The current explanations of the Casimir force are based on taking the energy of the virtual photons created by the conduction electrons of plates (Lamoreaux 1997) or the Van der Waals forces (Capasso et al. 2009) into account. In this section, it will be shown that the force between two parallel uncharged metal plates emerges owing to the existence of the electric dipole moment of the virtual photons (spin vortices) created by the conduction electrons of these plates (see also Boldyreva 2012b).

If the total electric dipole moments of the first and the second plate, respectively $\mathbf{d}_{p1}$ and $\mathbf{d}_{p2}$ satisfy the following Condition:

$$\mathbf{d}_{p1} \| \mathbf{d}_{p2} \tag{2.5}$$

and for the distance r_{pd} between the plates the following holds: $\mathbf{r}_{pd} \perp \mathbf{d}_{p1}\left(\mathbf{d}_{p2}\right)$, then the force, F_{pd}, between the plates is determined to be

$$F_{pd} = 3d_{p1}d_{p2} / r_{pd}^4 . \tag{2.6}$$

The sign of F_{pd} depends on the mutual orientation of vectors $\mathbf{d}_{p1}$ and $\mathbf{d}_{p2}$: at $\mathbf{d}_{p1} \uparrow\downarrow \mathbf{d}_{p2}$ force F_{pd} is an attractive force and at $\mathbf{d}_{p1} \uparrow\uparrow \mathbf{d}_{p2}$ F_{pd} is a repulsive force (the latter case is unstable when it is disturbed). The attractive effect is referred to as the Casimir effect. The repulsive effect taking place under definite conditions is referred to as the Casimir-Lifshitz effect.

It should be noted that Eq. (2.6) only applies if the size of the dipoles is much less than the distance between them. According to Eq. (1.42), the size of the electric dipole emerging in the spin vortex (virtual photon) created by a quantum object equals its wavelength. For conduction electrons in metals, the wavelength is about $\approx 10^{-7} cm$. In the most experiments $r_{pd} \sim 10^{-6} cm$. If the total electric dipole moment of either plate may be determined by the mere addition of the electric dipole moments of the virtual photons created by individual electrons without the addition of the sizes of the dipoles, then the use of Eq. (2.6) is quite in order.

Let us consider the plates of the unit area, taking only the electrons present in the ζ thick layer of the plate surface into account. Let us assume that the plates are identical: that is, $d_1 = d_2$. We shall make a rather strong assumption that the electric dipole moments of the virtual photons created by the electrons in the ζ thick layer in either plate are oriented in the same direction and, consequently, may be added together as scalar variables. (Note that this assumption is similar to that used in the current explanation of the Casimir force: the energies of all virtual photons in vacuum, which are associated with the conducting plates, are added together.) Then, based on Eqs (1.45) and (2.6) we have

$$F_{pd} = \frac{3\mu_B^2 U_q^2}{r_{pd}^4 c^2 p_q^2} \zeta^2 N_0^2, \qquad (2.7)$$

where N_0 is the conduction electron concentration in metals. The energy of a conduction electron in metals equals the Fermi energy: that is, $U_q = \varepsilon_F$. The momentum p_q for a conduction electron in metals is determined to be $p_q = \sqrt{2m_e \varepsilon_F}$. Using these relations for the Eq. (2.7), we obtain

$$F_{pd} = \frac{3\mu_B^2 \varepsilon_F}{r_{pc}^4 c^2 2m_e} \zeta^2 N_0^2. \qquad (2.8)$$

The conduction electron concentration in metals, N_0, is of the order of 10^{22}, and the Fermi energy is determined by the following equation: $\varepsilon_F = \hbar^2 (3\pi^2 N_o)^{2/3} / (2m_e)$ (Kittel and Kroemer 1980). Substituting the right-hand side of the latter equation for ε_F in Eq. (2.8), as well as substituting the values of all constants and assuming ζ equal to the atom size, that is, $\zeta \approx 10^{-8}$ cm, we obtain $F_{pd} \approx 4 \cdot 10^{-23} / r_{pd}^4$ (N).

The obtained expression for F_{pd} is very close to the one determining the Casimir force F acting on a unit area of two parallel electrically neutral metallic plates, with the distance between them being not greater than some atomic diameters: $F = \hbar c \pi^2 / \left(240 r_{pd}^4\right) \approx 10^{-23} / r_{pd}^4$ (N) (Lamoreaux 1997).

It should be noted that a moment will act between conducting plates, and not only a force, if Condition (2.5) does not hold. This theoretical conclusion is in accordance with experimental data, according to which the so-called Casimir torque was measured (Somers et al. 2018).

Note. As it will be shown in Section 9.1, the Casimir effect will not be observed for the superconducting plates because the electrons in a superconductor form Cooper pairs with the total zero electric dipole moment of the virtual photons created by the electrons of Cooper pairs.

2.1.3. Exchange Interaction

The exchange interaction between quantum objects in terms of wave characteristics is introduced as follows: if the wave function frequencies of the objects are equal and the distance between the objects is less than their wavelengths (that is, their wave functions overlap in space), then there is a coherence in behavior of these quantum objects, which manifests itself as an exchange interaction (Wichmann 1971). In this section, it is shown that the exchange interaction may be an electric dipole-dipole interaction. This suggestion is based on the analysis of some of the physical phenomena in which the exchange interaction between two quantum objects takes place: the creation of Cooper pairs in superconductors and in superfluid ^{3}He-B, and the formation of a covalent (molecular) $\sigma-$bond. Let us consider these phenomena in detail (see also Boldyreva 2018b).

Experimental data

Let us determine the common properties of the Cooper pair of electrons in superconductors, a Cooper pair of ^{3}He atoms in superfluid ^{3}He-B, and the pair of electrons forming a covalent (molecular) $\sigma-$bond.

1) All of the objects involved in the exchange interactions are quantum objects: that is, the state of these objects is described by the wave function.

2) The quantum objects that constitute Cooper pairs and covalent $\sigma-$bond have equal and oppositely directed momenta; we shall generally denote them as $\left(\mathbf{p}_q\right)_1$ and $\left(\mathbf{p}_q\right)_2$: that is,

$$\left(\mathbf{p}_q\right)_1 = -\left(\mathbf{p}_q\right)_2 . \tag{2.9}$$

3) The speed u of the quantum objects that constitute Cooper pairs and covalent $\sigma-$bond meets the Condition (1.48): that is: $u \ll c$.

For the Cooper pair electrons in the ***s***-state, $u \approx 10^7$ cm/s (Bardeen et al. 1957); for the Cooper pair of ^{3}He atoms that constitute superfluid ^{3}He-B, $u \approx 10^4$ cm/s (Salomaa and Volovik 1987); and for electrons in a $\sigma-$bond, $u \approx 2 \cdot 10^8$ cm/s (Cammarata and Rondinelli 2014).

4) There is an overlapping of the wave functions of the quantum objects that constitute the pair: that is, the size of pair, a_p, is less than the sum of the wavelengths ($2\lambdabar_q$) of the quantum objects that constitute the pair:

$$a_p < 2\bar{\lambda}_q . \qquad (2.10)$$

For Cooper pairs in superconductors and superfluid, $a_p \sim \bar{\lambda}_q$. The size a_p of the electron pair in a σ – bond of a hydrogen molecule (the most robust bond for the hydrogen molecule) equals $6 \cdot 10^{-9}$ cm while, at the same time, the hydrogen atom electron wavelength $\bar{\lambda}_q$ is $4.4 \cdot 10^{-9}$ cm (Cammarata and Rondinelli 2014).

5) The motion of the quantum objects constituting the Cooper pair in the same direction at a definite (critical) velocity of this motion results in the destruction of this Cooper pair. The following takes place in experiments: the destruction of Cooper pairs in a superconducting medium under the electric current greater than the critical one; the destruction of Cooper pairs in a superfluid medium at its motion at a speed greater than the critical speed; and the decay of the σ – bond and the destruction of Cooper pairs in superconducting and superfluid media under an increase in temperature.

It should be noted that, in this case, equality (2.9) does not hold.

6) The energies of two quantum objects (respectively, $(U_q)_1$ and $(U_q)_2$) involved in the exchange interaction are equal:

$$(U_q)_1 = (U_q)_2 . \qquad (2.11)$$

Consequently, according to Eqs (1.32)–(1.33), they create virtual photons of equal spin precession frequencies. That is, the difference between the spin precession frequencies, $\Delta\omega_v$, of these virtual photons is equal to zero:

$$\Delta\omega_v = 0 . \qquad (2.12)$$

The equality of the precession frequencies means that the spins of the virtual photons created by the quantum objects may have a *constant mutual orientation*. According to Condition (1.41), the electric dipole moments of those virtual photons will also have a *constant mutual orientation*. Therefore, both the interaction of the spins of these virtual photons and their electric dipole-dipole interaction are possible.

> *Note*. It is noteworthy that, in 1930, F. London introduced an intermolecular electric dipole interaction, the so-called London Dispersion Force (LDF), to explain the covalent bond. London supposed that it is a weak interaction arising from induced instantaneous polarization in molecules (Eisenschitz and London 1930).

The electric dipole-dipole interaction of quantum objects that constitute a Cooper pair or a $\sigma-$bond

As the quantum objects that constitute a Cooper pair or a $\sigma-$bond have the same electric sign, then, according to Eqs (1.45), (1.48) (or property 3 in Section 2.1.3), (1.50)–(1.51), (2.9), and (2.11) for the electric dipole moments (respectively $(\mathbf{d}_v)_1$ and $(\mathbf{d}_v)_2$)) of the virtual photons created by these quantum objects, it holds that

$$(\mathbf{d}_v)_1 = -(\mathbf{d}_v)_2 . \tag{2.13}$$

The characteristics of interacting virtual photons (virtual particles pairs) for case (2.13) are given in Fig. 2-2. L_{vp} is the distance between the virtual photons; q_v is the electric charge of a virtual particle that constitutes a virtual photon; λ_q is the wavelength of quantum objects creating these virtual photons; $\mathbf{F}_1$ and $\mathbf{F}_2$ are forces acting on each virtual particle in the virtual photon, $\mathbf{F}_1 \perp (\mathbf{d}_v)_1 \left((\mathbf{d}_v)_2\right)$; and $\mathbf{F}_r$ is the resulting force acting on either of the interacting virtual photons. Under Condition (2.13), the resulting force F_r is an attractive force and it is expressed (in the CGS system) as $F_r = 2\left(F_1 - F_2 \cdot L_{vp} / \sqrt{L_{vp}^2 + \lambdabar_q^2}\right)$, where F_1 and F_2 are determined as $F_1 = q_v^2 / L_{vp}^2$ and $F_2 = q_v^2 / \left(L_{vp}^2 + \lambdabar_q^2\right)$, respectively.

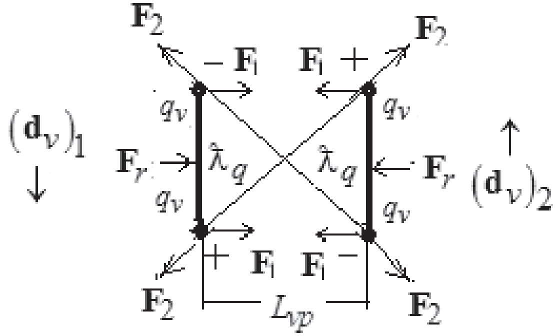


Fig. 2-2. The characteristics and mutual orientation of virtual photons (virtual particles pairs): $(\mathbf{d}_v)_1$ and $(\mathbf{d}_v)_2$ are electric dipole moments; L_{vp} is the distance between virtual photons; q_v is the electric charge of a virtual particle; $\mathbf{F}_1$ and $\mathbf{F}_2$ are the forces acting on each virtual particle, $\mathbf{F}_1 \perp (\mathbf{d}_v)_1 \left((\mathbf{d}_v)_2\right)$; $\lambdabar_q$ is the wavelength of the quantum objects that created the virtual photons; and $\mathbf{F}_r$ is the resulting force acting on either of the virtual photons.

Using expressions for F_1 and F_2 in F_r, we obtain

$$F_r = \frac{2 \cdot q_v^2}{L_{vp}^2}\left(1 - \frac{1}{\left(1 + \lambdabar_q^2 / L_{vp}^2\right)^{3/2}}\right). \qquad (2.14)$$

If $L_{vp} >> \lambda\!\!\!^{-}_q$, the Eq. (2.14) with an accuracy of $\left(\lambda\!\!\!^{-}_q / L_{vp}\right)^2$ may be written as $F_r = 3q_v^2 \lambda\!\!\!^{-2}_q / L_{vp}^4$. Let us introduce denotations $\left|\left(\mathbf{p}_q\right)_1\right| = \left|\left(\mathbf{p}_q\right)_2\right| = p_q$ and $\left(U_q\right)_1 = \left(U_q\right)_2 = U_q$ based on Eqs (2.9) and (2.11). If interacting quantum objects are electrons, then, by taking Eqs (1.36) and (1.44) into account, F_r takes the following form:

$$F_r = \frac{3\ \mu_B^2\ U_q^2}{p_q^2\ c^2\ L_{vp}^4}. \qquad (2.15)$$

If $L_{vp} << \lambda\!\!\!^{-}_q$, the Eq. (2.14) may be written as $F_r = 2 \cdot q_v^2 / L_{vp}^2$; taking Eq. (1.44) into account, F_r takes the following form:

$$F_r = \frac{2\ \mu_B^2\ U_q^2}{\hbar^2\ c^2\ L_{vp}^2}. \qquad (2.16)$$

The value of L_{vp} is determined by the size a_p of the pair of the quantum objects that take part in the exchange interaction and, according to Condition (2.10), the case $L_{vp} >> \lambda\!\!\!^{-}_q$ does not hold. Then the energy W_r of the interaction of the virtual photons created by the quantum objects of Cooper pairs or objects forming a σ – bond (and, consequently, the energy of the interaction of the quantum objects creating these virtual photons), on the basis of Eq. (2.16) may be determined by expression $W_r = 2\,\mu_B^2 U_q^2 / \left(\hbar^2 c^2 L_{vp}\right)$.

Let us consider the condition under which the energy W_r of the electric dipole-dipole interaction of the virtual photons may have the same order of magnitude as the energy of the exchange interaction of the quantum objects creating these virtual photons. As an example, the interaction of the electrons constituting the σ – bond in a hydrogen molecule is considered. Using the value of electron energy (Wichmann 1971) $U_q = 13.6$ eV, we find that W_r equals the energy of a σ – bond in a hydrogen molecule (4.5eV) at $L_{vp} \approx 10^{-15}$ cm. At the same time, the hydrogen atom electron wavelength $\lambda\!\!\!^{-}_q$ is $0.44 \cdot 10^{-8}$ cm. Thus, the calculated value L_{vp} is consistent with Condition (2.10), which evidences the overlapping of wave functions of electrons that constitute the σ – bond. Therefore, the energy of the dipole-dipole interaction of the virtual photons may have the same order of magnitude as the energy of the exchange interaction of the quantum objects creating the pairs if the distance between these quantum objects is less than the wavelength of their wave function.

Let us consider such effects as the disappearance of superconductivity at the critical value of electric current (that is, at the critical value of speed of motion of the electrons constituting the Cooper pairs), the disappearance of superfluidity at the critical value of speed of motion of superfluid medium, and the destruction of Cooper pairs and the σ – bond at their thermal motion while increasing the temperature. In all of these cases, the motion of the quantum objects that constitute a Cooper pair occurs in the same direction. That is, the quantum objects of a Cooper pair acquire their respective velocities, $\mathbf{y}_1$ and $\mathbf{y}_2$, such that

$$\mathbf{y}_1 = \mathbf{y}_2 = \mathbf{y}; \qquad (2.17)$$

the respective electric dipole moments $(\mathbf{d}_v)_1^{\mathbf{y}}$ and $(\mathbf{d}_v)_2^{\mathbf{y}}$ of the virtual photons created by these quantum objects are associated with these velocities. At $\mathbf{v}_1(\mathbf{v}_2) << c$, according to Eqs (1.50)–(1.51) and (2.17), $(\mathbf{d}_v)_1^{\mathbf{v}} \uparrow\uparrow (\mathbf{d}_v)_2^{\mathbf{v}}$. In this case, the electric dipole repulsive force acts between the virtual photons created by the quantum objects of a Cooper pair (Purcell 1965), which may lead to the destruction of the pair.

2.1.4. Transverse Optical Force

According to Eq. (1.15), the photon has an electric dipole moment d_{ph} equal to μ_B. Thus, the dipole-dipole interaction of photons may take place. Let us consider two photons having electric dipole moments $(\mathbf{d}_{ph})_1$ and $(\mathbf{d}_{ph})_2$, respectively, and electric components (polarizations) $(\mathbf{E}_{ph})_1$ and $(\mathbf{E}_{ph})_2$, respectively. According to the definition of the electric dipole moment of electric dipole and electric field inside it (Purcell 1965), we have $(\mathbf{E}_{ph})_1 \uparrow\downarrow (\mathbf{d}_{ph})_1$ and $(\mathbf{E}_{ph})_2 \uparrow\downarrow (\mathbf{d}_{ph})_2$. Consequently, at the relative orientation of the electric components of two photons as $(\mathbf{E}_{ph})_1 \rightarrow\rightarrow (\mathbf{E}_{ph})_2$, the attractive electric dipole-dipole force must act between these photons, and at the relative orientation of electric components of two photons as $(\mathbf{E}_{ph})_1 \rightarrow\leftarrow (\mathbf{E}_{ph})_2$, the repulsive electric dipole-dipole force must act between these photons. These features of the force acting between the photons are consistent with the experimentally observed properties of the transverse optical force $\mathbf{F}_{tof}$ acting between parallel beams of light: the beams of light displaced in phase are repulsive, and beams with the same phase are attractive (see Fig. 2-3) (Mo et al. 2008).

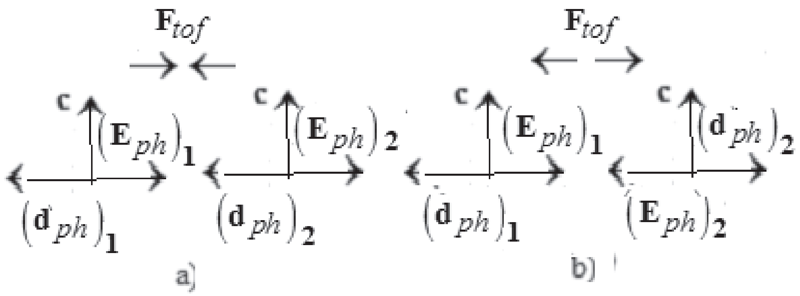


Fig. 2-3. The interacting light beams: $\left(\mathbf{d}_{ph}\right)_1$ and $\left(\mathbf{d}_{ph}\right)_2$ are electric dipole moments, $\left(\mathbf{E}_{ph}\right)_1$ and $\left(\mathbf{E}_{ph}\right)_2$ are electric components, **c** is the velocity of light, and $\mathbf{F}_{tof}$ is the transverse optical force; in variant (a) the force is attractive, while in variant (b) the force is repulsive.

Note. As the speed of photons (depending on the medium where they propagate) may be equal to the speed of the propagation of the electric force between the photons, the observed optical force may be a resulting force between beams of photons.

2.1.5. The Electric Interaction of Current-Carrying Wi res, with the Wires Neutral in the Absence of a Current

Between current-carrying wires (electrically neutral in the absence of electric current) not only a magnetic interaction takes place but also an electric interaction. The electric interaction arises due to the electric dipole interaction of the virtual photons (spin vortices) produced by moving charges in the current-carrying wires. According to Eqs (1.50)–(1.51) under Condition (1.48), a repulsive electric dipole-dipole force acts between the wires with currents in the same direction and an attractive electric dipole-dipole force acts between the wires with currents in different directions. Consequently, magnetic and electric forces between current-carrying wires (electrically neutral in the absence of electric current) are directed oppositely at any mutual orientation of the currents.

Let us estimate the electric dipole-dipole force $\mathbf{F}_{II}$ acting between the two current-carrying wires of unit length (Boldyreva 2012b). To this end, let us estimate the total electric dipole moment $\mathbf{d}_I$ of the wire with current **I**. The value $\mathbf{d}_I$ is determined to be $\mathbf{d}_I = k_I \mathbf{d}_v$, where $\mathbf{d}_v$ is the electric dipole moment of virtual photon created by a quantum object and k_I is determined to be $k_I = I/(uq_I)$ (q_I is the value of charge of carrier of current and u is the speed of the carrier; the cross-section of wires is determined by the size of the virtual photon created by current carrier). Taking Eq. (1.46) and Eqs (1.50)–(1.51) under Condition (1.48) into account, we obtain

$$\mathbf{d}_I = -\frac{\mathbf{I}\mu_B}{2q_I c}. \tag{2.18}$$

Using Eq. (2.18), the electric dipole-dipole force F_{II} emerging between two parallel current-carrying wires of unit length with equal currents I will be determined to be

$$F_{II} = \frac{3d_I^2}{L_{II}^4} = \frac{3\mu_B^2 I^2}{4q_I^2 c^2 L_{II}^4}, \tag{2.19}$$

where L_{II} is the distance between the current-carrying wires and L_{II} is greater than the length of the wires.

Let us compare F_{II} with the force F_{mm} of the magnetic interaction (per unit length of wire) of two parallel wires with currents created by moving electrons: that is, $q_I = e$. Using the expression for $F_{mm} = 2I^2 / \left(c^2 L_{II}\right)$ and Eq. (2.19), we obtain: $F_{II} / F_{mm} = 3\mu_B^2 / \left(8e^2 L_{II}^3\right) \approx 140 \cdot 10^{-24} / L_{II}^3$ (in the CGS system of units). Consequently, at $L_{II} < 5 \cdot 10^{-8}$cm the electric dipole-dipole force F_{II} between wires with a current created by moving electrons is greater than the magnetic force F_{mm} between them.

Surely, the derived value for L_{II} is rather approximate, since the interactions of per unit length of wire of different types of wires are compared: wires of unit length in the electric interaction and wires of infinite length in the magnetic interaction.

2.2. Interaction by Spin Supercurrent

2.2.1. The Characteristics of the Spin Supercurrent

The first attempt to describe the phenomenon of long transport of spin polarization (spin supercurrent) was made by Vuorio (Vuorio 1976). In the following years the spin supercurrent was studied in experiments with superfluid ^{3}He-B by Borovic-Romanov, Bunkov, Dmitriev, Fomin et al. (Borovic-Romanov et al. 1989, Bunkov 2009, Dmitriev and Fomin 2009). In these experiments, a spin supercurrent occurred between regions with identically oriented and coherently precessing spins of ^{3}He atoms. Let us consider the features of a spin supercurrent.

1) The value of a spin supercurrent is determined by the following characteristics of the precession of spins of the spin structures between which the supercurrent arises: the mutual orientation of their precession frequencies, precession angles

(angles [phases] of precession) α, and deflection angles (angles of deflection) β. For example, the value of a spin supercurrent $(I_{ss})_z$ in the direction of the orientation (axis *z*) of the precession frequencies of the ^{3}He atoms' spins in superfluid ^{3}He-B is determined to be

$$(I_{ss})_z = -g_1 \partial\alpha / \partial z - g_2 \partial\beta / \partial z \,, \qquad (2.20)$$

where g_1 and g_2 are coefficients depending on β and the properties of the superfluid.

2) Since a spin supercurrent is a process that equalizes the spin part of the parameter order in the quantum liquid described by single wave function (particularly, in superfluid ^{3}He-B), the spin supercurrent must be a dissipation-free process.

3) The spin supercurrent tends to equalize the respective characteristics of the spins of interacting spin structures (see Fig. 2-4):

$$|\alpha_1 - \alpha_2| \ge |\alpha_1' - \alpha_2'| , \qquad (2.21)$$

$$|\beta_1 - \beta_2| \ge |\beta_1' - \beta_2'| , \qquad (2.22)$$

where α_1 and α_2 are the values of the precession angles of the spins of interacting spin structures before the action of the spin supercurrent; α_1' and α_2' are the values of the precession angles of the structures' spins after the action of the spin supercurrent; β_1 and β_2 are the values of the deflection angles of the spins of the interacting spin structures before the action of the spin supercurrent; β_1' and β_2' are the values of the deflection angles of the structures' spins after the action of the spin supercurrent.

4) As a result of the spin supercurrent action, a change in the spin precession frequencies of interacting spin structures may take place. Let us prove it using the example of two spin structures in Fig. 2-4. The spins of these structures precess with frequencies ω_1 and ω_2.

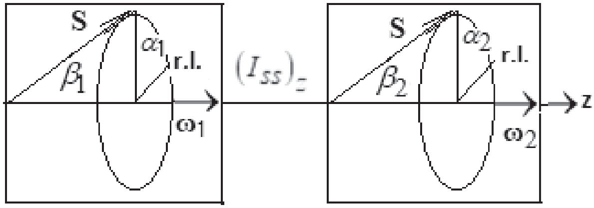


Fig. 2.4. The schema of spin structures. $(I_{ss})_z$ is a spin supercurrent between spin structures with the following characteristics: α_1 and α_2 are the precession angles; β_1 and β_2 are the deflection angles, $\boldsymbol{\omega}_1$ and $\boldsymbol{\omega}_2$ are the precession frequencies oriented along axis z, **S** is spin, and r.l. is a reference line.

Assume that before the action of spin supercurrent the precession angles α_1 and α_2 of the spins of these structures are associated with the respective precession frequencies ω_1 and ω_2 (ω_1 and ω_2 are independent of time *t*) as follows:

$$\alpha_1 = \omega_1 t + \alpha_{01}, \tag{2.23}$$

$$\alpha_2 = \omega_2 t + \alpha_{02}, \tag{2.24}$$

where α_{01} and α_{02} are the values of the precession angles at $t = 0$. The changes in precession angles α_1 and α_2 as a result of the action of the spin supercurrent at arbitrary moment *t* may result in changes of the precession frequencies of the spins of interacting spin structures. That is, according to Eqs (2.21) and (2.23)–(2.24), the following may take place:

$$\left|\omega_1 - \omega_2\right| > \left|\omega_1^{'} - \omega_2^{'}\right|, \tag{2.25}$$

where $\omega_1^{'}$ and $\omega_2^{'}$ are the precession frequencies of interacting spin structures' spins after the action of the spin supercurrent. The changes in frequencies ω_1 and ω_2 ($\Delta\omega_1$ and $\Delta\omega_2$) are, accordingly,

$$\Delta\omega_1 = \omega_1^{'} - \omega_1, \tag{2.26}$$

$$\Delta\omega_2 = \omega_2^{'} - \omega_2. \tag{2.27}$$

Let us consider such spin structures as spin vortices. According to Eq. (1.2) for the photon and Eqs (1.32)–(1.33) for the virtual photon, the energy of the spin vortex associated with the precessing spin is proportional to the frequency of its precession. Consequently, the changes in the frequencies of the precession, $\Delta\omega_1$ and $\Delta\omega_2$, of the spin vortices result in changes, ΔU_1 and ΔU_2, of their energies: that is,

$$\Delta U_1 = S \cdot \Delta\omega_1 \ , \tag{2.28}$$

$$\Delta U_2 = S \cdot \Delta\omega_2 \ , \tag{2.29}$$

where *S* is the spin of spin vortex in the spin structure.

Since the spin supercurrent is a dissipation-free process then, for spin vortices that constitute photons, with due account for the principle of energy conservation, the following holds: $\Delta U_1 = -\Delta U_2$. Then, according to Eqs (2.28)–(2.29),

$$\Delta\omega_1 = -\Delta\omega_2. \tag{2.30}$$

Let us return to Eq. (2.21) and introduce the following notations: $\Delta\alpha_1 = \alpha_1^{'} - \alpha_1$ and $\Delta\alpha_2 = \alpha_2^{'} - \alpha_2$. Taking Eqs (2.23)–(2.24) and (2.30) into account, we obtain the following for photons interacting by means of a spin supercurrent:

$$\Delta\alpha_1 = -\Delta\alpha_2 . \tag{2.31}$$

With regard to virtual photons, the values of their characteristics are determined not only by the action of the spin supercurrent but also by the properties of the quantum objects creating these virtual photons. Therefore, equalities (2.30) and (2.31) may not hold for virtual photons.

5) At a definite difference $\Delta\alpha_c = \alpha_1 - a_2$ in the precession phases of the spins of interacting spin structures, a precession phase slippage (drop) takes place. The critical spin supercurrent $\left(I_{ss}\right)_z^c$ corresponds to the value $\Delta\alpha_c$. Fig. 2-5 shows the character of the dependence of the spin supercurrent between two spin structures with respective precession frequencies ω_1 and ω_2 on the hypothetical difference in the precession angles, $\Delta\varphi$, which is determined to be $\Delta\varphi = \left(\omega_1 - \omega_2\right)t$. Up to the value of $\Delta\varphi$ equal to $\Delta\alpha_c$, the hypothetical difference in the precession angles is equal to the precession angles difference $\Delta\alpha$ ($\Delta\varphi = \Delta\alpha$) determining the spin supercurrent according to Eq. (2.20). We assume that at t=0 $\Delta\alpha = 0$.

In Fig. 2-5, the line *a–b* corresponds to the change in the supercurrent in the process of phase slippage. Variants (a) and (b) correspond to two cases of changes in spin supercurrent during the precession phase slippage: with a change in the sign and without a change in the sign. $\left(I_{ss}\right)_z^{ps}$ is the residual current (after phase slippage).

As a result of phase slippage, a drop in the value and a change in the sign of spin supercurrent may take place. Consequently, Eq. (2.20) holds true in the absence of phase slippage.

According to Eqs (2.23)–(2.24), the possibility of phase slippage is negligible (without taking into account the difference $|\alpha_{01}-\alpha_{02}|$) if the difference $\Delta\omega$ between the precession frequencies of the spins in the interacting spin structures satisfies the following:

$$\Delta\omega \to 0 . \tag{2.32}$$

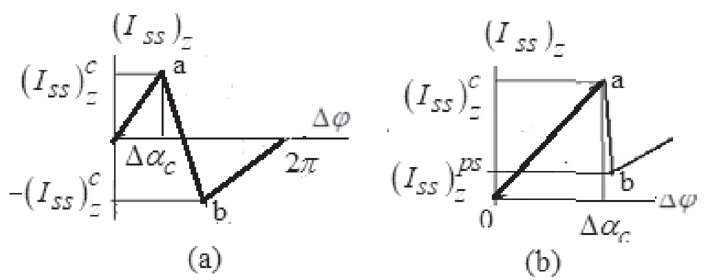


Fig. 2-5. The character of the dependence of the spin supercurrent $(I_{ss})_z$ between two spin structures on the hypothetical difference in the precession angles $\Delta\varphi$. $(I_{ss})_z^c$ is the critical spin supercurrent. The line *a–b* corresponds to the phase slippage; $(I_{ss})_z^{ps}$ is the residual current; and $\Delta\alpha_c$ is the phase difference at which the phase slippage takes place.

6) The effectivity of the action of the spin supercurrent between the spin structures does not depend on the distance between them. For example, the region of the action of spin supercurrent in superfluid ^{3}He-B is only limited by the volume of the superfluid.

7) According to relations (2.21–2.22), and as a result of the action of the spin supercurrent, a “transfer” of the precession and the deflection angles of spin from one spin structure to another takes place: in other words, it can be said that the spin supercurrent performs a “transfer” of the angular momentum

in space. According to equality (1.23), the "motion" of the angular momentum in the physical vacuum (and, consequently, the spin supercurrent) is a dissipation-free process (see also property 2 above). This suggests that the spin supercurrent is not accompanied by emergence of mass, that is, it is *an inertia free process*, and, consequently, the speed of the spin supercurrent y_{SS} may be greater than the speed of light:

$$y_{SS} > c\,. \tag{2.33}$$

This expression does not contradict experimental data that only demonstrate the speed limit of inertial systems.

8) The spin supercurrent is not an electric or magnetic process and, consequently, it is not screened by electromagnetic and, possibly, the molecular screens.

2.2.2. The Properties of Quantum Correlations

Quantum correlations belong to the category of phenomena that are collectively called "quantum non-locality". The essence of the phenomenon can be described using the following example. Let two quantum objects (Fig. 2-6) ***a*** and ***b***, which are emitted by the same source and have the same wave function at the initial moment of time, move in different directions.

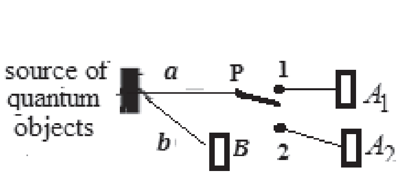


Fig. 2-6. Schematic diagram of the experiment that illustrates the quantum correlations between quantum objects. ***a*** and ***b*** are quantum objects; A_1, A_2, and B are detectors; and P is a switch with positions 1 and 2.

Object ***a*** is directed, depending on the position (1 or 2) of switch *P*, towards either detector A_1 or detector A_2 (these detectors have different characteristics), while object ***b*** is directed towards detector *B*. According to the postulates of quantum mechanics, the properties of object ***b*** being detected will depend on which detector detects ***a***.

Let us consider the properties of quantum correlations and compare them with the properties of spin supercurrent (Boldyreva 2014b).

1) *Correlations take place between quantum objects of zero or non-zero rest mass.*

In the experiments showing quantum nonlocality, quantum objects with both zero and non-zero rest mass were used. Both types of objects produce spin vortices in a physical vacuum. This allows one to suppose that quantum correlations take place between spin vortices.

It follows from this supposition that quantum correlations may not take place between quantum objects producing groups of spin vortices with total zero spin in the physical vacuum. For example, there will be no quantum correlations in superconductors between Cooper pairs because the total spin of the virtual photons created by the quantum objects of the Cooper pair equals zero (see Section 9.1).

2) *Correlations do not only take place between quantum objects at the moment of the simultaneous registration of the objects.*

Experimentally, it is verified that correlations between two quantum objects may take place when one quantum object is detected and another quantum object is still in the physical vacuum (Belinskii 2003). It may mean that the quantum correlations between the quantum objects are performed by a process in the physical vacuum.

3) *Correlations take place both between "entangled" quantum objects (which may be generated using an atomic*

cascade, for example) and between photons of the same frequency emitted by different sources (Klyshko 1994). *It is an empirical fact that photons with crossed polarization do not correlate.*

The main properties of "entangled" quantum objects are equal values of wave function frequencies and the non-arbitrary mutual orientation of the frequencies. In the model proposed in this work, the wave function frequency of the quantum object equals the precession frequency of the spin of the spin vortex created by this object. Therefore, photons (which are spin vortices in the physical vacuum) with equal frequencies and without crossed polarization are essentially also "entangled" quantum objects.

The considered conditions of the emergence of quantum correlations are in accordance with the conditions of the effective action of the spin supercurrent. The requirement of equality of the wave function frequencies of "entangled" quantum objects is in accordance with property 5 of the spin supercurrent (Eq. [2.32]). The requirement of the definite mutual orientation of these frequencies is in accordance with the definition of the spin supercurrent (Eq. [2.20]).

4) *Correlations take place independent of the distance between the interacting spin structures* (Tittel et al. 1998, Ren et al. 2017).

This property is in accordance with property 6 of the spin supercurrent (Section 2.2.1): the latter may arise between spin structures independent of the distance between them.

5) *The speed of quantum correlations is greater than the speed of light; this follows from the possibility of the correlations of photons separated in space and simultaneously emitted.*

Experiments exist (Scarani et al. 2000) in which it is shown that the speed of quantum correlations is greater by a factor of 10^4 than the speed of light.

This property is in accordance with property 7 of the spin supercurrent: Condition (2.33).

6) *It follows from experiments that quantum correlations are of a non-electric and non-magnetic nature.*

This property is in accordance with property 8 of the spin supercurrent (Section 2.2.1): the spin supercurrent is not screened by electromagnetic screens.

7) *The relations between the characteristics of light fields in experiments on quantum correlations are similar to the relations between changes in the values of the respective characteristics of interacting spin structures under the action of a spin supercurrent.*

Let us demonstrate this using the example of two-photon interference (Klyshko 1994). Fig. 2-7 shows a diagram of an experimental setup where two beams of light undergo phase delays. Fields γ_1 and γ_2 of frequency ω_γ and also fields b_1 and b_2 of frequency ω_b are mixed by respective beam splitters. The detectors and coincidence circuit measure the correlation of intensities. The observed anticorrelation and correlation of the intensities of output fields γ and b depend periodically on phase delays ϑ_1 and ϑ_2.

Depending on the statistics of the incident beams of light, two types of interference may take place: one with phase $\vartheta_1 - \vartheta_2$; the other with phase $\vartheta_1 + \vartheta_2$. The first interference is referred to as the Brown and Twiss intensity interference, and the second one is called the two-photon interference. Under definite conditions, both types of interference are a result of conversion by beam splitters of the phase fluctuations of input fields into the intensity fluctuations of output fields.

What are the conditions? Let fields γ_k and b_k (k=1, 2) have constant unit amplitudes and phases which drift with time t: $\gamma_k(t) = \exp\left[-ix_k(t)\right]$, $b_k(t) = \exp\left[-iy_k(t)\right]$.

The condition for the first type of interference of intensities is determined by equalities, $x_1 = y_1$ and $x_2 = y_2$.

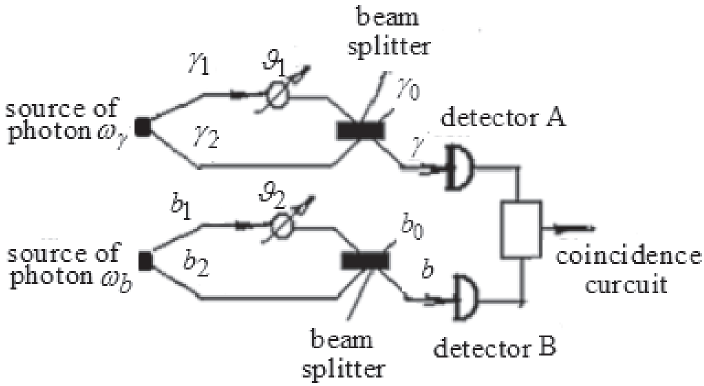


Fig. 2-7. A diagram of a four-mode intensity interferometer. γ_1, γ_2, b_1, and b_2 are input beams of light; ϑ_1 and ϑ_2 are phase delays of light beams; ω_γ is the frequency of beams γ_1 and γ_2; ω_b is the frequency of beams b_1 and b_2. The detectors and coincidence circuit measure the correlation of intensities.

The condition for the second type of interference of intensities is as follows:

$$x_1 + y_1 = x_2 + y_2, \tag{2.34}$$

that is, fluctuations of light beam phases occur in such a way that the sum of the phases remains constant.

These two conditions can be called the condition of the correlation and the condition of the anticorrelation of phases, respectively. Condition (2.34) holds, for example, when using nondegenerate parametric oscillators, whose signal wave and idler wave phases (as well as the frequencies) drift in opposite directions. That is, for the changes in the phase of field γ, Δx, and in the phase of field *b*, Δy, the following is valid:

$$\Delta x = -\Delta y \quad . \tag{2.35}$$

The obtained relations (2.35) between changes in phases of light fields are similar to the relation (2.31) between changes in the values of the angles (phases) of the precessing spins of photons under the action of a spin supercurrent. The frequencies of beams (ω_γ and ω_b) in the experiment on the two-photon interference, as well as the phases drift in opposite directions, which is in accordance with Condition (2.30) of the fourth property of the spin supercurrent. (It should be mentioned that Eq. [2.30] holds true for photons.)

Thus, the above properties of quantum correlations between quantum objects can be explained on the basis of the properties of spin supercurrents arising between the spin vortices created by interacting quantum objects in the physical vacuum. Consequently, it may be supposed that quantum correlations between quantum objects are accomplished by a spin supercurrent.

2.3. Transmutation of the System of Chemical Elements

A system of chemical elements contains quantum objects: protons, neutrons, and electrons. According to the postulates of quantum mechanics, these quantum objects produce virtual photons (spin vortices) in the physical vacuum. Spin supercurrents may arise between the virtual photons. According to Eqs (2.21)–(2.22) and (2.25), as a result of the action of a spin supercurrent the precession frequencies, the angles of the precession and deflection of virtual photons created by the quantum objects change. The change in the spins' orientation influences (according to Condition [1.41] and Eq. [1.47]) the spin-orbit interaction and, consequently, the energy of the quantum objects creating these virtual photons. The change in the frequency of the precession of spins of the virtual photons also means (according to Eqs [1.32–1.33]) a change in the energy of the quantum objects.

The change in the energy of quantum objects constituting, for example, an atom, may result in the following phenomena: the emission of electromagnetic radiation; the ionization of the atom (if the quantum object is an electron); the electron-proton annihilation and as a result of that a change in the charge of the nucleus and, consequently, a change in the type of atom.

The spin supercurrents arising between the virtual photons created by a system of chemical elements may be accompanied by the generation of energy in the physical vacuum (see Section 7.1).

From the properties of the spin supercurrent it follows:

1) A spin supercurrent may not arise between quantum objects creating spin vortices having total zero spin (for example, between Cooper pairs, as the spin vortices created by quantum objects constituting the pair have total zero spin, see Section 9.1). The most probable is the emergence of a spin supercurrent in substances that have “free” quantum objects, such as in metals containing “free” electrons.

2) According to the data of Section 7.1.2, spin supercurrents may arise in a nonlinear rotating magnetic field and, consequently, the probability of the generation of energy in a system of chemical elements increases in the magnetic field of that type.

3) Since the spin supercurrent is not screened by a substance, it is difficult to localize it in the part of a reactor where the system of chemical elements under study is placed.

4) As the characteristics of spin supercurrent depend on the form of spin structures where it arises (see Section 6.1), the form of the atoms influences the probability of the emergence of transmutation of the system of chemical elements.

The above features of transmutation of the system of chemical elements are in accordance with the experimental data. For example, the emergence of optical radiation, a change in the elemental and isotopic composition of the complex of reacting chemical elements, and abnormally high heat release are observed in experiments on the saturation of nickel by hydrogen (Focardi et al. 1994, Battaglia et al. 1999, Parkhomov et al. 2017). The anomalous great liberation of heat was also obtained in the saturation of nickel by hydrogen with the addition of lithium (Levi 2014). Some of the above-mentioned phenomena are observed in zones adjacent to the active zones of reactors.

Note. It cannot be excluded that abnormally high heat release in the transmutation of the system of chemical elements is connected with the form of reacting substances as well; hydrogen, nickel, and lithium as simple substances have a cavity structure: hexagonal lattice in hydrogen, and cubical lattice in nickel and lithium.

2.4. Pseudomagnetism

Let us consider the following phenomena.
1) In the motion of neutrons and protons in a substance with the polarized spins of nuclei and in the motion of electrons in a substance with the polarized spins of substance's electrons, a precession of spins of moving quantum objects relative to the direction of substance's spin polarization takes place. The magnetic field does not affect this interaction, and the energy of the latter exceeds the energy of magnetic interaction more than thousand times. This interaction is called a pseudomagnetic interaction (Abragam and Goldman 1983, Pokazaniev and Skrotskii 1979).
2) Ferromagnetism is caused by the formation of domains with spins of electrons oriented in one direction. Studies have shown that the ordered orientation of spins in domains is due

to a specific type of interaction: in (Pokazaniev and Skrotskii 1979) this interaction is referred to as pseudomagnetic interaction, and in (Stephenson 1973) as an exchange interaction. The energy of this interaction between electrons may be a thousand times greater than the energy of the magnetic interaction between them.

3) When passing light through a magnetized medium (that is, through a medium with oriented spins), light polarization twisting may take place. 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). This phenomenon is called the Faraday effect and it is not a magnetic effect (Richardson and Riehl 1977). It is supposed that the Faraday effect is caused by the pseudomagnetic interaction between the spins of photons, on the one hand, and the oriented spins of the medium's electrons, on the other (Pokazaniev and Skrotskii 1979).

Let us consider the common features of all considered cases.

1) All objects which take part in a pseudomagnetic interaction are quantum objects with spin. They create spin vortices in the physical vacuum.

2) The interacting quantum objects are of the same "nature": for example, all of them are either nucleons or leptons. It is possible that interacting objects must have similar energy characteristics (particularly, similar values of the precession frequencies of spins of the spin vortices created by interacting quantum objects).

3) The interaction influences the mutual orientation of the spins of interacting spin structures.

4) The character of a pseudomagnetic interaction is, in many aspects, analogous to that of magnetic interaction, which is why the interaction is called "pseudomagnetic". However, the energy of this interaction is a thousand times greater than the

energy of a magnetic interaction and the magnetic field does not influence it.

These properties are analogous to the properties of spin supercurrent: (1) the spin supercurrent arises between quantum objects with spin; (2) according to Eqs (1.2), (1.32)–(1.33), and (2.32), the maximum effect takes place for quantum objects of equal energies; (3) it influences the mutual orientation of the spins of interacting spin vortices, see Eqs (2.21)–(2.22); and (4) in many ways, the character of a spin supercurrent is analogous to that of magnetic moment acting on a magnetic dipole.

Therefore, the properties of a spin supercurrent are consistent with the properties of a pseudomagnetic interaction: that is, spin supercurrents may be considered to be belonging to pseudomagnetic interaction.

Based on the analogy between magnetic and pseudomagnetic interactions, we may suppose that pseudomagnetic interaction includes not only a moment acting on spins (spin supercurrent) but a force $\mathbf{F}_{pm}$ acting on spins as well, which is also dependent on their mutual orientation.

Taking into account the features of magnetic dipole-dipole interaction of two electrons or two positrons, or an electron with a positron, we may suppose the following. If spins $\mathbf{S}_1$ and $\mathbf{S}_2$ of any objects are oriented along one straight line: that is,

$$\mathbf{S}_1 \rightarrow\rightarrow \mathbf{S}_2 \,, \tag{2.36}$$

F_{pm} is determined to be

$$F_{pm} = \left|\phi_{pm}(S_1, S_2)\right| q_1 q_2 / \left|q_1 q_2\right| , \tag{2.37}$$

where $\phi_{pm}\left(S_1, S_2\right)$ is a function of the characteristics of the spin of interacting quantum objects; q_1 and q_2 are the electric charges of interacting objects with due regard for their signs. If $F_{pm}>0$, the force is attractive, but if $F_{pm}<0$, the force is repulsive.

It is possible that the creation of mass and the electric dipole moment in a spin vortex is performed by force $\mathbf{F}_{pm}$ connected with the spin of the spin vortex; and Condition (2.36) is satisfied due to the action of spin supercurrent.

CHAPTER THREE

OPTICS OF MOVING BODIES

One of the main problems studied by physicists from the beginning of the 20th century is the problem of the dragging of light by moving bodies. Experimental data obtained during the last 100 years testify that only partial dragging is possible. Special relativity (SR) explained the results of these experiments introducing a model of four-dimensional pseudo-Euclidian space with metrics $ds^2 = \sum_{i=1}^{3} x_i^2 - c^2 dt$ (x_i is a coordinate, c is the speed of light, t is time). The principle of constancy of the speed of light was introduced in SR, which states "in all *inertial systems* the velocity of light has the same value when measured with length–measures and clocks of the same kind" (Einstein 1905, Born 1962).

In this work, an explanation of experimental data is proposed in the framework of the three-dimensional Euclidean space model with metrics $ds^2 = \sum_{i=1}^{3} x_i^2$: that is, without linking space and time together. The explanation takes the interaction of photons with the detecting inertial system into account. Three aspects of the interaction are discussed: 1) the equalization of the speed of light in an inertial system; 2) the transformation of energy; and 3) the duration of the interaction.

3.1. The Equalization of the Speed of Light in an Inertial System

In 1908, Walter von Ritz suggested “that the motion of light is a relative motion like all the others; that only relative velocities play a role in the laws of nature" (Gillispie 1975). Ritz kept the two homogeneous Maxwell’s equations intact, but modified the equations involving the sources in such a way that the speed of light was equal to *c* only when measured relative to the source. The so-called *Ritz emission theory* is in accordance with the observation for the aberration of star positions, the Fizeau experiment, the original Michelson–Morley experiment, and also most of the other experiments carried out to determine the "ether wind" (Ritz 1908). It is customary, however, to cite the Michelson–Morley experiments performed with an extraterrestrial light source (sun or star light) and light from binary stars as they rule out Ritz's theory (Jackson 1999). There were attempts to prove the consistency of Ritz's theory using P. Ewald (1912) and C. Oseen’s (1915) extinction theorem (Enders 2011); the most important contribution in this respect was made by J. Fox (Fox 1965). The theorem states that if an incident electromagnetic wave traveling at speed *c* appropriate to vacuum enters a dispersive medium, its fields are cancelled by part of the fields of the induced dipoles (macroscopically by the polarization ***P***) and replaced by another wave propagating with a phase velocity characteristic of the medium. The incident wave is extinguished by interference and replaced by another. The motion of the source and the speed of light relative to it are irrelevant in this theorem.

There are, however, some experiments that are not explained by the extinction theorem. The experiment performed at CERN, Geneva, in 1964 (Alvager and Barley 1964) is considered to provide the most convincing evidence against the Ritz theory. In this experiment, the speed of 6 GeV photons produced in the decay of very energetic neutral pions was measured by the flight time over paths up to 80 meters. The pions were produced by the bombardment of a beryllium target with 19.2 GeV protons and they had speeds (which were inferred from the measured speeds of charged pions produced in the same bombardment) of 0.99975c. Within experimental error, it was found that the speed of the photons emitted by the extremely rapidly moving source was equal to *c*.

The extinction theorem, in which the interaction of a photon and a medium takes place by means of the magnetic and electric components of a photon, does not explain the results of the experiment. The equalization of the speed of light found in the experiments indicates the existence of some other additional interaction. Taking into account the creation of spin vortices by quantum entities, the extinction theorem must be extended by considering the interaction of a spin vortex that constitutes the photon and the spin vortices created by quantum objects that constitute the inertial system and determine its inertial properties (Boldyreva 2017c). It is necessary also to take into account the change (in the direction of motion **u**, see Eq. [1.55]) in the projection of the spin of virtual photons created by those quantum objects.

Note. It follows from the above that the process which does not create spin vortices in the physical vacuum, i.e. does not interact with the spin vortices created by quantum objects that constitute the inertial system, may propagate at a speed greater than the speed of light. In particular, the spin supercurrent may be such a process, as it emerges between *spin vortices but does not create them (see Section 2.2.1).*

3.2. The Transformation of Photon Energy in an Interaction with an Inertial System

3.2.1. The Derivation of an Equation for Energy Transformation Based on Photon Properties

The energy U_{ph} of the detected photon may be represented not only as the energy of the precessing spin (Eq. [1.2]) but also as the energy of the kinetic mass m_{ph} of the photon. In this case, the photon energy can be represented by two terms. The first term is the kinetic energy of the translational motion of the center of mass, in which all of the mass m_{ph} is assumed to be contained. The second term is the energy of the circular motion of the mass m_{ph} caused by the precession motion of the photon's spin. The energy of the detected photon where the source and detector of photon are immobile to each other is determined by Eq. (1.21). If the detector of the photon moves relative to the source at speed *v*, then, using Eq. (1.21), the energy of detected photon U_{ph} may be expressed as

$$U_{ph} = \frac{\hbar\omega_{ph}(\mathbf{c}+\mathbf{v})^2}{2\cdot c^2} + \frac{\hbar\,\omega_{ph}}{2}, \qquad (3.1)$$

where ω_{ph} is the frequency of photon irradiated by the source. Eq. (3.1) may be considered to be a formula for the transformation of the photon energy from one inertial frame to another moving relative to the first one at velocity **v** (Boldyreva 2017c).

The expression (3.1) may be deduced not only from the corpuscular model of a photon but also from the principles of conservation (Boldyreva and Sotina 2003).

3.2.2. The Derivation of an Equation for Energy Transformation using the Principles of Conservation

Consider an inertial frame of reference linked to the detector, where the source of the light of mass M is moving at velocity $\mathbf{v}$. The source of light is assumed to be at rest with respect to the Earth. The energy of the source is composed of the kinetic energy $Mv^2/2$ and the internal energy W_0 of the excited atoms. When a photon is emitted by an atom, the internal energy of the source changes and becomes equal to W_1. Besides, the source recoils because of the emission pressure; its velocity gains an increment of $\mathbf{v}_1 - \mathbf{v}$ ($\mathbf{v}_1$ is the velocity of the source after the emission of the photon). From the principles of conservation of energy and momentum for the photon and source, it follows that

$$\frac{Mv^2}{2} + W_0 = \frac{\left(M - m_{ph}\right)v_1^2}{2} + W_1 + U_{ph}, \tag{3.2}$$

$$M\mathbf{v} = \left(M - m_{ph}\right)\mathbf{v}_1 + m_{ph}\left(\mathbf{c} + \mathbf{v}\right), \tag{3.3}$$

where m_{ph} is the kinetic mass of the emitted photon; U_{ph} is the energy of the detected photon. Taking into account that $\hbar\omega_{ph} = W_0 - W_1$, where ω_{ph} is the frequency of emitted photon, from (3.2) and (3.3) we obtain the following:

$$\begin{aligned} U_{ph} - \hbar\omega_{ph} &= \frac{Mv^2}{2} - \frac{\left(M\mathbf{v} - m_{ph}\left(\mathbf{c} + \mathbf{v}\right)\right)^2}{2\left(M - m_{ph}\right)} \\ &= \frac{m_{ph}v^2 + 2m_{ph}\left(\mathbf{c}\cdot\mathbf{v}\right) - m_{ph}^2\left(\mathbf{c} + \mathbf{v}\right)^2 / M}{2\left(1 - m_{ph}/M\right)}. \end{aligned} \tag{3.4}$$

If $M >> m_{ph}$, the terms containing m_{ph} / M may be neglected. In this approximation, Eq. (3.4) is transformed as follows:

$$U_{ph} = \hbar\omega_{ph} + m_{ph}(\mathbf{c} \cdot \mathbf{v}) + m_{ph}v^2 / 2. \qquad (3.5)$$

From experiments (see also Eq. [1.13]), it follows that $m_{ph} = \hbar\omega_{ph} / c^2$; then Eq. (3.5) may be written in the following form: $U_{ph} = \hbar\omega_{ph}(\mathbf{c} + \mathbf{v})^2 / \left(2 \cdot c^2\right) + \hbar\omega_{ph} / 2$. This expression for U_{ph} coincides with Eq. (3.1), which is derived on the basis of the concept that the photon is a spin vortex.

The interaction of a photon with a detector (measuring system)

It is experimentally established (for example, in the photoelectric effect) that the absorption of light occurs in quanta of energy $\hbar\omega_d$, where ω_d is the frequency of the light being detected (Compton 1923). If the mass of the detector, as well as the mass of the source, are great, the motion of the detector due to the pressure of light is negligible; therefore, the energy loss for the photon may also be neglected. Then, in the interaction of the photon and the detector, all of the energy U_{ph} of the photon in the inertial frame is equal to the detected energy $\hbar\omega_d$: that is, $U_{ph} = \hbar\omega_d$. Thus Eq. (3.1) can be written as

$$\hbar\omega_d = \frac{\hbar\omega_{ph}(\mathbf{c} + \mathbf{v})^2}{2 \cdot c^2} + \frac{\hbar\omega_{ph}}{2}. \qquad (3.6)$$

3.2.3. Longitudinal and Transverse Doppler Effects

Consider an inertial frame of reference fixed relative to the detector, where the source of light is moving at velocity **v** (Boldyreva and Sotina 2003, Boldyreva 2012b and 2017c). The source of light is assumed to be at rest with respect to the Earth and, according to the experimental data, the speed of light relative to the source is equal to *c*. To determine the frequency ω_d, Eq. (3.6) is used where ω_{ph} is the photon frequency in the frame of the source of the photons. Let us introduce vector **w**, directed from the source to the detector, $\mathbf{w} = \mathbf{c} + \mathbf{v}$, then Eq. (3.6) can be expressed as

$$\hbar\omega_d = \hbar\omega_{ph}\left(\frac{(\mathbf{w})^2}{2c^2} + \frac{1}{2}\right). \qquad (3.7)$$

Quantity w/c can be derived from the following equation: $c^2 = (\mathbf{w} - \mathbf{v})^2 = w^2 + v^2 - 2wv\cos\vartheta_{wv}$ (ϑ_{wv} is the angle between vectors **w** and **v**). Dividing both sides of this equation by c^2 and denoting

$$\beta_c = v/c \qquad (3.8)$$

we obtain $(w/c)^2 - (w/c)2\beta_c\cos\vartheta_{wv} - (1-\beta_c^2) = 0$. Solving this equation relative to w/c we obtain,

$$\begin{aligned} w/c &= \beta_c\cos\vartheta_{wv} \pm \sqrt{1-\beta_c^2\sin^2\vartheta_{wv}} \\ &= \sqrt{\beta_c^2 - \beta_c^2\sin^2\vartheta_{wv}} \pm \sqrt{1-\beta_c^2\sin^2\vartheta_{wv}} \end{aligned}.$$

Taking into account that $w/c > 0$, we obtain only one solution: $w/c = \beta_c\cos\vartheta_{wv} + \sqrt{1-\beta_c^2\sin^2\vartheta_{wv}}$. Using Eq (3.7), we have:

$$\omega_d = \omega_{ph}\left(1+\beta_c \cos\vartheta_{wv}\cdot\left(\beta_c \cos\vartheta_{wv} + \sqrt{1-\beta_c^2 \sin^2\vartheta_{wv}}\right) - \beta_c^2/2\right). \tag{3.9}$$

To an accuracy of β_c^3, the expression for ω_d may be written as

$$\omega_d = \omega_{ph}\Big(1+\beta_c \cos\vartheta_{wv} + \beta_c^2 \cos^2\vartheta_{wv} - \beta_c^2/2 - \beta_c^3 \cos\vartheta_{wv}/2 + \beta_c^3 \cos^3\vartheta_{wv}/2 + o\left(\beta_c^3\right)\Big), \tag{3.10}$$

where $o\left(\beta_c^3\right)$ are summands of a higher order of smallness than β_c^3. Eq. (3.10) coincides accurate to β_c^2 inclusive with the equation describing the Doppler effect in SR (Born 1962):

$$\omega_d = \omega_{ph}\frac{\sqrt{1-\beta_c^2}}{1-\beta_c \cos\vartheta_{wv}} = \omega_{ph}\Big(1+\beta_c \cos\vartheta_{wv} + \beta_c^2 \cos^2\vartheta_{wv} - \beta_c^2/2 - \beta_c^3 \cos\vartheta_{wv}/2 + \beta_c^3 \cos^3\vartheta_{wv} + o\left(\beta_c^3\right)\Big).$$

From Eq. (3.9) at $\cos\vartheta_{wv} = 0$, the transverse effect of Doppler follows $\omega_d = \omega_{ph}\left(1-\beta_c^2/2\right)$, while at $\cos\vartheta_{wv} = 1$ or $\cos\vartheta_{wv} = -1$ the longitudinal effect of Doppler follows: $\omega_d = \omega_{ph}\left(1+\beta_c+\beta_c^2/2\right)$ or $\omega_d = \omega_{ph}\left(1-\beta_c+\beta_c^2/2\right)$, respectively.

Note. In the above case, the source of the light is at rest relative to the Earth. However, Eq. (3.9) will not change if the source moves with respect to the Earth and the photon speed is made equal to the fundamental constant *c* with respect to the Earth, with the energy being transformed according to Eq. (3.1). It should be noted that until now the transverse Doppler effect was only explained by SR.

3.3. The Duration of a Photon's Interaction with the Inertial System. The Fizeau Experiment

The interaction of a photon with an inertial system results in a time delay for the photon. This time delay, in turn, results in a decrease in the average photon speed. The time delay τ of light on a unit length of substance with refractive index n may be determined as

$$\tau = (n-1)/c. \tag{3.11}$$

Let us use the data from the Fizeau experiment as an example to deduce the formula determining the speed of light in a moving medium. We shall deduce the formula on the basis of the Ritz emission theory, the Galilean law of the addition of velocities, and with due regard for the duration of the photons' interaction with the atoms (molecules) of the moving transparent medium using Eq. (3.11) (Boldyreva and Sotina 2003).

Fresnel advanced a formula specifying the speed of light c_n in a transparent medium moving at velocity **v** relative to the detector using the concept of "luminiferous" ether (Born 1962):

$$\mathbf{c}_n = \frac{\mathbf{c}}{n} + \left(1 - \frac{1}{n^2}\right)\mathbf{v}. \tag{3.12}$$

Formula (3.12) coincides accurate to $\beta_c = v/c$ with the formula derived in SR using four-dimensional kinematics (provided we keep the terms to the first order in β_c only). Formula (3.12) was confirmed experimentally by A. Fizeau in 1851 for light beams passing through a tube where a liquid flows at velocity **v** (Born 1962).

In this work the formula determining the speed of light in a moving medium will be derived for an element of medium of an arbitrary length L (the scheme of experiment is shown in Fig. 3-1). The source and detector are at rest relative to the Earth.

Let us consider the following three cases:
The 1st case: $\mathbf{v} = 0$.
According to Eq. (3.11), the time delay Δt of the light beam on length L is determined as follows:

$$\Delta t = L(n-1)/c. \quad (3.13)$$

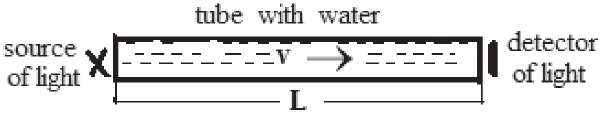


Fig. 3-1. The scheme of the experiment. L is the length of the tube with water; **v** is the velocity of water. The source of the light and the detector of the light are at rest relative to the Earth.

The 2nd case: $\mathbf{v} \neq 0$, $\mathbf{c} \uparrow\uparrow \mathbf{v}$ (see Fig. 3-1).
In the frame linked to the moving medium, the speed of the photon outside the medium will be $c - v$; therefore, the time t_1 required for the photon to travel the length L in the vacuum will be equal to

$$t_1 = L/(c-v). \quad (3.14)$$

If a vacuum is "filled" with a transparent medium (water), the traveling time in the medium will be

$$t_1 + \Delta t = L/c^*, \quad (3.15)$$

where c^* is the average speed of photon in the frame linked to the moving medium.

The experiments show that the refractive index n of medium only slightly depends on the frequency of light passing through the medium. This means that the delay time Δt can be considered to be independent of the value of v to the first approximation of β_c (since the frequency is related to speed v due to the Doppler effect). Thus, one may assume that the same value of Δt is used in Eqs (3.13) and (3.15). Under this assumption, from Eqs (3.13)−(3.15) we have $L / c^* = L/\left(c-v\right)+L\left(n-1\right)/c$. From the expression we have for c^*,

$$c^* = \frac{c\cdot\left(c-v\right)}{c+(n-1)\left(c-v\right)}. \tag{3.16}$$

If the frame is linked to the detector, the speed c_n of light equals

$$c_n = \left(c^* + v\right). \tag{3.17}$$

Using expression $\beta_c = v/c$ and Eqs (3.16)–(3.17), we obtain

$$c_n = \frac{c}{n}\cdot\frac{1-\beta_c\left(1-n\right)+\beta_c^2\left(1-n\right)}{1-\beta_c\left(1-1/n\right)}.$$

Keeping the terms to the first order of β_c in the latter equation, we obtain

$$\begin{aligned} c_n &\approx \frac{c}{n}\cdot\left(1-\beta_c\left(1-n\right)\right)\left(1+\beta_c\left(1-\frac{1}{n}\right)\right) \\ &\approx \frac{c}{n}+\left(1-\frac{1}{n^2}\right)v. \end{aligned} \tag{3.18}$$

The 3rd case: $\mathbf{v} \neq 0, \mathbf{v} \uparrow\downarrow \mathbf{c}$.

Then, in the frame linked to the moving medium, the speed of the photon outside the medium will be $c+v$; therefore, the time t_1 required for the photon to travel the length L of the vacuum will be equal to

$$t_1 = L/(c+v). \quad (3.19)$$

In this case, according to Eqs (3.13), (3.15), and (3.19), the average speed c^* of the photon in the frame linked to the moving medium is determined to be $L/c^* = L/(c+v) + L(n-1)/c$. From the latter expression, we have

$$c^* = \frac{c\cdot(c+v)}{c+(n-1)(c+v)}. \quad (3.20)$$

If the frame is linked to the detector, the speed c_n of light equals

$$c_n = \left(c^* - v\right). \quad (3.21)$$

Using expression $\beta_c = v/c$, from Eqs (3.20)–(3.21) we obtain

$$c_n = \frac{c}{n}\cdot\frac{1+\beta_c(1-n)+\beta_c^2\ (1-n)}{1+\beta_c(1-1/n)}.$$

Keeping the terms to the first order of β_c in the latter equation for c_n, we obtain

$$\begin{aligned} c_n &\approx \frac{c}{n}\cdot\left(1+\beta_c(1-n)\right)\left(1-\beta_c\left(1-\frac{1}{n}\right)\right) \\ &\approx \frac{c}{n} - \left(1-\frac{1}{n^2}\right)v. \end{aligned} \quad (3.22)$$

Generally, using Eqs (3.18) and (3.22) we obtain Eq. (3.12).

$$\mathbf{c}_n = \frac{\mathbf{c}}{n} + \left(1-\frac{1}{n^2}\right)\mathbf{v}.$$

CHAPTER FOUR

MAGNETISM

In quantum field theory, the physical vacuum is defined not as an empty space but as the ground state of a field that consists of "quantum oscillators" (QOs) possessing zero-point energy. The idea of "filling" the physical vacuum with quantum oscillators belongs to A. Einstein and O. Stern, who put it forward while analyzing the formula derived by M. Planck (Planck 1912) for calculating the energy of an atomic oscillator (Einstein and Stern 1913).

The properties of both QOs and a physical vacuum consisting of QOs will be considered below. It is shown also that the motion of this vacuum causes magnetic phenomena.

4.1. The Properties of QOs

1) Energy.

By definition (Einstein and Stern 1913) the energy of quantum oscillators equals zero-point energy that is defined as $\hbar\Omega_{QO}/2$, where Ω_{QO} is the frequency of the oscillations. However, it is unknown what is the number of QOs that contribute to the value of $\hbar\Omega_{QO}/2$. Consequently, we may express the energy W_{QO} of one QO as

$$W_{QO} = \gamma_{QO}\hbar\Omega_{QO}/2, \qquad (4.1)$$

where γ_{QO} is a proportionality factor, $\gamma_{QO} \leq 1$.

2) Spin.

Physical effects exist which are impossible to explain without ascribing an intrinsic degree of freedom to the physical vacuum, namely the spin. For example, a photon has a spin angular momentum and so-called orbital angular momentum (Barnett S.M. 2010, Kidd et al. 1989; see also Section 1.1); 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. Another example, in the photon's emission by a free-moving electron at the speed higher than the speed of light (the Cherenkov effect [Cherenkov 1937]), the electron conserves its own spin angular momentum. Consequently, the principle of conservation of angular momentum only holds at the emission of the photons if QOs constituting the physical vacuum have spin.

Thus, we may suppose that both the spin $\mathbf{S}_{ph}$ of the photon and the spin $\mathbf{S}_{v}$ of the virtual photon consist of the spins of QOs that constitute the physical vacuum: that is,

$$\mathbf{S}_{ph} = \left(\mathbf{S}_{QO}\right)_{S_{ph}}, \tag{4.2}$$

$$\mathbf{S}_{v} = \left(\mathbf{S}_{QO}\right)_{S_{v}}, \tag{4.3}$$

where $\left(\mathbf{S}_{QO}\right)_{\mathbf{S}_{ph}}$ is the total spin of the QOs that constitute the photon's spin, and $\left(\mathbf{S}_{QO}\right)_{\mathbf{S}_{v}}$ is the total spin of the QOs that constitute the spin of the virtual photon. In other words, the spins of spin vortices constituting photons and virtual photons consist of spins of QOs.

3) Electric dipole moment.

The existence of the electric polarization of a physical vacuum in an electric field suggests that QO is an electric dipole. From Eqs (4.2) and (4.3), it follows that the electric dipole moments of both the photon and the virtual photon consist of the electric dipole moments of QOs, $\mathbf{d}_{QO}$, then, according to Conditions (1.10), (1.41), and (4.2)–(4.3), we have

$$\mathbf{d}_{QO} \uparrow\uparrow \mathbf{S}_{QO}. \tag{4.4}$$

As the direction of electric field $\mathbf{E}_{QO}$, which was created by the electric dipole, is oriented oppositely to its electric dipole moment, $\mathbf{E}_{QO} \uparrow\downarrow \mathbf{d}_{QO}$, from Condition (4.4) it follows that

$$\mathbf{S}_{QO} \uparrow\downarrow \mathbf{E}_{QO}. \tag{4.5}$$

4) Mass.

Mass m_{QO} must be associated with QO's energy W_{QO}. Accepting the well-known relation between mass and energy of QOs and taking Eq. (4.1) into account, for m_{QO} we have

$$m_{QO} = \frac{\gamma_{QO}\hbar\Omega_{QO}}{2c^2}. \tag{4.6}$$

5) Interactions of QOs.

The following interactions between QOs may take place: gravitational (QO has a mass); electric dipole-dipole (QO has an electric dipole moment); and by means of a spin supercurrent (QO has a spin).

4.2. An Equation Describing the Physical Vacuum (in a Stationary State) Consisting of QOs

It is known (Sedov 1971–1972) that there is a 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. That is, magnetic phenomena might be due to the motion of a medium described at the stationary motion (without regard to gravitational forces) by the following equation (Sedov 1971–972):

$$\rho\upsilon^2 / 2 - p = const\,, \qquad (4.7)$$

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

Based on the above-mentioned (Section 4.1) characteristics of QOs and the properties of virtual photons created by quantum objects (Section 1.2), the following assumption can be made: a physical vacuum consisting of QOs with zero-point energy could be such a medium. Let us consider this in more detail.

1) Positive density.
The mass of QOs (Eq. [4.6]) may create positive density ρ of the physical vacuum.

2) Negative pressure.
The existence of the electric dipole moment d_{QO} of a QO means the existence of a repulsive force (it may be a pseudomagnetic force (Eqs [2.36]–[2.37]) between the unlike charges that constitute the QO, thereby compensating the attractive Coulomb force between these charges. The existence of this type of repulsive force may be treated as the existence of omniradial tensions inside the QOs. In terms of hydrodynamics, it means that the physical vacuum as a continuous medium may be regarded as a medium with negative pressure (Sedov 1971–1972).

3) The absence of shear viscosity.
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 may be negligible.

4) Electric current as a vortex line.
According to the postulates of quantum mechanics, a quantum object which is a singularity in electric or magnetic fields (electric charge or/and magnetic dipole) creates a virtual

photon (Feynman 1949) that has precessing spin $\mathbf{S}_{\nu}$ and, according to equality (4.3), it may be considered to be a spin vortex in the physical vacuum consisting of QOs. Consequently, the virtual photons created by charged quantum objects, whose motion produces an electric current, form a vortex line in the physical vacuum consisting of QOs. The circulation connected with this vortex line is defined by Eq. (1.56).

5) The vortices in the physical vacuum consisting of QOs may terminate in the bulk of this vacuum due to the complete transfer of the angular momenta connected with vortices to their spins.

4.3. The Connection of the Speed of Motion of a Physical Vacuum Consisting of QOs with Magnetic Phenomena

Let us derive the equation that establishes the relationship between magnetic induction and the speed of motion of a physical vacuum whose stationary motion is described by Eq. (4.7) (Boldyreva and Sotina 1992, Boldyreva 2012b and 2016). These equations are written, first, for the vacuum whose permeability $\mu = 1$, and, secondly, using the CGS system of units, so that the equations include a constant *c*, which is the characteristic of the medium whose motion results in magnetic phenomena.

The interaction of infinite vortex lines and the interaction of infinite current-carrying wires.

If (as it is conceived in hydrodynamics [Sedov 1971–1972]) we consider force **F** as the integral $\mathbf{F} = -\int_s p\mathbf{n}ds$, where **n** is an external normal to the impermeable surface *s*, then, taking Eq. (4.7) into account, we have $\mathbf{F} = -(1/2)\int_s \rho\upsilon^2\mathbf{n}ds$. (That is, all of the dynamic characteristics will have the sign opposite to what they would have for conventional—with positive pressure—ideal incompressible liquid with the same kinematic properties.) The force F_Γ acting on a unit length of either of the two infinite mutually parallel vortex lines having the same values of circulation Γ is $F_\Gamma = \rho\Gamma^2 / \left(2\pi r_w\right)$, where r_w is the distance between the vortex lines (Sedov 1971–1972). The force F_I acting on a unit length of either of the two infinite mutually parallel current-carrying wires having the same values of current **I** is $F_I = 2I^2 / \left(r_w c^2\right)$, where r_w is the distance between the current-carrying wires (Purcell 1965). The force F_I (and the force F_Γ) is attractive if currents in these wires have the same directions, and F_I is repulsive if currents in these wires have the opposite directions. As the electric current, due to the creation of virtual photons by moving electric charges, is a vortex line in the physical vacuum consisting of QOs, it is possible to equate the above expressions for forces F_Γ and F_I. Taking Eq. (1.56) into account, we obtain

$$\Gamma = \frac{I\sqrt{4\pi}}{c\sqrt{\rho}}. \tag{4.8}$$

The field of velocities generated by a closed vortex line and the magnetic induction around a current loop.

The field of velocities $\boldsymbol{\upsilon}$ generated by a closed vortex line having circulation Γ along an arbitrary loop enclosing the vortex line is defined as $\boldsymbol{\upsilon} = \frac{\Gamma}{4\pi}\int_{L'} \frac{d\mathbf{l} \times \mathbf{r}}{r^3}$, where $d\mathbf{l}$ is an infinitesimal vector element of the vortex line; L' is the length of the line; and $\mathbf{r}$ is a radius vector from $d\mathbf{l}$ to the point of observation. Outside the vortex line, $curl\boldsymbol{\upsilon} = 0$. The structure of the equation for $\boldsymbol{\upsilon}$ is the same as the structure of the equation for the Biot-Savart law in the CGS system of units, which defines the magnetic induction **B** generated by a loop with current **I**: $\mathbf{B} = \frac{I}{c}\int_{L'} \frac{d\mathbf{l} \times \mathbf{r}}{r^3}$ (L' is the length of the loop, and $d\mathbf{l}$ is an infinitesimal vector element of the vortex line, oriented along **I** at the wire element location) (Purcell 1965). Having solved the simultaneous equations for $\boldsymbol{\upsilon}$, **B**, and Eq. (4.8), we obtain an equation relating the magnetic induction **B** to the velocity $\boldsymbol{\upsilon}$ of motion of a physical vacuum consisting of QOs :

$$\mathbf{B} = \boldsymbol{\upsilon}\sqrt{4\pi\rho}\,. \tag{4.9}$$

It should be noted that the velocity $\boldsymbol{\upsilon}$ in Eq. (4.9) and electric current **I** in Eq. (4.8) are determined relative to the same reference frame.

Note. It follows from equality (4.9) that the motion of an object with velocity $\boldsymbol{\upsilon}_q$ may be equivalent to the exposition of it to an external magnetic field with magnetic induction: $-\boldsymbol{\upsilon}_q\sqrt{4\pi\rho}$. There is indirect experimental evidence that in the absence of magnetic field in the frame of physical vacuum there is a magnetic field in the frame of a moving object. The term “indirect” is used because in the experiments in question the evidence refers to the neutrino whose properties are mysterious in some respects. At present the concept of massive neutrino with its magnetic moment aligned with its spin is considered to be most acceptable to physicists. The spin of a neutrino moving relative to the “cosmic” vacuum is oriented against the velocity (the neutrino is left-handed); at the same time, in an external magnetic field (whose magnetic induction in the experiments was much greater than that of the Earth) the neutrino spin got oriented with the magnetic induction direction (Eidelman 2005, Tsuji et al. 2004).

4.4. The Field-Free Magnetic Vector Potential

In classical electrodynamics, the induction **B** of the magnetic field is determined (Purcell 1965) by equation $\mathbf{B} = curl\mathbf{A}$ where **A** is the magnetic vector potential. If the magnetic field is shielded, that is **B**=0, it is possible that $\mathbf{A} \neq 0$, which is referred to as the field-free magnetic vector potential. The magnetic vector potential has a physical meaning of its own. In 1949, W. Ehrenberg and R. Siday predicted the ability of a magnetic vector potential to directly influence the characteristics of quantum objects, even though there is no electromagnetic field at the location of the objects (Ehrenberg and Siday 1949). In 1959, the possibility of such an effect was considered by Y. Aharonov and D. Bohm (Aharonov and Bohm 1959). Subsequently, a great number of experiments have been conducted which confirmed the theoretical predictions (Chambers 1960). In general, these experiments were as follows (see Fig. 4-1): the beam of electrically charged quantum objects emitted by a source is split into two beams: C_1 and C_2. Beam C_1 propagates through the region where **B**=0 and **A**=0. Beam C_2 passes through a magnetized toroidal solenoid.

The solenoid is shielded in such a way that outside the substance of solenoid there is no magnetic field, **B**=0, but the field-free vector potential is present: $\mathbf{A} \neq 0$. Both beams of the quantum objects arrive at the entrances of an interferometer. The interference rings obtained suggest that there is a change in the wave function characteristics of the quantum objects passing through the region $\delta_{\mathbf{A}}$ where **B**=0 and $\mathbf{A} \neq 0$.

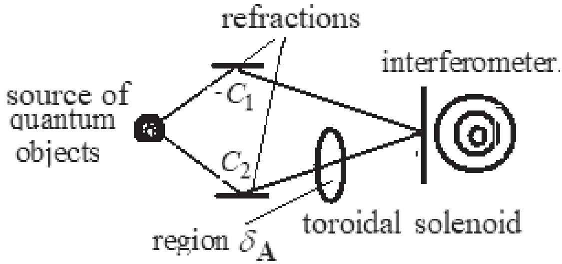


Fig. 4-1. Schematic diagram of the experiment on the study of the effects of the magnetic vector potential on quantum objects. The source of the quantum objects emits beams C_1 and C_2. Beam C_1 propagates through the region where A=0. Beam C_2 passes in the region $\delta_{\mathbf{A}}$ where **B**=0 and $\mathbf{A} \neq 0$. Interference rings are produced by the interferometer.

In quantum mechanics, the description of the action of the field-free magnetic vector potential is based on Schrodinger's equation (Wichmann 1971) without introducing any physical process. As the action of the field-free magnetic vector potential takes place in the space where the electromagnetic field is absent, this potential has both a non-electrical and a non-magnetic nature. Let us consider this phenomenon in detail.

The emergence of interferometer rings at the output of the interferometer means a change in the wave characteristics of the quantum objects of beam C_2 moving in region $\delta_{\mathbf{A}}$ (in the region of the action of the field-free magnetic vector potential). This means that the magnetic vector potential can influence the frequency or the phase of the wave function of quantum objects.

According to the physical interpretation of the matter wave presented in this work, the frequency and phase of the wave function of the quantum object are, respectively, the precession frequency $\boldsymbol{\omega}_v$ and the precession angle (phase) α

of the spin of the virtual photon created by the quantum object. It cannot be excluded that the character of interference may be influenced by the difference in values of the angles of deflection β of the spins of the virtual photons created by the quantum objects of beams C_1 and C_2. Consequently, the magnetic vector potential may also influence the angle of deflection, β, of the virtual photon created by the quantum object of beam C_2.

The changes in any of the following characteristics of spin, $\boldsymbol{\omega}_v$, α, or β, mean the existence of a moment acting on the spin. According to expression (4.3), the characteristics of the spin of a virtual photon are the characteristics of the spins of QOs that constitute the physical vacuum at the location of the quantum object creating this virtual photon. Thus, it may be supposed that magnetic vector potential **A** is a function φ of moment $\mathbf{M_A}$ that affects the QOs' spins and, consequently, according to expression (4.3), the spins of the virtual photons that consist of the QOs spins:

$$\mathbf{A} = \varphi\left(\mathbf{M_A}\right). \tag{4.10}$$

It is possible that the characteristics of the QOs' spins are determined by spin supercurrents emerging between the QOs, on the one hand, and the virtual photons created by the charged quantum objects whose motion results in the emergence of magnetic field **B** (or created by "magnetic" electrons, if the magnetic field is created by a permanent magnet), on the other (Boldyreva 2019b).

CHAPTER FIVE

THE ELECTROMAGNETIC (WAVE-VORTEX-SPIN) PROCESS in a Physical Vacuum Consisting of QOs

This chapter shows that the wave-vortex-spin process may arise in a physical vacuum consisting of QOs. This process is also an electromagnetic process (Boldyreva and Sotina 1992, Boldyreva 2012b and 2015a).

5.1. The Equations Describing the Wave-Vortex-Spin Process

In Section 4.2, it was shown that for the description of the stationary motion (the velocity of motion is constant at each point) of the physical vacuum consisting of QOs with zero-point energy the model of ideal incompressible liquid may be used. Since the characteristics of the QO's spin, according to Eq. (4.3), are similar to the characteristics of the spin of the virtual photon, then, they, according to Eqs (1.32)–(1.33), (1.39), (1.51) and (1.53)–(1.54), are depending on QO's velocity. Consequently, at the non-stationary motion the spin supercurrent determined by Eq. (2.20) may arise between the QOs. As the spin supercurrent influences the characteristics of the QOs' spins, one may introduce rotational viscosity (which may not only be due to the action of the spin supercurrents but also the electric dipole-dipole interaction of QOs) and describe the dynamics of the physical vacuum consisting of QOs in the non-stationary case using the model of an incompressible spin liquid (i.e., a liquid with intrinsic degrees of freedom that are characterized by both vector **S** of the total spin of infinitesimal volume element of the liquid and the rotational viscosity). The wave-vortex-spin process may arise in this medium. Let us deduce the equations describing this process.

5.1.1. The First Equation Describing the Wave-Vortex-Spin Process

The physical vacuum consisting of quantum oscillators having spin is, essentially, a medium consisting of gyroscopes. Consequently, if a moment arises causing a change in spin's direction, the precession motion of the spin with the frequency oriented oppositely to this direction (see Eq. [1.52]) takes place.

If to consider a unit volume of physical vacuum, then under the action of a moment changing the direction of its spin the emerging frequency of spin precession $\boldsymbol{\omega}_{QO}$ may be expressed as: $2\boldsymbol{\omega}_{QO} = curl\boldsymbol{\upsilon}$, where $\boldsymbol{\upsilon}$ is the emerging velocity of the physical vacuum.

Thus, the transformation of the microrotations (**S**) into macrorotations ($curl\boldsymbol{\upsilon}$) and vice versa is possible in a physical vacuum consisting of QOs: that is, the following holds true:

$$\frac{\partial \mathbf{S}}{\partial t} = -\frac{1}{k_S} curl\boldsymbol{\upsilon}, \qquad (5.1)$$

where t is time, $\boldsymbol{\upsilon}$ is the velocity of physical vacuum, $k_S > 0$ is a proportionality factor, and **S** is the total spin of the element of the volume of the physical vacuum (the spin consists of the spins of QOs constituting the vacuum). (It should be noted that Eq. [5.1] describes the result of experiment of Einstein-de Haas [Einstein and Haas 1915]: the rotation of ferromagnetic during its magnetization, that is, during orientation of spins of its "magnetic" electrons).

5.1.2. The Second Equation Describing the Wave-Vortex-Spin Process

There are two methods for the deduction of the second equation describing the wave-vortex-spin process: 1) from the equation for the motion of an incompressible spin liquid (that is, with intrinsic degrees of freedom) without shear viscosity and with rotational viscosity in the nonstationary case; 2) phenomenological.

The first method: using the equation of the motion of a physical vacuum as an incompressible spin liquid (that is, with an inner degree of freedom) without shear viscosity, and with rotational viscosity in the nonstationary case.

If we neglect the flow of impulse through the boundary, then the equation for the motion of an ideal liquid will be (Sedov 1971–1972)

$$\rho \frac{\partial \mathbf{\upsilon}}{\partial t} = \left(\nabla_i P_{ji} \right) \exists_j \,, \tag{5.2}$$

where ρ is the liquid density, $\mathbf{\upsilon}$ is the velocity of the moving liquid, $\exists_j$ is the basis vector, and P_{ji} are components of the stress tensor in this basis vector (*i, j* = 1, 2, 3,…). In the Cartesian coordinate system:

$$\nabla_i P_{ji} = \frac{\partial P_{j1}}{\partial x} + \frac{\partial P_{j2}}{\partial y} + \frac{\partial P_{j3}}{\partial z} \,. \tag{5.3}$$

Using the formalism developed in mechanics for writing the equations of the motion of a medium (liquid) with intrinsic degrees of freedom, we shall express the stress tensor components P_{ji} as follows (Sedov 1971–1972):

$$P_{ji} = B_{jilm} S_{lm}\,,\ l, m = 1, 2, 3, \qquad (5.4)$$

where S_{lm} are the components of the antisymmetric tensor of intrinsic rotations. In the model, the tensor characterizes the total spin of the infinitesimal volume element of the liquid. We define S_{lm} as

$$S_{lm} = \sum_{q=1}^{3} \varepsilon_{qlm} s_q = s_1 \varepsilon_{1lm} + s_2 \varepsilon_{2lm} + s_3 \varepsilon_{3lm}\,. \qquad (5.5)$$

The coefficients ε_{qlm} are defined as follows:

$$\varepsilon_{qlm} = \begin{cases} 1\ \ at\ \ q,l,m = 1,2,3;\ 2,3,1;\ 3,1,2 \\ -1\ at\ q,l,m = 2,1,3;\ 1,3,2;\ 3,2,1 \\ 0\ \ in\ other\ cases. \end{cases}$$

ε_{qlm} can be expressed through Kronecker's delta δ, and then Eq. (5.5) will take the following form:

$$S_{lm} = s_1\left(\delta_{l2}\delta_{m3} - \delta_{l3}\delta_{m2}\right) + s_2\left(\delta_{l3}\delta_{m1} - \delta_{l1}\delta_{m3}\right) + s_3\left(\delta_{l1}\delta_{m2} - \delta_{l2}\delta_{m1}\right). \qquad (5.6)$$

The coefficients B_{jilm} depend on the properties of the liquid; thus, they must form a rank IV tensor, and they must not vary with any orthogonal transformation of the coordinates. As mentioned above, the medium modeling the properties of the physical vacuum is characterized by intrinsic degrees of freedom and rotational viscosity, which manifests itself in nonstationary cases, there is no shear viscosity. For such a medium the tensor in question in the linear case has the following components in the Cartesian coordinate system provided the space is homogeneous and isotropic:

$$B_{jilm} = b_1 \delta_{jm}\delta_{il} + b_2 \delta_{ji}\delta_{lm} + b_3 \delta_{jl}\delta_{im}\,, \qquad (5.7)$$

where b_1, b_2, and b_3 are constants. Substituting the right-hand members of Eqs (5.6) and (5.7) in Eq. (5.4), we obtain the following expression for the stress tensor components:

$$P_{ji} = b_1\Big[s_1\left(\delta_{j3}\delta_{i2} - \delta_{j2}\delta_{i3}\right) + s_2\left(\delta_{j1}\delta_{i3} - \delta_{j3}\delta_{i1}\right) + s_3\left(\delta_{j2}\delta_{i1} - \delta_{j1}\delta_{i2}\right)\Big] + b_3\Big[s_1\left(\delta_{j2}\delta_{i3} - \delta_{j3}\delta_{i2}\right) + s_2\left(\delta_{j3}\delta_{i1} - \delta_{j1}\delta_{i3}\right) + s_3\left(\delta_{j1}\delta_{i2} - \delta_{j2}\delta_{i1}\right)\Big]. \tag{5.8}$$

Taking (5.5) in (5.8) into account, we have

$$P_{ji} = b_1\left(-s_1\varepsilon_{1ji} - s_2\varepsilon_{2ji} - s_3\varepsilon_{3ji}\right) + b_3\left(s_1\varepsilon_{1ji} + s_2\varepsilon_{2ji} + s_3\varepsilon_{3ji}\right) = \left(-b_1 + b_3\right)S_{ji}. \tag{5.9}$$

Further, we shall rewrite Eq. (5.2) using (5.3) and (5.9):

$$-\frac{\rho}{b_1 - b_3}\frac{\partial \mathbf{v}}{\partial t} = \left(\frac{\partial S_{11}}{\partial x} + \frac{\partial S_{12}}{\partial y} + \frac{\partial S_{13}}{\partial z}\right)\exists_1 + \left(\frac{\partial S_{21}}{\partial x} + \frac{\partial S_{22}}{\partial y} + \frac{\partial S_{23}}{\partial z}\right)\exists_2 + \left(\frac{\partial S_{31}}{\partial x} + \frac{\partial S_{32}}{\partial y} + \frac{\partial S_{33}}{\partial z}\right)\exists_3 = \left(\frac{\partial s_3}{\partial y} - \frac{\partial s_2}{\partial z}\right)\exists_1 + \left(\frac{\partial s_1}{\partial z} - \frac{\partial s_3}{\partial x}\right)\exists_2 + \left(\frac{\partial s_2}{\partial x} - \frac{\partial s_1}{\partial y}\right)\exists_3 = curl\mathbf{S},$$

or

$$\frac{\partial \mathbf{v}}{\partial t} = \frac{b_3 - b_1}{\rho} curl\mathbf{S}. \tag{5.10}$$

The second method: phenomenological

According to Eq. (4.3), the characteristics of the QOs' spin are similar to the characteristics of the spin of the virtual photon, which depend on its velocity (Eqs [1.32]–[1.33], [1.39], [1.51] and [1.53]–[1.54]). Thus the creation of $\partial \mathbf{v}/\partial t \neq 0$ in the physical vacuum results in a change in the precession frequency of the QOs' spins and their angle of deflection; therefore, we have $\partial \mathbf{\Omega}_{QO} / \partial t \neq 0$ and $\partial \beta / \partial t \neq 0$. As a result of the change in the orientation of the precessing spin of the QOs that constitute a physical vacuum and due to the principle of conservation of angular momentum, the inequality $curl\mathbf{S} \neq 0$ may hold.

5.1.3. The System of Equations Describing the Wave-Vortex-Spin (Electromagnetic) Process in a Physical Vacuum Consisting of QOs

To make it clear that Eqs (5.1) and (5.10) describe the wave-vortex-spin process in the physical vacuum consisting of QOs, let us introduce the following factor χ:

$$\chi = \sqrt{\frac{b_3 - b_1}{\rho \cdot k_S}}. \tag{5.11}$$

Using Eq. (5.11) in Eqs (5.1) and (5.10), we obtain

$$\frac{\partial\left(\chi k_S \cdot \mathbf{S}\right)}{\partial t} = -\chi curl \mathbf{\upsilon}, \tag{5.12}$$

$$\frac{\partial \mathbf{\upsilon}}{\partial t} = \chi\, curl\left(\chi k_{\mathbf{S}} \cdot \mathbf{S}\right). \tag{5.13}$$

Factor χ is measured in the same units as speed, and Eqs (5.12) and (5.13) describe the wave-vortex-spin process in the physical vacuum consisting of QOs. The transformation of energy is performed as follows: the specific kinetic energy W_υ of the motion of the physical vacuum

$$W_\upsilon = \rho \upsilon^2 / 2 \tag{5.14}$$

transforms (in the absence of dissipation) into the specific energy W_S of the spin system of the vacuum and vice versa:

$$W_\upsilon = W_S. \tag{5.15}$$

As follows from Eqs (1.6) and (1.40), the electric field is connected with the spin in a spin vortex of a physical vacuum consisting of QOs; this electric field arises as a result of the separation of the charges in the spin vortex (it is possible that this charges' separation is performed by a pseudomagnetic force; see Eqs [2.36]–[2.37]). If we introduce the speed Y of motion of these charges during the separation, the energy W_S may be determined as the specific kinetic energy of this motion, W_Y :

$$W_S = W_Y . \tag{5.16}$$

The W_Y may be determined to be

$$W_Y = \rho_+ Y^2 / 2 + \rho_- Y^2 / 2 = \rho Y^2 / 2 , \tag{5.17}$$

where ρ_+ is the density of the positive charges constituting vortices and ρ_- is the density of the negative charges constituting vortices, $\rho_+ + \rho_- = \rho$. Thus, according to Eqs (5.14)–(5.17), the transformation of energy in the wave-vortex-spin process is performed as follows: the specific kinetic energy W_υ of the circular motion of the physical vacuum transforms into the specific energy W_S of the spin system of the vacuum, and then the latter transforms into the specific kinetic energy W_Y of the motion of the physical vacuum inside the vortices. If we assume that

$$\mathbf{Y} = -\chi \cdot k_S \cdot \mathbf{S} , \tag{5.18}$$

then Eqs (5.12) and (5.13) may be presented in the following forms:

$$\frac{\partial \mathbf{Y}}{\partial t} = \chi \cdot curl \boldsymbol{\upsilon} , \tag{5.19}$$

$$\frac{\partial \boldsymbol{\upsilon}}{\partial t} = -\chi \cdot curl \mathbf{Y} . \tag{5.20}$$

The system of Eqs (5.18)–(5.20) describes the wave-vortex-spin process in the physical vacuum consisting of QOs. According to the definition of electric field (created by motion of charges inside the spin vortex) and Eqs (1.6) and (1.40), **Y** is the velocity of negative charges.

Since the charges' separation in the spin vortices results in the emergence of electric field **E**, the specific kinetic energy W_Y equals the specific energy W_E of electric field *E*: that is,

$$W_E = W_Y . \tag{5.21}$$

Then, with due account for the definition of the specific electric energy (Purcell 1965) $W_E = E^2/(8\pi)$, from Eqs (5.17), (5.21), and (1.6) it follows that

$$\mathbf{E} = \mathbf{Y}\sqrt{4\pi\rho} . \tag{5.22}$$

The use of Eqs (4.9) and (5.22) in Eqs (5.19) and (5.20) results in $\partial\mathbf{E}/\partial t = \chi \cdot curl\mathbf{B}$ and $\partial\mathbf{B}/\partial t = -\chi \cdot curl\mathbf{E}$. Thus, the wave-vortex-spin process in the physical vacuum consisting of QOs described by Eqs (5.18)–(5.20) is also an electromagnetic process, and we may suppose that the velocity of the electromagnetic process is equal to the velocity of light: that is,

$$\boldsymbol{\chi} = \mathbf{c} . \tag{5.23}$$

Then Eqs (4.9), (5.18)–(5.20), and (5.22)–(5.23) suggest that the system of equations describing the electromagnetic process in the physical vacuum consisting of QOs is as follows:

$$\mathbf{E} = -c \cdot k_S \sqrt{4\pi\rho} \cdot \mathbf{S} , \tag{5.24}$$

$$\frac{\partial\mathbf{E}}{\partial t} = c \cdot curl\mathbf{B} , \tag{5.25}$$

$$\frac{\partial\mathbf{B}}{\partial t} = -c \cdot curl\mathbf{E} . \tag{5.26}$$

The characteristics of the wave-vortex-spin (electromagnetic) process are given in Fig. 5-1.

Eqs (5.25)–(5.26) are coincident with the equations derived by J. Maxwell.

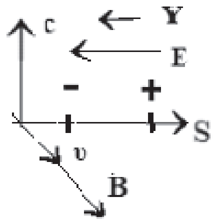


Fig. 5-1. The characteristics of a wave-vortex-spin (electromagnetic) process: **c** is the velocity of light; **S** is spin; **B** is the magnetic induction; **υ** is the velocity of a physical vacuum consisting of QOs; **Y** is the velocity of negative charges; and "+" and "–" denote the positive and negative charges creating electric component **E**.

5.1.4. Comparison of the Properties of the Physical Vacuum Consisting of QOs as a Luminiferous Medium with the Properties of the Model Proposed by J. Maxwell

In 1839, James McCullagh advanced a model of ether that was capable of counteracting the rotational motion of the neighboring particles constituting the ether. In fact, he derived the same equations for light as Maxwell's and described many optical phenomena properly. Maxwell developed McCullagh's model (Maxwell 1861); he supposed the following.

1) The luminiferous medium is a two-phase medium: the first consists of vortices, while the second consists of particles of a smaller size than the vortices. The motion of the first phase determines the magnetic interactions, while the motion of the second phase determines the electric interactions and the transfer of angular momentum between the vortices of the first phase (Maxwell 1861).

This concept is in agreement with the model of the physical vacuum consisting of QOs. The motion of such vacuum determines the magnetic interactions. The existence of the electric interactions is postulated in this model: that is, it is assumed that electric interactions are determined by the motion of a "finer" medium than the magnetic one. The transfer of angular momentum takes place between QOs and it is accomplished by spin supercurrent.

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.

This property is a property of the physical vacuum consisting of QOs as well.

3) The vortices "roll without sliding", which is essentially the rotational viscosity.

This property is that of the physical vacuum consisting of QOs as well. In the latter case the property is due to the electric dipole-dipole interaction of QOs and spin supercurrent between them.

4) The generation of some vortices consisting of the vortices of the luminiferous medium's first phase during the propagation of electromagnetic waves takes place.

This agrees completely with the present model in which the electromagnetic process is also a wave-vortex-spin process in the physical vacuum consisting of QOs.

5) The component **E** in the equations of propagation of light is due to a "displacement current" in the luminiferous medium: that is, the electric field is created in the luminiferous medium due to the relative motion of the constitutive unlike charged particles.

This agrees with the concepts of the considered model of a physical vacuum. In this model, the electric component of the electromagnetic oscillations is a result of the electric polarization of spin vortex that constitutes the photon, which is a consequence of the relative motion of unlike charges that constitute the vortex.

6) The process of transfer of angular momentum introduced in the Maxwell's model is inertia-free process (Boldyreva 2021b).

This property is characteristic as well of spin supercurrent transferring the angular momentum between the spin vortices in the physical vacuum consisting of QOs.

Though the model of the luminiferous medium introduced by Maxwell has the properties similar to those of the physical vacuum consisting of QOs, however, it does not explain some effects that are explained by using of Eqs (5.24)-(5.26) deduced in the model of the physical vacuum.
1) The preservation of the plane of the electric polarization of electromagnetic oscillations.
This effect is due to relationship between **E** and spin **S** (Eq. [5.24]): that is, this effect is of a gyroscopic nature.
2) The quantization of energy of electromagnetic oscillations.
This phenomenon is explained by the properties of spin **S**. As follows from Eqs (1.2), (1.8), and (1.22)–(1.23), the energy connected with a photon spin is only equal to the energy of its precession and is proportional to the spin's value. The energy of the translational motion of spin is equal to zero. It means, with due regard for Eqs (5.15)–(5.16), and (5.21), the quantization of any kind of energy in the electromagnetic process by the value of spin **S** (for the photon, the value of spin is $\hbar$).
3) The creation of electromagnetic oscillations under a change in the characteristics of the spin system of the physical vacuum. For example, O. Korschelt, a researcher of cavity structures in the 19th century, observed a feeble glow in the structures in the dark (Korschelt 1921).
Section 6.1 shows that cavity structures are "filled" by spin supercurrents, which change the characteristics of the spins of

the virtual photons created in a physical vacuum by quantum objects that constitute the substance of cavity structures. According to Eqs (4.3), (5.24)–(5.26), an electromagnetic process arises due to changes in the characteristics of the spin system of the physical vacuum consisting of QOs.

5.2. Classification of Photons

Currently, in quantum optics three types of photon (so-called *M*-photon, *Q*-photon, and *C*-photon) are used for the description of optical experiments demonstrating the properties of light (Klyshko 1994). Let us consider these types of photon in detail.

The *M-photon* is a hypothetical elementary particle of the light field, which generates a pulse at the output of the photodetector. Although there is no rigorous definition of the *M*-photon in the framework of any consistent theory, a lot of optical studies treat the photon as a particle (with the wave properties characteristic of the particle). It is assumed that any radiation field consists of a set of almost independent photons with definite *a priori* features to be revealed after a time.

Section 1.1 shows that the concept of the *M*-photon is based on the properties of the photon as a spin vortex in a physical vacuum consisting of QOs with zero-point energy.

The *Q-photon* is an objective entity, which corresponds to the Fock state of the light field with n=1 or a superposition of such states with nearly equal energies (Fock 1932). Essentially, the Q-photon was introduced to describe quantum correlations of photons.

It is shown in Section 2.2.2 that quantum correlations of photons are due to a spin supercurrent arising between the photons as spin vortices in a physical vacuum consisting of QOs.

The C-*photon* is a classical wave packet, that is, a quasimonochromatic electromagnetic radiation localized in space, which carries a quantum of energy $\hbar\omega_{ph}$, where ω_{ph} is the central frequency of the radiation spectrum. The wave packets are described by the equations of classical electrodynamics: that is, by Maxwell's equations. The "corpuscular" properties of the C-photon reveal themselves only at the moment of its detection.

Section 5.1.3 shows that light is a wave-vortex-spin process in a physical vacuum consisting of QOs. The magnetic properties of the photon are due to the motion of the physical vacuum in this process. The electric properties of photon are due to the electric polarization of the physical vacuum in the vortex constituting the photon. The energy $\hbar\omega_{ph}$ of photon is the energy of precession with the frequency ω_{ph} of spin (whose value is $\hbar$) in the vortex that constitutes the photon.

Thus, the concept of photon as a spin vortex in a physical vacuum consisting of QOs allows one to describe the properties of all types of photon: *M*, *Q*, and *C*.

5.3. Antenna Near-Field Effect

There is experimental evidence of existence near an antenna (an oscillating electric dipole) of a superluminally propagating electromagnetic field (Walker and Dual 1998; Walker 1999 and 2000). The well-known explanation of this phenomenon is based on the assumption that a superluminal motion takes place at distances of about one wavelength from the source of oscillations. The wavelength of the wave function of quantum objects (which for photon is equal to its wavelength) is the size at which the Heisenberg uncertainty principle (Heisenberg 1927) holds true. That is, the uncertainty Δp_x in the measured value of component p_x of the quantum object's momentum **p** is determined to be $\Delta p_x \geq \hbar / \Delta x$ (Δx is the uncertainty in the measured value of the quantum object's coordinate *x*). As momentum is a function of the speed of the quantum object, the uncertainty in the measured value of the momentum also means the uncertainty in the measured value of the speed of the quantum object. Thus, from the conception of quantum mechanics, the antenna near-field effect is in accordance with the second postulate of special relativity that asserts the constancy of the velocity of light.

This section shows that the antenna near-field effect may be due to the properties of the physical vacuum consisting of QOs and the properties of the spin supercurrent emerging between the QOs (Boldyreva 2019b).

As the antenna generating the electromagnetic oscillations is an electric dipole, it interacts with QOs located near antenna as with electric dipoles. The force acting between electric dipoles decreases with distance *r* between the dipoles as r^4; therefore, this interaction will be most effective in the region located near the antenna (we call this region δ). As a result of this interaction, the electric dipole moment $\left(\mathbf{d}_{QO}\right)_\delta(t)$ of every QO located near the antenna (in region δ) at arbitrary time *t* will be determined as

$$\left(\mathbf{d}_{QO}\right)_\delta(t) = \left(\mathbf{d}_{QO}\right)_\delta(0)\cos\left(\omega_a t\right), \qquad (5.27)$$

where ω_a is the frequency of electromagnetic oscillations radiated by the antenna, and $\left(\mathbf{d}_{QO}\right)_\delta(0)$ is an electric dipole moment of QO in region δ at *t*=0. According to Condition (4.4), it follows from (5.27) that

$$\left(\mathbf{S}_{QO}\right)_{\delta}(t)=\left(\mathbf{S}_{QO}\right)_{\delta}(0)\cos\left(\omega_{a}t\right), \tag{5.28}$$

where $\left(\mathbf{S}_{QO}\right)_{\delta}(t)$ is the spin of the QO located in region δ and determined at arbitrary time *t*; and $\left(\mathbf{S}_{QO}\right)_{\delta}(0)$ is the spin of the QO located in region δ at *t*=0.

The change in $\left(\mathbf{S}_{QO}\right)_{\delta}(t)$ in time means a change in the precession and deflection angles of the precessing spin of the QO located near the antenna (in region δ). Consequently, according to Eq. (2.20), a spin supercurrent arises between the QOs located near antenna, on the one hand, and the QOs located in other regions of physical vacuum, on the other. As a result of the action of the spin supercurrent, the characteristics of the spins of QOs located in other regions (outside area δ) of the physical vacuum change: that is, the following takes place in the physical vacuum:

$$\left(\mathbf{S}_{QO}\right)_{pv}(t)=\left(\mathbf{S}_{QO}\right)_{pv}(0)\cos\left(\omega_{a}t\right), \tag{5.29}$$

where $\left(\mathbf{S}_{QO}\right)_{pv}(0)$ and $\left(\mathbf{S}_{QO}\right)_{pv}(t)$ are the values of spin of any QO located in other regions (outside area δ) of the physical vacuum at *t*=0 and at arbitrary time *t*, respectively. According to Eq. (5.24), the electric oscillations $\mathbf{E}_{pv}(t)$ connected with the QO's spin $\left(\mathbf{S}_{QO}\right)_{pv}(t)$, which have the properties of oscillations radiated by the antenna, arise in the physical vacuum. According to Eqs (5.24)–(5.26), electromagnetic oscillations arise in the physical vacuum.

As the electromagnetic oscillations arise due to the action of spin supercurrent, the speed of their propagation in the physical vacuum consisting of QOs equals the speed of spin supercurrent, which is greater than the speed of light (see

Eq. [2.33]). It is quite similar to Cherenkov's effect (Cherenkov 1937): an electron moving at a speed greater than the speed of light (in a medium) radiates photons. If we only observed the radiated photons, we would discover that the speed of motion of photons is greater than the speed of light.

Note. Researchers of antenna near-field effect also discovered the oscillation of the gravitational field near antenna (Walker and Dual 1998). A discussion of this phenomenon is in Section 7.2.

5.4. The Condition of the Disappearance of the Electromagnetic Process (Wave-Vortex-Spin Process)

Eqs (5.24)–(5.26) describing the electromagnetic process in the physical vacuum consisting of QOs may be transformed as follows:

$$\mathbf{E} = -c \cdot k_S \sqrt{4\pi\rho} \cdot \mathbf{S}\,, \tag{5.30}$$

$$\left(c \cdot k_S \sqrt{4\pi\rho}\right) \frac{\partial \mathbf{S}}{\partial t} = -c \cdot curl\mathbf{B}\,, \tag{5.31}$$

$$\frac{\partial \mathbf{B}}{\partial t} = +c \cdot \left(ck_S \sqrt{4\pi\rho}\right) curl\mathbf{S}\,. \tag{5.32}$$

This process could not propagate in the region where the orientation of the spins of QOs that constitute the vacuum may not alter (i.e. spins can be considered to be "frozen"):

$$\partial \mathbf{S} / \partial t = 0\,. \tag{5.33}$$

This may take place in the following cases, for example:

(1) At the rotation of the physical vacuum consisting of QOs; in this case an orientation of the spins of QOs arises due to the Barnett effect (Barnett S.J. 1935) (see Eq. [5.1] Due to equality (4.9), the orientation of the spins of QOs may take place in a rotating magnetic field.

(2) When spin supercurrents are created, they suppress any change in the orientation of QOs' spins due to equalizing the

orientation of the QOs' spins in the physical vacuum (Eq. [2.20]) (Boldyreva 2018d).

It is worth noting that an increase in the temperature of a molecular substance decreases the probability of "freezing" the spins of QOs. This is due to the fact that the thermal speed of molecules influences the characteristics (see Eqs [1.51] and [1.53]–[1.55]) of the spins of the virtual photons created by the quantum objects that constitute the molecules. According to Eq. (4.3), the action on the characteristics of the spins of the virtual photons also means the action on the characteristics of the spins of the QOs that constitute the physical vacuum.

One of the most striking examples demonstrating the effect of visibility loss is a series of experiments conducted by J. Searl in 1940–1950 (Sandberg 1985 and 1987). In the experimental setup, there was a magnetic ring (stator), along which cylindrical rollers could move; a pair of magnetic poles were attached to roller heads, so that a rotating nonlinear magnetic field could be created. At the critical value of speed of rotation, the invisibility of the setup is observed. According to inequality (7.2) and transformation (7.3) (see Section 7.1), spin supercurrents arise in a rotating nonlinear magnetic field.

The effect of short-term invisibility is observed as well for a cavity structure. For example, the cocoon of an ichneumon of the Ichneumonidae family, which belongs to the Bathyplectes anurus species (cocoon of a parasitic fly or wasp), demonstrated short-term invisibility upon exposure to sunlight (Grebennikov 2006). According to Eq. (6.1), the cocoon is a cavity structure "filled up" with spin supercurrents.

5.5. Dark Matter

Dark matter is a hypothetical form of matter that is thought to account for approximately 85% of the matter in the Universe. This matter is invisible but it takes part in gravitational interactions. The fact that this matter takes part in gravitational interactions implies that dark matter consists of objects that have a mass similar to those that constitute "ordinary" matter and, thus, create virtual photons. According to Eq. (4.3), this means that the rotation of dark matter and a decrease in its temperature (Blumenthal et al. 1984) through virtual photons might result, as it was shown above, in "freezing" the spins of QOs that constitute a physical vacuum at the location of the dark matter. That is, the condition of the impossibility of spreading electromagnetic oscillations (Eq [5.33]) holds in this location.

> *Note.* In the most works, this invisibility is particularly explained by the fact that the strong gravitation field of dark matter does not allow photons to leave the location of the matter (Blumenthal et al. 1984).

5.6. The Cosmic Microwave Background (CMB)

The cosmic microwave background is an electromagnetic emission that is ever-present in the physical vacuum. The origin of this emission is connected with the Big Bang (Chernin 2001).

However, in the model of a physical vacuum consisting of QOs, this phenomenon has a different explanation. There are nonlinear magnetic rotating fields created by planets, stars, interstellar matter in outer space. According to equality (4.9), the rotation of the magnetic field may cause the orientation of QOs spin, due to the Barnett effect. Besides, the orientation of spin may be performed under the action of spin supercurrent emerging in non-linear rotating magnetic fields (see Section 7.1). Consequently, according to Eqs (5.24)–(5.26), the electromagnetic emission caused by a change in QOs spins' characteristics must exist in outer space, and the CMB may be such an emission.

5.7. Dark Energy

The dark energy of the Universe is characterized by the homogeneous distribution of positive density, negative pressure, and the possibility of expansion (Peebles and Ratra 2003).

According to Section 4.1 (see also Boldyreva 2012b and 2019a), the properties of dark energy are identical to the properties of a physical vacuum consisting of QOs with zero-point energy: positive density, negative pressure, and the possibility of changes in the distance between the QOs, for example, due to the electric dipole-dipole interaction between them. The physical vacuum consisting of QOs may be classified as "dark" since the light that propagates in it is a process.

CHAPTER SIX

THE PROPERTIES OF FORM (CAVITY STRUCTURES)

The following bodies are cavity structures: empty honeycombs, pyramids, mesh structures, porous materials, bundles of long tubes, and others (Fig. 6-1).

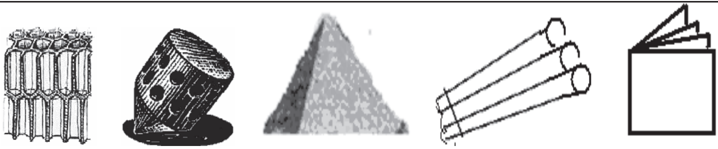


Fig. 6-1. Types of cavity structures. From left to right: empty honeycombs; breeding site of solitary bees; pyramid; bundle of long tubes; and open book.

The phenomenon connected with the form of ambient bodies, in particular with cavity structures (the influence on living and non-living objects, light radiation, and other things), has had no established name for a long time. In the 1930s, A. de Belizal and L. Chaumery proposed the term "form radiation" (De Belizal and Morel 1965). In A. Mermet's (Mermet 1959) classic work, the term "radiesthesia" is also used. The Russian scientist, V. Grebennikov, called the phenomenon the "cavity structure effect" (Grebennikov 1984 and 2006). The latter name seems to be the best, because it most accurately reflects the physical aspect of the phenomenon: that is, the presence of a cavity and curvature in the form of the body. The properties of cavity structures will be considered in detail below.

6.1. The Energy of Cavity Structures

Like all quantum objects that are singularities in electric and/or magnetic fields, quantum objects (electrons, protons, neutrons) that constitute the substance of a cavity structure create virtual photons, i.e., spin vortices in the physical vacuum consisting of QOs. According to Eqs (1.51) and (1.53)-(1.54), the orientation of the precession frequency of spin in the spin vortex created by a quantum object is determined by the object's velocity. Consequently, if a quantum object constitutes an atom, then the spin orientation is determined by the direction of the object's orbital velocity. As the mutual space arrangement of the orbits of the quantum objects that constitute the substance of the cavity structure depends on the form of the latter, the mutual orientation of the precession frequencies of the spin vortices created by these quantum objects cannot be arbitrary. In particular, the precession frequencies of the spins of the spin vortices created by the quantum objects of a cavity structure may not be aligned with the same straight line. An example of the possible configuration of r spin vortices created by the quantum objects that constitute the substance of a cavity structure is shown in Fig. 6-2: the directions of precession frequencies ($\boldsymbol{\omega}_1$, $\boldsymbol{\omega}_p$, $\boldsymbol{\omega}_q$, ..., $\boldsymbol{\omega}_r$) of the spins of these spin vortices are tangential to a ring. In this configuration, according to definition (see Eq. [2.20]), a spin supercurrent $\left(I_{ss}\right)_{pq}$ between the arbitrary p and q spin vortices will never be zero, that is,

$$\left(I_{ss}\right)_{pq} \neq 0. \tag{6.1}$$

Thus, the space inside the ring will be constantly "filled" with spin supercurrents (Boldyreva 2013b).

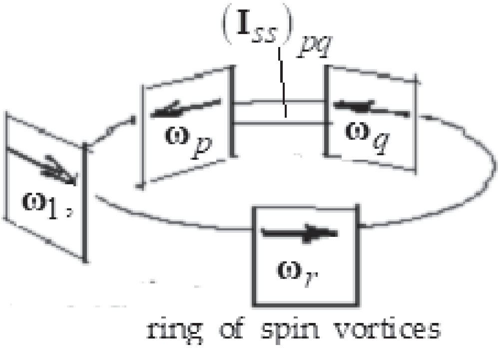


Fig. 6-2. A ring of spin vortices with respective precession frequencies $\boldsymbol{\omega}_1$, $\boldsymbol{\omega}_p$, $\boldsymbol{\omega}_q$, …, $\boldsymbol{\omega}_r$. $(\mathbf{I}_{ss})_{pq}$ is a spin supercurrent.

Many phenomena associated with cavity structures may be explained by the action of the spin supercurrents.

1) The generation of energy inside a cavity structure.

For example, in 1952, Czech researcher, K. Drbal discovered the possibility of a pyramid "maintaining razor blades and straight razors sharp" without an auxiliary source of energy. He was granted a patent for this discovery (Drbal 1952).

According to Condition (6.1), the recorded energy of a cavity structure may be created by spin supercurrents.

2) The glow of cavity structures.

For example, O. Korschelt, a 19th century researcher of cavity structures, observed the feeble glow of the structures in the dark (Korschelt 1921).

Since the spin supercurrent that exists in cavity structures may change the characteristics of the spins of QOs constituting the physical vacuum, then, according to Eqs (5.12)–(5.13) and (5.24)–(5.26), a wave-vortex-spin (electromagnetic) process may arise in the physical vacuum.

3) The change in weight.

It is known (Keys to the insects of the European USSR 1981) that the cocoon of an ichneumon of the Ichneumonidae family, belonging to Bathyplectes anurus species (cocoon of parasitic fly or wasp) could jump upon exposure to sunlight, as the cocoon is a cavity structure. In the experiments by Grebennikov (Grebennikov 2006), the jumps were 30 mm long and 50 mm high, which exceeded the cocoon's size by a factor of 30; such jumps (levitation) were performed even when the cocoon had been placed on a "cloud" of loose cotton wool.

As follows from Eqs (5.24)–(5.26), electromagnetic oscillations have a spin component and this component may cause a definite orientation of the spins of the virtual photons created by the quantum objects that constitute the cocoon. The spin polarization of virtual photons, according to Eq. (4.3), also means the spin polarization of physical vacuum that consists of QOs. In this case, according to Eqs (4.4) and (8.14), a force can affect the cocoon in the Earth's inhomogeneous electric field.

It is worth noting that the cocoon is a cavity structure and, according to Eq. (6.1), it is "filled" with a spin supercurrent. The action of the spin supercurrent can also result in the spin polarization of a physical vacuum. However, the fact that levitation only takes place in sunlight proves that, in this case, the action of the spin supercurrent may only be an additional factor.

4) Short-term invisibility.

In Grebennikov's experiments with a cocoon of an ichneumon from the Ichneumonidae family belonging to Bathyplectes anurus species, the cocoon exerts short-term invisibility during its jumps (Grebennikov 2006).

In Section 7.1.5 it is shown that the emergence of the invisibility of bodies may be a result of the action of spin supercurrents on the spins of QOs constituting the physical vacuum.

5) The existence of a region near a pyramid that has the property of shielding various fields.

This region (Parr called this region a “bubble”) was discovered by J. Parr in 1977–1987 (Parr 1980–1981, 1988 and 1993). Parr placed energy sources that emitted various fields (gamma rays and radio frequency sources) inside a pyramid and measured the extent the bubble shielded or blocked them. He has demonstrated in thousands of experimental runs that this bubble does indeed block off all known energy fields and influenced the weight of ambient bodies. Nothing can pass in or out of the bubble. By rotating a pyramid in an alternating magnetic field, he could increase the bubble’s shielding properties.

The emergence of a region called a “bubble” near a cavity structure may be due to the action of the spin supercurrents created by the substance of the cavity structure (Eq. [6.1]). The increase in the shielding properties of this bubble at the rotation of the pyramid in an alternating magnetic field will be explained in Section 7.1.

6) The “shells” around a cavity structure.

Russian scientist, V. Grebennikov, discovered that empty honeycombs were embanked by a system of invisible “shells”, which were able to be detected by specially devised instruments. The “shells” may be detected by a man’s hand as regions of high air density. The action of these “shells” could not be shielded by brick screens.

This phenomenon is explained in Section 7.1.3 by the action of spin supercurrent.

7) After-effect of the cavity structure.

Grebennikov also discovered that the action of cavity structures on objects may not cease after their removal. The duration of such an after-effect may be some hours or even days.

This property is in accordance with the properties of spin supercurrent and the physical vacuum consisting of QOs (see Section 7.4).

There is much evidence of the use of cavity structures to influence biological systems. Let us consider some examples of this type of action.

6.2. The Effect of Cavity Structures on Biological Systems

That cavity structures possess energy has been known since ancient times and this property was used for the action of cavity structures on biological systems. For example, places of worship in Eastern countries, such as pagodas (Figures 6-3 and 6-5) and pyramids (Fig. 6-4) intended for storing treasures, particularly, leather, furs, expensive wines, and the mummies of deceased rulers, were made in the form of cavity structures. Upper parts of Orthodox tent-shape type churches (Figures 6-6 and 6-7) and Roman Catholic churches (Fig. 6-8) can also be classified as cavity structures. Stonehenge in England also belongs to this type of place of worship. It was also built in the form of cavity structures: two rings of stones with one placed inside the other (Fig. 6-9). In addition, there are two earth banks and a ditch between them (Fig. 6-10).

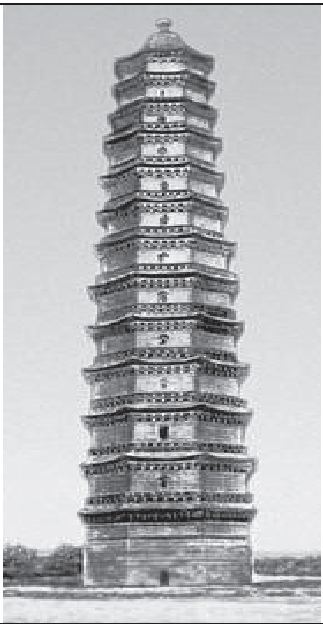


Fig. 6-4. The Giza Pyramids, Egypt XXVI–XXIII BC.

Fig. 6-3. Tie Ta Pagoda (Iron Pagoda), Keifeng, China, 1041.

Fig. 6-5. Yakushi-ji pagoda, Nara, Japan, c. 7–8 C.

Fig. 6-6. An Orthodox wooden church, Russia, 18C.

Fig. 6-7. An Orthodox triple-domed tent-shape, Uglich, Russia. 17th C.

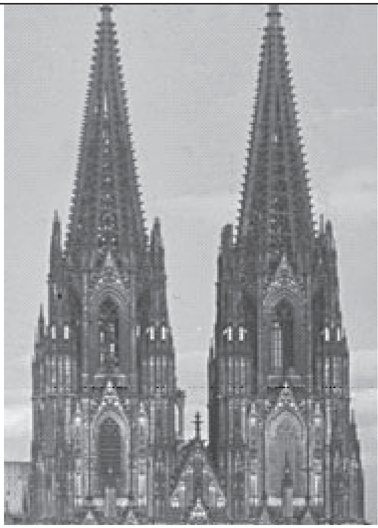


Fig. 6-8. Cologne Cathedral, Germany, 1248– 19th C.

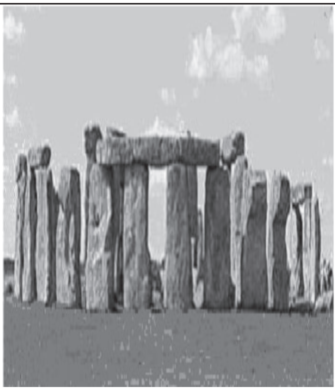


Fig. 6-9. Stonehenge: A stone structure in Wiltshire, England, constructed from 3000 BC to 2000 BC.

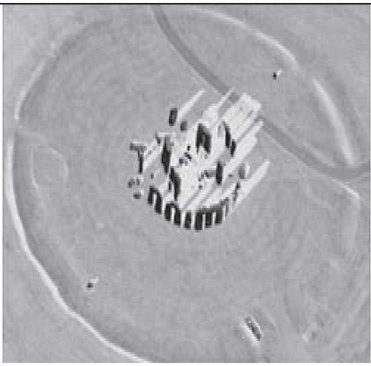


Fig. 6-10. Aerial view of Stonehenge. There are two earth banks around the outer circle of stones and a ditch between them.

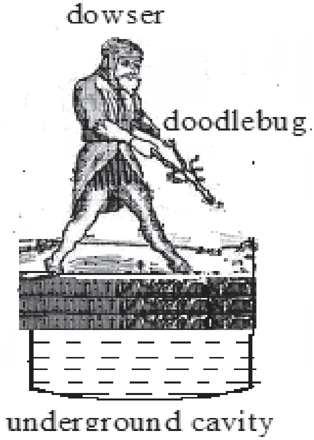


Fig. 6-11. The search for an underground substance by a dowser using a doodlebug.

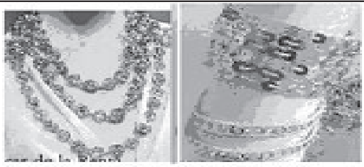


Fig. 6-12. Necklaces and bracelets.

Fig. 6-13. A priest’s headwear.

Dowsing is another example (Betz 1995) of the influence of underground cavity structures on people (Fig. 6-11).

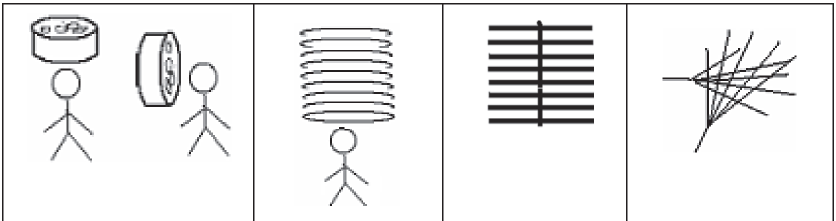
It is possible that necklaces and bracelets were originally used medicinally, and it was only with time that they became ornaments (Fig. 6-12). A priest’s headwear can also be classified as a cavity structure (Fig. 6-13).

Let us consider some examples of experiments that illustrate the influence of cavity structures on biological systems.

1) A. De Belizal and P. Morel (De Belizal and Morel 1965), as well as J. Pagot (Pagot 1978), describe experiments with coaxially joined hollow-wooden hemispheres. Placing nine such hemispheres of 9 cm diameter above pieces of fish or meat resulted in their mummification in less than a calendar day. Seven hemispheres of 25 cm diameter that were placed above rats in a cage caused them to panic, which was then followed by a kind of catalepsy.

2) Experiments conducted by De Belizal and Morel have shown that a seed's germinating ability changes when it is placed in a pyramid.
3) V. Grebennikov found that the breeding sites of solitary bees affected microorganisms at a distance and, in particular, the viability of yeast was suppressed (dough inflation was reduced by 26 percent); the same occurred with certain saprophytic soil plants (growth was reduced by 33 percent).
4) An experiment carried out by J. Brock of Texas (Kelly 2012) showed that keeping 20-day-old rabbits for 57 days in pyramid-shaped hutches resulted in significantly increased weight (by up to 35 percent) and size compared with the rabbits from the control group kept in standard hutches.
5) While studying the effect of nanoparticles on biological systems, it was found that the effect depended on the particle's form. For example, in experiments on the action of AgNP nanoparticles on *E. coli* (Egorova 2010, Pal et al. 2007), it was found that the toxic action of AgNP depended on their form: triangular particles were more active than spherical ones.
6) There is a great deal of evidence of the use of cavity structures for therapeutic purposes during many previous centuries. For example, the healing properties of pyramids are well known (see the survey by J. Little [Little 1990]). It is noteworthy that, in Russia, headaches have been treated by a sieve (a cylinder with a mesh bottom) for centuries. The sieve was placed on the head or held in front of the face with the mesh parallel to the face (Fig. 6-14[a]). People living on the banks of the Lower Amur used to cure a sick child by putting a hoop consisting of 9 wooden rings on him or her (Fig. 6.14[b]; Smolyak 1991). Chinese physicians fighting against the plague epidemic in Manchuria in 1910–1911 wore face masks that were, in fact, sets of cavity structures; it was believed that such forms of mask considerably reduced the

risk of infection, Fig. 6-14(c). The following form of self-healing may also be used: laying the palms of hands on a problem area of the body so that the fingers of one hand are at an angle to the fingers of the other hand, thus forming a grate, Fig. 6-14(d). Many peoples have had ceremonies that consist of honoring a person by singing and dancing in a circle. The person being honored would stand at the center of the circle; these ceremonies were initially intended to exert a certain therapeutic action on the person (Fig. 6-15).



(a) (b) (c) (d)

Fig. 6-14. Types of CS used for therapeutic purposes.

In Europe, O. Korschelt (1853–1940) was likely the first person to be granted a patent for specially fabricated cavity structures to be used for medical purposes (Korschelt 1893). Fig. 6-16 shows examples of the cavity structures made by Korschelt. The cavity structure in Fig. 6-16(a) is a tin-plate cylinder with soldered zinc or steel teeth. The cavity structure in Fig. 6-16(b) is made out of metal wire. The cavity structure shown in Fig. 6-16(c) is a wooden disk with a copper chain coiled on it. The size of each cavity structure does not exceed 50 cm. The cavity structure used was suspended from the ceiling, Fig. 6-16(c), or attached to a floor-type setup, Fig. 6-16(d). Korschelt treated stomach problems, nerve diseases, insomnia, and pain using such cavity structures.

Korschelt might have learned of these structures' curative value while attending Tokyo Medical School in Japan. Pagodas, which are tiered buildings with multiple eves, are common in Japan, China, and many other Eastern countries (Figures 6-3 and 6-5).

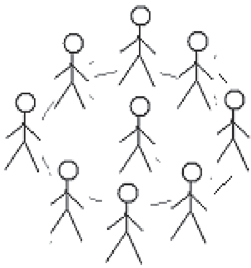
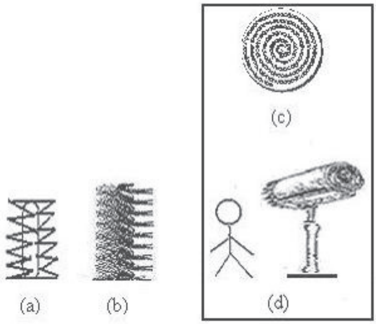
	

Fig. 6-15. Honoring a person by dancing and singing in a ring.	**Fig. 6-16**. The type of cavity structure used by Korschelt for therapeutic purposes.

In Russia, the medical aspect of a cavity structure was studied by V. Grebennikov. (Figures 6-17 and 6-18).

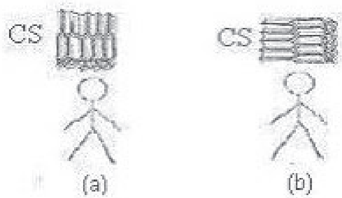
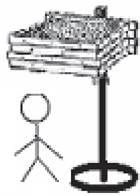
	

Fig. 6-17. Two variants of the orientation of a cavity structure (honeycombs) as a human medical treatment.	**Fig. 6-18**. Device based on empty honeycombs used for therapeutic purposes.

In particular, Grebennikov showed the possibility of using the parts of empty honeycombs as a medical treatment for humans. There is a museum in Novosibirsk (Russia) where a device intended for therapeutic purposes based on empty honeycombs is exhibited (Fig. 6-18).

> *Note.* Any biological system has a form that is a cavity structure. Consequently, first, a biological system creates an energy field ("bubble") nearby and, secondly, the internal "energy" properties of any biological system depend not only on the biochemical processes performed in it but also on its form.

The Special Features of Cavity Structure Effects on Biological Systems

The main results obtained in studies of the effects of cavity structures on biological systems are as follows:
1) Cavity structures exert an influence on biological systems independent of the substance the structure is made from, such as plastics, paper, wood, or metal, etc. However, its efficacy depends on the cavity structure substance and its form (sphere, pyramid, and so on).

These properties are in accordance with the definition of a spin supercurrent (Eq. [2.20]): The type of substance affects the factors of proportionality (g_1 and g_2) in Eq. (2.20). The form of cavity structure influences the mutual orientation of precession frequencies of spin vortices created by the cavity structure substance.
2) Its efficacy depends on the orientation of the cavity structure with respect to biological systems. For example, the therapeutic effect of the cavity structure orientation in Fig. 6-17(a) on a human appears more pronounced than that of the cavity structure in Fig. 6-17(b).

This is in accordance with the vector nature of spin supercurrent following from its definition (see Eq. [2.20]).
3) Cavity structures exert their influence on biological systems independent of the presence of any screens between

the cavity structure and the biological system, such as brick walls or metal shields, etc.

This is in accordance with the eighth property of spin supercurrent (see Section 2.2.1); it is not shielded by electromagnetic and some molecular screens.

4) The biological system that is in the coverage range of a cavity structure, even a very efficient one, may stop reacting to the action of the cavity structure over time: that is, the biological system shows a habituation effect with respect to the cavity structure.

This property follows from the definition of spin supercurrent (Eq. [2.20]): if as a result of the action of spin supercurrent the difference between the angles of spin precession and between the angles of the deflection of the spin vortices created by the quantum objects of a biological system, on the one hand, and those created by cavity structures, on the other, become equal to zero, the spin supercurrent ceases.

5) The efficacy of a cavity structure depends on its orientation with respect to the Earth and/or the Sun. It is this phenomenon that O. Korschelt observed while analyzing the therapeutic action of the cavity structures he created (Korschelt 1921).

This property may be explained by the following: 1) the Sun's electromagnetic radiation influences the characteristics of virtual photons (spin vortices) created by the quantum objects of a biological systems and the cavity structure substance; 2) since, according to Eq. (1.41), the electric dipole moment is associated with the spin of the virtual photon, the Earth's electric field influences the orientation of the spins of interacting virtual photons.

Thus, according to Eq. (2.20), the value of the spin supercurrent depends on the orientation of spin structures with respect to the Earth and/or the Sun.

Thus, all of the considered features of a cavity structure's effect on biological systems are in accordance with the properties of the spin supercurrent considered in Section 2.2.1.

Chapter Seven

The Spin System of Physical Vacuum Consisting of QOs as a Source of Energy and Angular Momentum

In this section, physical phenomena are considered whose analysis, without taking into account the spin system of a physical vacuum consisting of quantum oscillators (QOs), suggests the possibility of the violation of principles of the conservation of energy and angular momentum. In particular, these are the following physical phenomena: generation of energy in rotating nonlinear magnetic fields; changes in the weights of rotating bodies and bodies placed in a rotating magnetic field; the rotation of a symmetric body performing accelerated translational motion; and the emission of photon by an atom or an electron in the Cherenkov effect (Boldyreva 2018d).

7.1. The Generation of Energy in a Physical Vacuum Consisting of QOs and a Spin Supercurrent

Let us consider experiments in which the generation of energy takes place, particularly those with rotating nonlinear magnetic fields.

Among the first experiments with nonstationary magnetic fields was a series of experiments conducted by J. Searl in 1940–1950 (Sandberg 1985 and 1987, Thomas J. 1994). In the experimental setup, there was a magnetic ring (stator), along which cylindrical rollers could move, and a pair of magnetic poles attached to roller heads so that a nonlinear rotating magnetic field could be created. In 1990–1993, experiments with rotating magnets were conducted by S. Godin and V. Roshchin (Roshchin and Godin 1999 and 2000). The following phenomena were observed in these experiments:

1) Radiation of light.
2) At the critical value of the speed of rotation, the experimental setup began working without the consumption of energy and, in this case, the speed of rotation was able to increase.
3) The emergence of recurring zones of elevated magnetic induction (only in experiments by Godin and Roshchin) not shielded by the reinforced concrete walls of a laboratory room.
4) A decrease in the temperature of substances in the recurring zones of elevated magnetic induction (only in experiments by Godin and Roshchin).
5) The loss of visibility of the experimental setup (only in experiments by Searl).
6) A change in the weight of the experimental setup.

Let us analyze the theoretical aspect of these phenomena.

7.1.1. Radiation of Light

The following inequalities may take place for a rotating nonlinear magnetic field with magnetic induction **B**:

$$\partial \mathbf{B} / \partial t \neq 0 , \tag{7.1}$$

$$\partial \mathbf{B} / \partial \mathbf{z} \neq 0 , \tag{7.2}$$

where **z** is an arbitrary axis in the physical vacuum consisting of QOs. From Condition (7.1), and taking into account Eqs (5.24)–(5.26), the possibility of the origination of electromagnetic oscillations follows.

7.1.2. The Generation of Energy in a Rotating Magnetic Field

The inequality $\partial \mathbf{B} / \partial \mathbf{z} \neq 0$ (Eq. 7.2) in a physical vacuum consisting of QOs according to Eq. (4.9) is equivalent to inequality $\partial \boldsymbol{\upsilon} / \partial \mathbf{z} \neq 0$, where $\boldsymbol{\upsilon}$ is the speed of physical vacuum: that is, the speed of QOs that constitute this vacuum.

It follows from Eqs (1.51) and (1.53)–(1.55) that the speed of virtual photons (spin vortices) influences the characteristics of their spins (the frequency of precession; angle of deflection). According to equality (4.3), there are analogies between the properties of the spins of virtual photons and those of QOs; consequently, the speed of QOs should influence the characteristics of their spins as well: that is, inequality $\partial \mathbf{S} / \partial \mathbf{z} \neq 0$ follows from inequality $\partial \mathbf{B} / \partial \mathbf{z} \neq 0$ (**S** is the total spin of the QOs that constitute a physical vacuum element). According to Eq. (2.20), a spin supercurrent $\left(\mathbf{I}_{ss}\right)_{\mathbf{z}}$ (projection of spin supercurrent on axis **z)** arises along axis **z**. Thus, the following transformation takes place in the physical vacuum:

$$\partial \mathbf{B} / \partial \mathbf{z} \neq 0 \ \left(\partial \boldsymbol{\upsilon} / \partial \mathbf{z} \neq 0\right) \Rightarrow \partial \mathbf{S} / \partial \mathbf{z} \neq 0 \Rightarrow \left(\mathbf{I}_{ss}\right)_{\mathbf{z}} \neq 0 \,. \quad (7.3)$$

Thus, the following assumption can be made: the generation of energy in rotating nonlinear magnetic fields may be due to the emergence of a spin supercurrent in a physical vacuum consisting of QOs (Boldyreva 2018d).

7.1.3. The Emergence of Recurring Zones of Elevated Magnetic Induction

In the experiments with rotating magnets conducted by S. Godin and V. Roshchin (Roshchin and Godin 1999 and 2000) recurring zones of elevated magnetic induction were observed. These zones were like concentric cylindrical “walls” around the rotating magnets and were arranged equidistantly. The zone boundaries were sharp, the distance between “walls” was close to 50–60 cm, the thickness of the “walls” was 5–8 cm, and the external radius was close to 15 m. The “walls” were not shielded by the reinforced concrete of a laboratory room.

It will be shown below that this physical phenomenon may be explained using the model of a physical vacuum consisting of QOs (Boldyreva 2018d) and taking into account that, according to equality (4.9), magnetic induction **B** is proportional to the velocity $\boldsymbol{\upsilon}$ of the physical vacuum.

Eq. (4.7) is written for the medium modeled under the stationary motion by an ideal incompressible liquid. In the non-stationary motion of a physical vacuum, the emerging (due to transformation [7.3]) spin supercurrent influences the mutual orientation of the spins of QOs and, due to Eq. (1.41), the mutual orientation of their electric dipole moments. Due to the electric dipole-dipole interaction (the pseudomagnetic interaction between spins of QOs also may take place) the change in the distance between QOs may emerge. The latter, in turn, may affect the concentration of QOs and, consequently, the density of the physical vacuum consisting of QOs. Consequently, a spin supercurrent may influence the density of a physical vacuum consisting of QOs. If the speed of the spin supercurrent y_{ss} is greater than the speed g_c of spreading the wave of the contraction in the physical vacuum consisting of QOs,

$$y_{ss} > g_c, \tag{7.4}$$

then jumps in density emerge (Sedov 1971–1972).

While estimating the possibility of fulfilling Condition (7.4) in the physical vacuum consisting of QOs, it is necessary to take into account that y_{ss} is greater than the speed of light (Condition [2.33]).

According to Eq. (4.9), the jumps in density ρ of the physical vacuum consisting of QOs mean jumps in the magnetic induction **B**; and, besides, according to the eighth property of the spin supercurrent (Section 2.2.1), the spin supercurrent is not screened by molecular screens.

Thus, the arising of recurring zones of elevated magnetic induction in the rotating magnetic fields is due to the action of the spin supercurrent emerging in the physical vacuum between the QOs that constitute this vacuum.

Note. The jumps in the density may be observed in any medium if the speed of the process causing the contraction of the medium is greater than the speed of spreading the contraction in the medium. In particular, the jumps in the density of air are observed near the output of the nozzle of a jet engine, such as the de Laval nozzle (Flack 2005).

7.1.4. A Decrease in the Temperature of Substances in Recurring Zones of Elevated Magnetic Induction

As was shown in Section 7.1.3 electric dipole moments of QOs that constitute the recurring zones have a definite mutual orientation. According to Eq. (1.50) (under Condition (1.48) it means definite mutual orientation of velocities of virtual photons and, consequently, of quantum objects located in these zones and creating those virtual photons. The definite mutual orientation of velocities of quantum objects, that is, the absence of their chaotic motion, in turn, means the decreasing in temperature of medium consisting of these quantum objects.

7.1.5. The Loss of Visibility of the Experimental Setup

According to Eq. (4.9), the rotation of the magnetic field means the rotation of the physical vacuum consisting of QOs. In this case, an orientation in the spins of QOs arises due to the Barnett effect (Barnett S.J. 1935). Besides, as a result of the transformation (7.3), a spin supercurrent arises in the rotating magnetic field, thereby creating the uniform orientation for the spins of the QOs. Consequently, the equality (5.33) ($\partial \mathbf{S} / \partial t = 0$) may be fulfilled in the rotating magnetic field and, in this case, electromagnetic oscillations do not spread in the physical vacuum.

Thus, certain phenomena (the generation of energy, the emergence of recurring zones of elevated magnetic induction and decreased temperature, and the loss of visibility) that were observed in a rotating magnetic field in the experimental setup may arise as a result of the action of the spin supercurrent in the physical vacuum.

7.2. The Change in the Weight of the Experimental Setup

In the electric field $\mathbf{E}_e$ the moment $\mathbf{M}_{QO}$ exerts the action on QOs constituting the physical vacuum in the region of the electric field. This moment is determined to be

$$\mathbf{M}_{QO} = \left(\mathbf{d}_{QO}\right)_e \times \mathbf{E}_e . \qquad (7.5)$$

According to Condition (4.4), the orientation of the QO's electric dipole moment means the orientation of the QO's spin as well. Consequently, if electric polarization is produced in a region of the physical vacuum consisting of QOs, then the spin polarization of this region arises as well.

This twice polarized physical vacuum may act on QOs constituting the spin vortices created by quantum objects by means of both electric dipole-dipole and spin interactions. The action on a virtual photon means, in turn, the action on the quantum object creating those virtual photons. Thus, if a body is placed in a twice `polarized physical vacuum then, according to Eqs (4.4) and (7.5) a force may act on it.

The Earth has a negative electric charge and, consequently, the force $\left(\mathbf{F}_{QO}\right)_{\delta}$ arising in the polarized region δ of a physical vacuum in the Earth's electric field may influence the weight of bodies located in the region δ. If the force $\left(\mathbf{F}_{QO}\right)_{\delta}$ is directed along the gravitational vector, the weight of the body increases; however, if the force $\left(\mathbf{F}_{QO}\right)_{\delta}$ is directed opposite to the gravitational vector, the weight of the body decreases (Boldyreva 2018d). This force $\left(\mathbf{F}_{QO}\right)_{\delta}$ may be significant if quantum objects constituting this body create the virtual photons with uniformly oriented spins and, according to (1.41), with uniformly oriented electric dipole moments.

In accordance with the properties of QOs, the orientation of spins and, consequently, the electric polarization of a physical vacuum may be due to the Barnett effect or to the action of a spin supercurrent (Section 2.2.1). Let us consider all of the relevant cases.

The electric polarization of physical vacuum by the Barnett effect

Let us consider experiments in which the observed change in weight may be explained by the action of the Barnett effect: the transference of angular momentum from the rotating body to the spins of the quantum objects of the body.

I. Let us analyze the experiment that was conducted by H. Hayasaka (Hayasaka 1989) with the gyroscope's rotations around the vertical axis relative to the Earth (the materials of the rotors were brass, aluminum, and silicon-steel). At the right-hand rotation, a decrease in the weight of gyroscope took place. The magnitude of the decrease in weight did not depend on shielding the gyroscope from the external magnetic field (0.35 G). A decrease in the weight of gyroscope was not observed on the left-hand rotation. The scheme of the experimental setup is shown in Fig. 7-1.

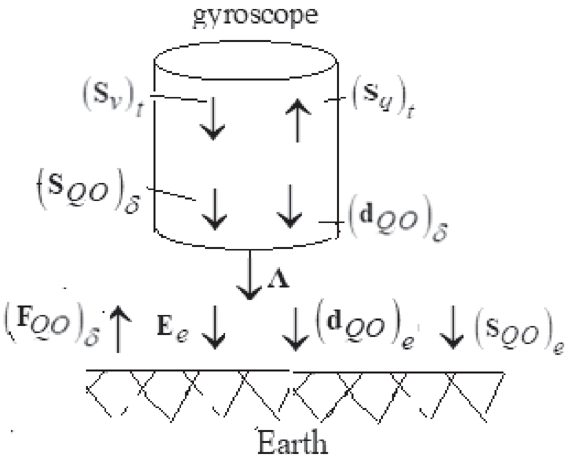


Fig. 7-1. Schema of the experimental setup illustrating the emergence of force $\left(\mathbf{F}_{QO}\right)_\delta$ acting on a gyroscope (a cylinder in this schema) rotating at angular velocity $\mathbf{\Lambda}$ directed along the Earth's electric field $\mathbf{E}_e$. $\left(\mathbf{S}_q\right)_t$ is the total spin of all quantum objects constituting the cylinder; $\left(\mathbf{S}_v\right)_t$ is the total spin of the virtual photons created by the quantum objects of the cylinder; and $\left(\mathbf{S}_{QO}\right)_\delta$ and $\left(\mathbf{d}_{QO}\right)_\delta$ are the total spin and the total electric dipole moment, respectively, of QOs in the region δ of the location of the cylinder. $\left(\mathbf{S}_{QO}\right)_e$ and $\left(\mathbf{d}_{QO}\right)_e$ are the spin and the electric dipole moment, respectively, of QO located outside region δ, which are determined by the action of Earth's electric field.

In this experiment the gyroscope rotated with an angular velocity $\mathbf{\Lambda}$ oriented to the Earth. Due to the Barnett effect, the angular momentum of the gyroscope is transferred to the spins of the quantum objects that constitute the gyroscope, and the following takes place: $\left(\mathbf{S}_q\right)_t \uparrow\downarrow \Lambda$, where $\left(\mathbf{S}_q\right)_t \neq 0$ is the total spin of all of the quantum objects constituting the gyroscope. According to Condition (1.69), we have

$$\left(\mathbf{S}_v\right)_t \uparrow\uparrow \Lambda, \tag{7.6}$$

where $\left(\mathbf{S}_v\right)_t$ is the total spin of virtual photons created by all of the quantum objects constituting the gyroscope. According to equality (4.3), $\left(\mathbf{S}_v\right)_t$ has the same direction and the same value as the total spin of the QOs that constitute the virtual photons in region δ where the rotating gyroscope is placed.

$$\left(\mathbf{S}_v\right)_t \sim \left(\mathbf{S}_{QO}\right)_\delta. \tag{7.7}$$

According to Eqs (4.4) and (7.7), the following takes place:

$$\left(\mathbf{d}_{QO}\right)_\delta \uparrow\uparrow \left(\mathbf{S}_{QO}\right)_\delta. \tag{7.8}$$

The electric dipole-dipole force between $\left(\mathbf{d}_{QO}\right)_\delta$ and $\left(\mathbf{d}_{QO}\right)_e$ is determined by expression:

$$\left(\mathbf{F}_{QO}\right)_\delta = \varphi_{QO}\left(\left(\mathbf{d}_{QO}\right)_e, \left(\mathbf{d}_{QO}\right)_\delta\right), \tag{7.9}$$

where φ_{QO} is a function. For example, at $\left(\mathbf{d}_{QO}\right)_e \rightarrow\rightarrow \left(\mathbf{d}_{QO}\right)_\delta$ the force $\left(\mathbf{F}_{QO}\right)_\delta$ is an attractive force, at $\left(\mathbf{d}_{QO}\right)_e \uparrow\uparrow \left(\mathbf{d}_{QO}\right)_\delta$ the force $\left(\mathbf{F}_{QO}\right)_\delta$ is a repulsive one.

If the force $\left(\mathbf{F}_{QO}\right)_\delta$ is directed oppositely to the gravitational force, then a decrease in the weight of rotating gyroscope takes place. The interaction connected with spins $\left(\mathbf{s}_{QO}\right)_e$ and $\left(\mathbf{s}_{QO}\right)_\delta$ (for example, pseudomagnetic interaction) cannot be excluded.

Thus, it follows from Eqs (7.5)-(7.9) that the character of interaction of rotating body with the physical vacuum consisting of quantum oscillators depends on the orientation of angular velocity of rotation relative to the Earth.

When considering the energy characteristics of the phenomenon of weight change, it is necessary to take the energy associated with the electric field $\mathbf{E}_e$ into account.

II. The results of the experiments by Godin and Roshchin (Roshchin and Godin 1999 and 2000) allow one to estimate some of the characteristics of a physical vacuum consisting of QOs. Let us consider these experiments in detail. At a definite speed of rotation, the effect of the changes in weight was observed: the weight change was as much as 35% of the weight of the experimental setup in the state of rest (the weight was 350 kg in the discussed experiments). The observed effect of the changes in weight (increase or decrease) was reversible relative to the direction of the rotor rotation under the complete symmetry of the rotor. At the clockwise rotation, a force emerged directed opposite to the gravitation vector (that is, the weight of the setup decreases). On rotating anticlockwise, a force emerges which is directed along the gravitation vector. The results of these experiments show that the force acting on a rotating body in the physical vacuum consisting of quantum oscillators may be rather significant.

(For their experimental setup in the period from 27.10.1999 to 27.10.2003, Godin and Roshchin owned the patent "An apparatus for generating mechanical energy and the method of mechanical energy production". Application 99122275/09, 27.10.1999, Russian Federation.)

> *Note*. The orientation of the QOs' spins due to the Barnett effect may result not only in a change in the weight of experimental setup but as well in a decrease in its temperature. This effect was observed in the above-considered experiment.

III. In a series of experiments conducted by Searl (Sandberg 1985 and 1987, Thomas J. 1994), the levitation of experimental setup creating a nonlinear rotating magnetic field is observed. Spin polarization, which enabled the levitation to take place, might have been as a result of either the Barnett effect or the action of the spin supercurrent (see Eqs [7.2]–[7.3]).

The orientation of the electric dipole moment of QOs due to the action of spin supercurrent

The spin polarization of a physical vacuum consisting of QOs and, consequently, according to (4.5), the electric polarization of the physical vacuum may be a result of the action of the spin supercurrent arising between the QOs (Eqs [2.21]–[2.22] and [2.25]). Let us consider some experiments in which the emergence of force $\left(\mathbf{F}_{QO}\right)_{\delta}$ is a result of a spin supercurrent action: the antenna near-field effect.

I. There is experimental evidence of the existence not only of a superluminally propagating electromagnetic field but also the oscillation of a gravitational field near the antenna (an oscillating electric dipole) (Walker and Dual 1998). In Section 5.4, the superluminal propagation of the electromagnetic field is explained by the properties of the spin supercurrent. As spin supercurrent may cause the spin polarization of the physical vacuum, then, according to Eqs (4.4) and (8.14), in the inhomogeneous electric field of the Earth a force may arise which acts on the bodies located near the antenna. The result of the action of this force may be interpreted as a change in the gravitational field near the antenna.

II. From experiments by J. Parr (Parr 1985) it follows that, first, the weight loss in bodies located not only inside the pyramid, but also near it (in the energetic region called a "bubble") takes place, and, secondly, the weight loss may be increased by rotating the pyramid in an alternating magnetic field.

A pyramid is a cavity structure and, as was shown in Section 6.1, it is "filled" by spin supercurrents. As this current is not shielded by a molecular substance, its action is not limited by the volume of cavity structure. Thus, weight loss in a pyramid and the "bubble" in its region may be the result of the spin supercurrent's action. The strengthening of this phenomenon in rotating magnetic fields is in accordance with this conclusion as an additional spin supercurrent emerges in rotating magnetic fields.

7.3. The Spin System of a Physical Vacuum Consisting of QOs as a "Source" of Angular Momentum

It was shown in Section 7.1 that the generation of energy in a physical vacuum consisting of QOs may be a consequence of the emergence of a spin supercurrent between the spin vortices in this vacuum. It will be shown in this section that taking the existence of spin in a QO into account results in the fulfilment of the principle of conservation of angular momentum, while explaining many physical phenomena, particularly the rotation of a symmetric body performing accelerated translational motion, the emission of a photon by an atom and an electron in the Cherenkov effect.

Let us consider these phenomena in detail.

7.3.1. The Rotation of a Symmetric Body Performing Accelerated Translational Motion

This phenomenon was observed in the experiments conducted by D. Baranov and V. Zatelepin (Baranov and Zatelepin 2019). They observed the rotation of an object performing accelerated translational motion and the maximum effect was observed for metal objects. In this case, the principles of the conservation of energy and angular momentum without taking the properties of the physical vacuum into account did not hold true.

Let us analyze the theoretical aspect of this phenomenon. To this end, let us consider a quantum object performing an accelerated translational motion with acceleration $\partial \mathbf{u} / \partial t \neq 0$ ($\mathbf{u}$ is the object's velocity; t is time). In this case, according to Eqs (1.51) and (1.53)–(1.55), inequality $\partial \mathbf{S}_v / \partial t \neq 0$ takes place, where $\mathbf{S}_v$ is the spin of the virtual photon (spin vortex) created by the moving quantum object. Due to Eq. (4.3), inequality $\partial \left(\mathbf{s}_{QO} \right)_{S_v} / \partial t \neq 0$ holds and, in accordance with Eq. (5.1), inequality $\left(curl \mathbf{v} \right)_{S_v} \neq 0$ also holds at the location of the virtual photon created by the quantum object. The latter inequality results in the emergence of the angular momentum $\left(\mathbf{J}_{QO} \right)_{S_v} \neq 0$ in the physical vacuum at the location of the virtual photon and so the following transformation takes place:

$$\frac{\partial \mathbf{u}}{\partial t} \neq 0 \Rightarrow \frac{\partial \mathbf{S}_v}{\partial t} \neq 0 \Rightarrow \left(curl \mathbf{v}\right)_{S_v} \neq 0 \Rightarrow \left(\mathbf{J}_{QO}\right)_{S_v} \neq 0 \,. \quad (7.10)$$

As according to equality (4.3), spin of virtual photon created by quantum object consists of spins of QOs, the transfer of angular momentum of QOs $\left(\mathbf{J}_{QO}\right)_{S_v}$ to virtual photon, whose spin they constitute, and then to the quantum object creating this photon is possible. Thus, the quantum object acquires angular momentum $\mathbf{J}_q$: that is, the rotation of quantum object takes place.

The rotation of the body is a result of the rotation of the quantum objects that constitute this body: that is, the angular momentum of body $\mathbf{J}_b$ equals

$$\mathbf{J}_b = \sum_i \left(\mathbf{J}_q\right)_i, \qquad (7.11)$$

where $\left(\mathbf{J}_q\right)_i$ is the angular momentum of the *i*-th quantum object. The value $\mathbf{J}_b$ depends on the mutual orientation of the spins of the virtual photons created by the quantum objects. If the body contains bound quantum objects, such as electrons that constitute Cooper pairs (see Section 9.1 for more detail), the total spin of the virtual photons created by the objects, and, consequently, the angular momentum connected with them, may be equal to zero. Therefore, a pronounced effect may be obtained for metals having free electrons, as the total spin of the virtual photons created by the electrons is not equal to zero.

Thus, the allowance for the properties of a physical vacuum consisting of QOs will result in the fulfilment of the principle of conservation of angular momentum at the rotation of the quantum object performing an accelerated translational motion.

7.3.2. The Angular Momentum of a Photon

The photon has a spin angular momentum $\mathbf{S}_{ph}$ and so-called orbital angular momentum $\mathbf{J}_{ph}$ (Barnett S.M. 2010, Kidd et al. 1989): that is, the total angular moment $\left(\mathbf{J}_{ph}\right)_t$ of the photon equals $\left(\mathbf{J}_{ph}\right)_t = \mathbf{S}_{ph} + \mathbf{J}_{ph}$. According to Eqs (1.4)–(1.5), (1.8), (1.18), and (1.20), $\mathbf{S}_{ph} \perp \mathbf{J}_{ph}$ and $S_{ph} = J_{ph} = \hbar$; consequently, $\left(\mathbf{J}_{ph}\right)_t = \hbar\sqrt{2}$. At the same time in emission of photon by an atom, only the orbital angular momentum is transferred to the photon in most atomic transitions. In the emission of photon by a free-moving electron in the Cherenkov effect (Cerenkov 1937), the production of a photon by an electron (moving at a superluminal speed) having only spin takes place. Consequently, the principle of conservation of angular momentum holds at the emission of a photon by an atom or an electron only if we take the spin system of the physical vacuum (in particular, the spins of the QOs that constitute the physical vacuum) into account.

7.4. The "Memory" of a Physical Vacuum Consisting of QOs

At the location of any body in the region δ of the physical vacuum, spin supercurrents arise between the virtual photons (spin vortices) created by quantum objects that constitute the body, on the one hand, and the QOs that constitute the physical vacuum, on the other. As follows from Eqs (2.21)–(2.22) and (2.25), as a result of the action of the spin supercurrent, the difference in the values of the respective characteristics of the virtual photons, on the one hand, and that of the QOs, on the other hand, decrease. Consequently, it can be said that the physical vacuum "acquires" the properties of the quantum objects that created these virtual photons: that is, the properties of the body consisting of these quantum objects. After removing the body from region δ, and in the absence of disturbances affecting the characteristics of the QOs' spins, the values of these characteristics may not return to their initial values (it should be taken into account that the QO is a gyroscope and the principle of conservation of angular momentum holds in this case). Thus, one may refer to the "memory" of the spin system of a physical vacuum consisting of QOs.

This theoretical conclusion agrees with experimental data. For example, the action of a cavity structure (pyramid, empty honeycomb, and others; for more detail see Section 6.1) on an object does not cease after the removal of the cavity structure: that is, the cavity structure may leave a "trace" in the physical vacuum (Grebennikov 2006). Note that, according to Eq. (6.1), the energy properties of cavity structures are determined by the action of the spin supercurrents emerging between the virtual photons created by the quantum objects of the cavity structure's substance.

Another example is the experiment with the rotating magnetic field conducted by F. Zaitsev and V. Chizhov (Bychkov and Zaitsev 2019). The source of the magnetic field—a permanent magnet—rotated with a frequency of 3000 rpm over ~10 min, and then it was quickly replaced by a 3-D Hall-effect sensor. Immediately after the removal of the magnet, the magnetic field at that point appeared to become ~10−20 percent less than the field that existed before the experiment ($\sim 50\mu T$). The time τ of the recovery of the magnetic field to value $\sim 50\mu T$ was equal to 3−6 min. When using an inhomogeneous (instead homogeneous) rotating magnetic field (due to the additional magnets), τ is increased by 20 percent. The value of τ also depends on the substance of magnet. When using a nonrotating magnet, $\tau=0$.

Let us discuss the results of this experiment in some detail. Due to the Barnett effect (Barnett S.J. 1935) and equation (1.69), the rotation of the magnet results in the orientation of the spins of the virtual photons ($\mathbf{S}_{\nu}$) created by the quantum objects that constitute the substance of magnet `(this determines the dependence observed in experiments of value τ on the substance of magnet). According to equality (4.3), the orientation of the virtual photons' spins also means the orientation of the QOs' spins. The characteristics of the physical vacuum's QOs' spins define the pressure p in this vacuum and, consequently, according to (4.7) and (4.9), define the magnetic induction value. The time τ in this case is the time of the recovery of the QOs' spins' characteristics to initial values.

The increase in value τ in an inhomogeneous rotating magnetic field may be explained by the following: according to transformation (7.3), the inhomogeneity of the magnetic field results in the emergence of spin supercurrent (for more detail see Section 7.1.2). The action of the spin supercurrent creates an additional change in the characteristics of the QO's spins and, consequently, an additional change in the pressure p of the physical vacuum. According to Eqs (4.7) and (4.9), the pressure p determines the speed of physical vacuum consisting of QOs, and, consequently, the value of the magnetic field.

Thus, the "memory" of a physical vacuum consisting of QOs is connected with the non-zero time for the recovery of the characteristics of the QOs spins after their change. A QO with a precessing spin is a gyroscope and, due to the principle of conservation of angular momentum, its characteristics has an enhanced resistance to changes due to external disturbances.

CHAPTER EIGHT

BALL LIGHTNING

At present, there are two basic approaches to models of ball lightning (BL) (Bychkov et al. 2016): "According to one of them, BL is a material object that stores energy within itself. According to the second, BL is an electric discharge plasma cloud burning in air due to energy supplied thereto from an external source." The model proposed in this work has the properties of both approaches. In this model, BL is a material object that consists of like-charged particles having mass and spin, and which interacts with the physical vacuum consisting of QOs by means of spin supercurrents. In particular, this interaction may result in the emergence of electromagnetic radiation.

It should be noted that the models of BL with intrinsic angular momentum have been advanced previously: for example, the spinning electric dipole model by R. Jennison (Jennison 1973) or the model by C. Seward representing the BL as a spinning plasma toroid or ring (Seward et al. 2001). However, in both of these models, special conditions need to be met for the intrinsic angular momentum to exist: in the first model, an asymmetry must be connected with the geometry of space (for example, the presence of a tree or building); and, in the second model, the orbital motion of electrons must be supported by the substance's ions where BL emerges. In the model proposed in this paper (see also Boldyreva 2018c), BL emerges as a result of the decay of QOs with intrinsic angular momentum: spin.

As a QO is an electric dipole (see Section 4.1), it may be supposed that it consists of two oppositely charged parts. In electric fields, the decay of QOs is possible. We shall call the charged parts that emerge as the result of the decay "free virtual particles". Like-charged free virtual particles may form a complex in which the two forces that are equal in magnitude act between the free virtual particles: the repulsive Coulomb force and the attractive compensation force connected with the spins of the free virtual particles (it may be a pseudomagnetic force, see Section 2.4). In addition to these forces, there is an interaction between the free virtual particles by means of spin supercurrents (see Section 2.2.1); the interaction aligns the spins of these particles in one direction and thus underlies Condition (2.36) of the action of a pseudomagnetic force (Eq. [2.37]). Let us consider the properties of a complex of like-charged free virtual particles in some detail.

8.1. The Emergence of a Complex of Free Virtual Particles

Since a QO is an electric dipole, then for every charged part that constitutes QO the following holds:

$$\left(\mathbf{F}_q\right)_{QO} = -\left(\mathbf{F}_S\right)_{QO}, \tag{8.1}$$

where $\left(\mathbf{F}_q\right)_{QO}$ is an attractive Coulomb force, and $\left(\mathbf{F}_S\right)_{QO}$ is a repulsive force that compensates the Coulomb force. Under an external disturbance, the equality (8.1) may be violated. This case may, for example, occur when a QO is located in an electric field. Then the resulting force $\left(\mathbf{F}_r\right)_{QO}$ acting on any of the charged parts that constitute the QO is determined as follows:

$$\left(\mathbf{F}_r\right)_{QO} = \left(\mathbf{F}_q\right)_{QO} + \left(\mathbf{F}_S\right)_{QO} + \left(\mathbf{F}_E\right)_{QO}, \tag{8.2}$$

where $\left(\mathbf{F}_E\right)_{QO}$ is the force with which the electric field acts on a charged part. Since the QO has an electric dipole moment, $\mathbf{d}_{QO}$, in electric field, $\mathbf{E}_B$, the moment $\mathbf{M}_{QO}=\mathbf{d}_{QO}\times\mathbf{E}_B$ will act on the QO. As a result of the action of this moment, the force $\left(\mathbf{F}_E\right)_{QO}$ is a repulsive force for any charged part: that is, $\left(\mathbf{F}_E\right)_{QO}\uparrow\uparrow\left(\mathbf{F}_S\right)_{QO}$. It is determined to be

$$\left(\mathbf{F}_E\right)_{QO}=q_{QO}\mathbf{E}_B\,, \qquad (8.3)$$

where q_{QO} is the charge of a charged part that constitutes the QO with due regard for the sign. Then it follows from Eqs (8.1)–(8.3) that $\left(\mathbf{F}_r\right)_{QO}$ is a repulsive force and, consequently, free virtual particles arise. It is supposed that at the decay of the QO its spin is transferred to both free virtual particles as it takes place at the decay of a photon in an electron and a positron.

A lot of like-charged free virtual particles may form a unified complex, as the pseudomagnetic force, which is repulsive for oppositely-charged particles ($\left(\mathbf{F}_S\right)_{QO}$ in Eq. [8.2]), is attractive for like-charged particles, which is in accordance with Eq. (2.37) under Condition (2.36). The Condition (2.36) (the aligning of spins in one direction) may be fulfilled in a complex of like-charged free virtual particles due to the action of the spin supercurrent between these particles.

8.2. Configuration of a Complex of Free Virtual Particles

The versions of the configurations of the complexes are shown in Fig. 8-1, the orientations of the spin $\mathbf{S}_{fvp}$ of the free virtual particle, $S_{fvp} = S_{QO} / 2$, are shown by arrows. In version (a) the like-charged free virtual particles form a straight line while, in version (b), the free virtual particles form a ring. The linear configuration is less stable than the ring configuration because in version (a) the first and last particles are more subject to perturbation influences than the rest particles. However, the ring configuration in Fig. 8-1(b) is only possible if distance r between the virtual particles is much less than diameter D_c: that is, if

$$r << D_c . \tag{8.4}$$

Only in this case, can the spins of the two adjacent virtual particles be considered to be oriented along the same straight line.

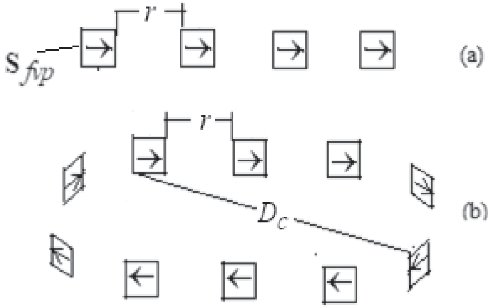


Fig. 8-1. Versions (a) and (b) of the configuration of complexes of like-charged free virtual particles (straight line and ring). The arrows show the orientation of the free virtual particles spins $\mathbf{S}_{fvp}$; D_c is the diameter of the ring; r is the distance between the neighboring free virtual particles; and $r << D_c$.

The fulfilment of Condition (8.4) and the action of the spin supercurrent may provide for the fulfilment of Condition (2.36) and, consequently, the possibility of the existence of an attractive pseudomagnetic force between like-charged free virtual particles as described by Eq. (2.37).

The types of complex shown in Fig. 8-1 may form large complexes. The configuration that ensures the highest stability of such large complexes is a ring-like one, such as circle, cylinder, or ball.

Let us consider the characteristics of large complexes of like-charged free virtual particles, such as mass, energy, and the forces acting on the complexes.

8.3. The Properties of a Complex of Free Virtual Particles

Let us assume that the total charge of a large complex is equal to Q_c. The number n of like-charged free virtual particles that constitute the large complex is determined to be

$$n = Q_c / q_{fvp}, \tag{8.5}$$

where q_{fvp} is the charge of a free virtual particle created in the QO decay. If the QO decay is performed without "electric losses", then q_{fvp} is equal to the q_{QO} introduced in Eq. (8.3). If we assume that between mass m_{fvp} and the charge q_{fvp} of the free virtual particle the same relationship exists as between the mass and charge of the virtual particles that constitute the photon (Eq. [1.12]) or the virtual photon (Eq. [1.43]), then, using the expression for the Bohr magneton $\mu_B = e\hbar / (2m_e c)$, we obtain the following for q_{fvp}:

$$q_{fvp} = 2\mu_B \cdot c \cdot m_{fvp} / \hbar. \tag{8.6}$$

The experiments show that in the photon decay the masses of emerging particles (in particular, of the positron and electron) are equal to each other, and their total mass equals the kinetic mass of the photon.

We suppose that the same holds for QO: that is, the mass m_{fvp} of the free virtual particle created in the decay of the QO is determined as $m_{fvp} = m_{QO}/2$ or, according to Eq. (4.6), as

$$m_{fvp} = \gamma_{QO}\hbar\Omega_{QO} / \left(4c^2\right). \qquad (8.7)$$

Using Eqs (8.6)–(8.7) in (8.5), we obtain the following expression for *n*:

$$n = \frac{2c \cdot Q_c}{\mu_B \gamma_{QO} \Omega_{QO}}. \qquad (8.8)$$

Mass of a complex.

Using Eqs (8.7)–(8.8), one may obtain the total mass M_c of a complex of like-charged free virtual particles, with total charge Q_c:

$$M_c = \frac{\hbar \cdot Q_c}{2c\mu_B} \qquad (8.9)$$

Energy of a complex.

The total energy of a complex, W_c, equals

$$W_c = W_k + W_\Omega + W_Q + W_{form}, \qquad (8.10)$$

where W_k is the kinetic energy; W_Ω is the energy associated with frequency Ω_{QO}; W_Q is the energy of the complex while taking into account that the charged free virtual particles are placed on the surface of a sphere; and W_{form} is the energy connected with the complex's form (see Section 6.1).

Taking Eq. (8.9) into account, the energy W_k is determined to be

$$W_k = \frac{\hbar \cdot Q_c}{4c\mu_B} y_{vc}^2 , \qquad (8.11)$$

where y_{vc} is the speed of the complex.

The energy of a QO associated with frequency Ω_{QO}, according to definition of a QO (Eq. [4.1]), equals $\hbar\gamma_{QO}\Omega_{QO} / 2$ then, due to the principle of conservation, the free virtual particle's energy is determined to be $\hbar\gamma_{QO}\Omega_{QO} / 4$. Thus, energy W_Q with due regard for Eq. (8.8) is determined to be

$$W_\Omega = \frac{\hbar \cdot c \cdot Q_c}{2 \cdot \mu_B} . \qquad (8.12)$$

According to definition of energy W_Q of a charged sphere, in the CGS system of units, it is determined to be (Purcell 1965):

$$W_Q = Q_c^2 / D_c . \qquad (8.13)$$

8.4. The Interaction of a Complex of Free Virtual Particles with a Physical Vacuum Consisting of QOs

The emission of electromagnetic oscillations by a complex.

Since free virtual particles that constitute the complex have spin, the emergence of a spin supercurrent is possible between the complex and QOs that constitute the physical vacuum. As the spin supercurrent influences the characteristics of the spins of QOs, the inequality $\partial\mathbf{S} / \partial t \neq 0$ may take place, where **S** is the total spin of the QOs located in an element of volume of the physical vacuum. According to Eqs (5.24)–(5.26), electromagnetic oscillations emerge. (Besides, the electric field of a charged complex acts on QOs as on electric dipoles which may lead to electromagnetic oscillations too).

The action of a complex on other objects by means of a spin supercurrent.

Since the free virtual particles that constitute the complex have spin, the emergence of a spin supercurrent is possible between the complex and ambient bodies. As a result of the action of the spin supercurrent, a change in the characteristics of the spins of the virtual photons created by the quantum objects that constitute the ambient bodies and, consequently, in the characteristics of these quantum objects, takes place. For example, the change in the characteristics of the spins of the virtual photons created by the atom's electrons results in changes of the spin-orbit (see Section 1.2.3) and dipole-dipole interactions of the atom's electrons. Thus, as a result of the action of the spin supercurrent, the following phenomena may be observed:

– the magnetization of metal bodies due to the orientation of the spins of the metal bodies' "free" electrons;
– the transmutation of the chemical elements due to the ionization of the atoms or due to the annihilation of electrons with protons of nucleus.

The forces acting on a complex in the physical vacuum.

In the electric field of the charged complex, the electric polarization of the physical vacuum consisting of QOs, which are electric dipoles, takes place. In external electric field $\mathbf{E}_e$ a force will act on the polarized QOs. The force $\left(\mathbf{F}_{QO}\right)_c$ acting on QOs that constitute the physical vacuum at the location of the complex acts on the complex as well; and this force may be expressed (Purcell 1975) as

$$\left(\mathbf{F}_{QO}\right)_c = \left(\left(\mathbf{d}_{QO}\right)_c \nabla\right)\mathbf{E}_e, \qquad (8.14)$$

where ∇ is the nabla operator, and $\left(\mathbf{d}_{QO}\right)_c$ is the total electric dipole moment of the QOs that constitute the physical vacuum at the location of the complex. The resulting electric force $\mathbf{F}_{rc}$ which acts on the complex in the external electric field may be expressed in the form $\mathbf{F}_{rc} = \left(\mathbf{F}_{QO}\right)_c + Q_c \mathbf{E}_e$ (with due regard for the BL charge Q_c sign), or by using expression (8.14):

$$\mathbf{F}_{rc} = \left(\left(\mathbf{d}_{QO}\right)_c \nabla\right)\mathbf{E}_e + Q_c \cdot \mathbf{E}_e . \qquad (8.15)$$

8.5. A Comparison of Ball Lightning Properties with Those of a Complex of Like-Charged Free Virtual Particles

Let us compare the properties of BL (Bychkov et al. 2009 and 2016) with those of a complex of like-charged free virtual particles created in the decay of QOs.

1) BL is formed in the streak lightning channel and near the current-carrying wires. Note that an electric field not only exists in the streak lightning channel but also near the current-carrying wires. In the latter case, this field is produced by the spin vortices created by moving charges in the wire, as the vortices are electric dipoles (see Section 2.1.5). Thus, the BL is formed in an electric field.

It is shown in Section 8.1 that a complex of free virtual particles is also created in electric fields.

2) BL has an electric charge.

The complex in question consists of free like-charged virtual particles.

3) BL may “cling” to electric wires or move along them.

According to Eq. (8.15), the force $\mathbf{F}_{rc}$ will act on BL in the electric field of the current-carrying wires.

4) BL emits light.
It is shown in Section 8.4 that, as a result of the interaction of the complex and the QOs that constitute a physical vacuum, an electromagnetic radiation emerges.
5) BL substance forms a separate phase in air.
The complex consists of particles created in the QOs decay (free virtual particles). The characteristics of these particles (size, mass, charge) differ from those of known real particles: that is, the complex is a separate phase in the air.
6) The form of BL may be, in particular, as follows: sphere, ellipsoid, pear-shaped form, or ring-like form (disk or cylinder). Observations show that the charge of BL may be located at its surface.

The closed and convex forms for the complex of like-charged free virtual particles are the most stable when fulfilling Condition (8.4) (provided that the attractive force between these particles is determined by Eq. [2.37] under Condition [2.36]). The Condition (8.4) is fulfilled, in particular, if the charged particles are located at the surface of the complex (see Fig. 8-1).
7) The spherical form of BL may recover from significant deformations produced when passing through very narrow slots.

The like-charged free virtual particles that constitute the complex are only placed on the surface of the complex and under Condition (8.4) a deformation of the complex is possible. The existence of a spin supercurrent (see Section 2.2.1) depending on the mutual orientation of free virtual particles' spins and aligning these spins in one direction facilitates the recovery of the complex's form from significant deformations.
8) BL may magnetize metallic bodies. The observation is given in (Leonov 1965) that BL passing over surgical instruments magnetized them; a day later the magnetic

properties vanished. It should be noted that the magnetic properties of the metallic body are due to the orientation of the spin magnetic moments of the quantum objects that constitute the body. It is observed as well the force interaction between BL and magnetized bodies.

Section 8.4 considers the capability of a complex of free virtual particles to magnetize ambient metallic bodies due to the action of a spin supercurrent arising between these particles and the virtual photons (spin vortices) created by the quantum objects of these ambient metallic bodies. The uniform orientation of spins of free virtual particles constituting the complex and of spin vortices created by the quantum objects of magnetized bodies (see Eq. [1.69]) may result in emergence of electric dipole and/or pseudomagnetic forces between them. After the cessation of the action of the spin supercurrent, the initial orientation of the spins of the quantum objects that constitute the body may be recovered.

9) Some bodies (generally, metallic bodies) disappear near BL (Likhosherstnykh 1983).

It is shown in Section 8.4 that the action of a spin supercurrent between a complex of free virtual particles and a system of chemical elements may cause the annihilation of the chemical elements.

10) BL may move at a constant altitude above ground level (the so-called "levitation" of BL).

As the Earth has an electric charge, then, as follows from Eq. (8.15), the force $\mathbf{F}_{rc}$ will act on a complex of free virtual particles in the Earth's electric field. If the sum of electric and gravitational forces acting on BL equals zero then the distance between the complex and the surface of the Earth will be constant.

11) An evaporation of a substance from BL may take place. The substance may exhibit the properties of metals (in particular, those of ferrites).

The like-charged free virtual particles in a complex have oriented spins (see Fig. 8-1). The orientation of spins also takes place in ferrites. Therefore, the substance that evaporates from the complex may have the properties of ferrites.

12) The energy stored in BL may vary in a wide range and, in some cases, it is equal to 10^{10} J/m^3; this is not equal to the kinetic energy of the translational motion of BL (the speed of the translational motion of BL does not exceed 10 m/s).

Let us calculate the energy of the complex of free virtual particles that has the approximate average characteristics for BL: diameter $D_c \approx 0.25$ m, electric charge $Q_c \approx 5 \cdot 10^{-7}$ C, and speed of translational motion of BL $y_{vc} \approx 10$ m/s. Then, according to Eqs (8.11)–(8.13), we, respectively, have kinetic energy $W_k \approx 10^{-22}$ J, $W_\Omega \approx 2 \cdot 10^{-1}$ J, and $W_Q \approx 9 \cdot 10^{-3}$ J. According to Eq. (8.10), the total specific energy of the complex, without taking into account the energy of form, W_{form}, is determined to be $\left(W_c - W_{form}\right)/V$, where V is the volume of the complex: $V = \pi D_c^3 / 6$. Under the assumed values of D_c, Q_c, and y_c, $\left(W_c - W_{form}\right)/V$ equals 25 J/m^3. According to inequality (6.1), the energy W_{form} of form is determined by spin supercurrents and, as shown in Parr's (Parr 1980–1981) experiments (Section 6.1.2), this energy may be sufficiently great and, consequently, it may contain a considerable part of the BL energy.

13) BL is an unstable object. BL may disappear, for example, because of the gradual consumption of its energy store and substance, or as a result of passing through an explosion caused by a short-term electric current pulse. Explosions of BL are observed as well in the absence of electric pulse.

The complex of charged free virtual particles may disappear due to the following: 1) the complex has an electric charge and, consequently, it may interact with external electric fields, in particular, it may explode on passing through an electric field; 2) between the complex and other spin systems a spin supercurrent may arise that changes the orientation of the complex's spins; due to violation of Condition (2.36) the force $\left(\mathbf{F}_S\right)_{QO}$ acting between free virtual particles constituting the complex are transformed from an attractive force into repulsive, and BL may not be merely destroyed but explodes; 3) a decrease in the number of free virtual particles in the complex as a result of external disturbances is possible.

Thus, the basic observed properties of Ball Lightning (BL) are in accordance with the properties of the complex of the like-charged free virtual particles emerging in an electric field on the decay of QOs constituting the physical vacuum.

CHAPTER NINE

SUPERCONDUCTIVITY AND SUPERFLUIDITY

In quantum mechanics, superconductivity and superfluidity are associated with the Bose-Einstein statistics, whereby any number of bosons can be in the lowest energy state (Bardeen et al. 1957, Matthias et al. 1963). Bosons are quantum objects with an integer spin. For example, bosons are pairs of electrons that constitute a superconductive medium and pairs of ^{3}He atoms in superfluid ^{3}He-B. These pairs are called Cooper pairs in honor of their researcher, L. Cooper; the formation of Cooper pairs is considered in Section 2.1.3.

From the point of view of classical mechanics, superconductivity and superfluidity are the result of a motion of Cooper pairs in a medium without viscosity. Let us analyze what properties of Cooper pairs provide the absence of viscosity in their motion.

As quantum objects create spin vortices in the physical vacuum, the characteristics of motion of these objects are determined not only by the interactions well-known in classical mechanics (electric, magnetic, gravitational), but also by interactions between spin vortices (virtual photons) created by the quantum objects.

The following interactions between spin vortices may take place: gravitational (spin vortex has a mass); electric dipole-dipole (spin vortex has an electric dipole moment); and by means of a spin supercurrent (spin vortex has a spin). Some of these interactions become impossible when the complexes of quantum objects are created with zero total spin $(\mathbf{S}_v)_t$ and zero total electric dipole moment $(\mathbf{d}_v)_t$ of the spin vortices produced by these objects. That is,

$$(\mathbf{S}_v)_t = 0\,, \tag{9.1}$$

$$(\mathbf{d}_v)_t = 0\,. \tag{9.2}$$

The first equality excludes the interaction by means of spin supercurrent; the second equality excludes the electric dipole-dipole interaction between such complexes. It is shown in this work that a Cooper pair may be similar to such a complex (Boldyreva 2008 and 2012b).

9.1. The Properties of Cooper Pairs

In this Section, the influence of temperature and magnetic induction on the properties of Cooper pairs in superconductive and superfluid media is considered.

Zero temperature and zero magnetic induction

Let us prove that at zero temperature, T=0, and at zero magnetic induction, B=0, the equalities (9.1)–(9.2) are valid for the spin vortices created by the quantum objects that constitute Cooper pair. To this end, let us present $(\mathbf{S}_v)_t$ and $(\mathbf{d}_v)_t$ in the following form:

$$(\mathbf{S}_v)_t = (\mathbf{S}_v)_1 + (\mathbf{S}_v)_2\,, \tag{9.3}$$

$$(\mathbf{d}_v)_t = (\mathbf{d}_v)_1 + (\mathbf{d}_v)_2\,, \tag{9.4}$$

where $(\mathbf{d}_v)_1$ and $(\mathbf{d}_v)_2$ are the electric dipole moments of the spin vortices created by the quantum objects that constitute a Cooper pair; $(\mathbf{S}_v)_1$ and $(\mathbf{S}_v)_2$ are the spins of the spin vortices created by the quantum objects that constitute a Cooper pair.

One of the properties of a Cooper pair (an electron pair in superconductors [Bardeen et al. 1957] and a ^{3}He atom's pair in superfluid ^{3}He-B [Salomaa and Volovik 1987]) at T=0 and B=0 is the fulfilment of equality (2.9): $\left(\mathbf{p}_q\right)_1 = -\left(\mathbf{p}_q\right)_2$, where $\left(\mathbf{p}_q\right)_1$ and $\left(\mathbf{p}_q\right)_2$ are the momenta of the pairs' quantum objects. Then, according to Eqs (1.41) and (1.50)–(1.51) under Condition (1.48) (this condition is fulfilled for a Cooper pair, see Section 2.1.3), and taking into account that spin vortices have the same value of spins, we have $\left(\mathbf{S}_v\right)_1 = -\left(\mathbf{S}_v\right)_2$. In this case, the equality (9.1) follows from equality (9.3).

Let us determine the total electric dipole moment $\left(\mathbf{d}_v\right)_t$ of the spin vortices created by quantum objects that constitute a Cooper pair. As an example, let us consider a Cooper pair that consists of electrons in s-state. According to Eqs (1.45) and (1.49), at the fulfilment of Condition (1.48), the dipole electric moment may be presented in the following form:

$$\left(\mathbf{d}_v\right)_t = \frac{\left(\mathbf{p}_q\right)_1 \cdot \mu_B \cdot \left(U_q\right)_1}{c \cdot \left(p_q\right)_1^2} + \frac{\left(\mathbf{p}_q\right)_2 \cdot \mu_B \cdot \left(U_q\right)_2}{c \cdot \left(p_q\right)_2^2}, \qquad (9.5)$$

where $\left(U_q\right)_1$ and $\left(U_q\right)_2$ are the energies of the quantum objects that constitute the Cooper pair. By definition (Eq. [2.11]), the quantum objects that constitute Cooper pairs have at T=0 and B=0 equal energies: $\left(U_q\right)_1 = \left(U_q\right)_2$. Using this equality and Eq. (2.9) in Eq. (9.5), we obtain equality (9.2).

Nonzero temperature and zero magnetic induction

Nonzero temperature T means the existence of the thermal motion of superfluid or superconductive media, where the quantum objects of a Cooper pair acquire the respective velocities, $(\mathbf{y}_p)_1$ and $(\mathbf{y}_p)_2$, such as

$$(\mathbf{y}_p)_1 = (\mathbf{y}_p)_2 = \mathbf{y}_p \tag{9.6}$$

and

$$y_p << c\,. \tag{9.7}$$

(The fulfilling of Condition [9.7] means the fulfilling of Condition [1.50] determining the mutual orientation of electric dipole moment of spin vortex and velocity of quantum object creating this spin vortex.)

The temperature T and speed y_p are related as follows:

$$y_p = \sqrt{2kT/m}\,, \tag{9.8}$$

where k is the Boltzmann constant, m is the mass of moving object.

The respective electric dipole moments $(\mathbf{d}_v)_1^{\mathbf{y}_p}$ and $(\mathbf{d}_v)_2^{\mathbf{y}_p}$ of the spin vortices created by these quantum objects are associated with these velocities. From equalities (9.6), Conditions (9.7), (1.48) and (1.50)–(1.51) it follows $(\mathbf{d}_v)_1^{\mathbf{y}_p} \uparrow\uparrow (\mathbf{d}_v)_2^{\mathbf{y}_p}$ and, consequently, Condition (9.2) does not hold in this case. In addition, an electric dipole-dipole repulsive force arises between the spin vortices created by the quantum objects of the Cooper pair (Purcell 1965), which may lead to their destruction.

The vanishing of superfluidity and/or superconductivity may emerge earlier than the destruction of the Cooper pair if the following inequality takes place: $(\mathbf{d}_v)_t > (\mathbf{d}_v)_t^c$, where $(\mathbf{d}_v)_t^c$ is a value of electric dipole moment corresponding to the critical value of the speed $\mathbf{y}_{pc}$ at which superfluidity or superconductivity disappears. The vanishing of superconductivity with the conservation of Cooper pairs is observed in experiments (Corson 1999).

From Eq. (9.5) let us determine $(\mathbf{d}_v)_t$ for a Cooper pair consisting of electrons moving at arbitrary speed $\mathbf{y}_p$. The energy of either electron in the pair equals $U_q + m_e y_p^2 / 2$ (m_e is electron's mass), where energy U_q relates to $B = 0$; and $T = 0$K: that is,

$$\left(U_q\right)_1 = \left(U_q\right)_2 = U_q + m_e y_p^2 / 2 \,. \tag{9.9}$$

In this case, the momentum of either electron in the pair, taking into account Conditions (9.6) and (2.9) (the latter condition is determined at $B = 0$ and $T = 0$K), equals respectively:

$$\left(\mathbf{p}_q\right)_1 = \mathbf{p}_q + \mathbf{y}_p m_e \,, \tag{9.10}$$

$$\left(\mathbf{p}_q\right)_2 = -\mathbf{p}_q + \mathbf{y}_p m_e \,, \tag{9.11}$$

where p_q is the value of momentum of either electron in the pair determined at $B = 0$ and $T = 0$K. Then, according to Eqs (9.5)–(9.7) and (9.9)–(9.11) $(\mathbf{d}_v)_t$ may be expressed in the following form:

$$\left(\mathbf{d}_v\right)_t = \frac{\mu_\mathrm{B}\left(U_q + m_e y_p^2/2\right)}{c\left|\mathbf{p}_q + \mathbf{y}_p m_e\right|^2}\left(\mathbf{p}_q + \mathbf{y}_p m_e\right)$$

$$+\frac{\mu_\mathrm{B}\left(U_q + m_e y_p^2/2\right)}{c\left|-\mathbf{p}_q + \mathbf{y}_p m_e\right|^2}\left(-\mathbf{p}_q + \mathbf{y}_p m_e\right).$$

From the latter expression for $\left(\mathbf{d}_v\right)_t$, using a fairly rough assumption for velocity $\mathbf{y}_p$ of a Cooper pair: $\mathbf{y}_p \uparrow\uparrow \mathbf{p}_q$, we may obtain the relationship between the critical value of the electric dipole moment $\left(d_v\right)_t^c$ and the speed $\mathbf{y}_p = \mathbf{y}_{pc}$ of the Cooper pair at which the superconductivity (or superfluidity) vanishes.

$$\left(d_v\right)_t^c = \left|\frac{\mu_\mathrm{B}\left(U_q + m_e y_{pc}^2/2\right)}{c}\frac{2m_e y_\mathrm{pc}}{p_q^2 - \left(m_e y_\mathrm{pc}\right)^2}\right|. \qquad (9.12)$$

Using Eqs (9.8) and (9.12), one may determine the relation between the critical value of the electric dipole moment $\left(d_v\right)_t^c$ and the critical temperature T_c at which the superconductivity (or superfluidity) vanishes:

$$\left(d_v\right)_t^c = \left|\frac{\mu_\mathrm{B}\left(U_q + kT_c\right)}{c}\frac{2\sqrt{2m_e kT_c}}{p_q^2 - 2m_e kT_c}\right|. \qquad (9.13)$$

Zero temperature and nonzero magnetic induction

The reaction of Cooper pairs to a magnetic field of induction **B** depends on the mutual orientation of spins and, consequently, of the magnetic dipole moments of the quantum

objects that constitute the pair. The following two cases are possible.
1st case. The quantum objects create Cooper pairs in the *p*-state: that is, with spins oriented in one direction (for example, Cooper pairs constituting ^{3}He atoms [Salomaa and Volovik 1987]). Consequently, the spin magnetic dipole moments $\boldsymbol{\mu}_q$ of these quantum objects are also oriented in one direction (Purcell 1965). As a result of the action of moment **M** on quantum objects

$$\mathbf{M} = \boldsymbol{\mu}_q \times \mathbf{B}, \qquad (9.14)$$

the following two variants are possible:
a) $\boldsymbol{\mu}_q \rightarrow\rightarrow \mathbf{B}$. In this case, the energy of every quantum object increases by the same value $\mu_q B$: that is,

$$\left(U_q\right)_1 = \left(U_q\right)_2 = U_q + \mu_q B. \qquad (9.15)$$

Using equalities (9.5), (9.7)–(9.8), (9.10)–(9.11) (at T=0), and (9.15), we obtain equality (9.2). According to Eqs (1.36), (1.44), and (2.14), the force $\mathbf{F}_r$ of the electric dipole-dipole interaction of the quantum objects of the Cooper pair increases when the object's energy increases. Thus, in this case the Cooper pair is not destroyed and the superfluid and/or superconductive property of the medium does not vanish. It should be noted that an additional superfluid A_1-phase emerges in ^{3}He in the magnetic field (Salomaa and Volovik 1987) and it is possible that it is a result of the increase in force $\mathbf{F}_r$.
b) $\boldsymbol{\mu}_q \rightarrow\leftarrow \mathbf{B}$ (the unstable state due to the action of moment **M**, Eq. [9.14]). In this case, the energy U_q of every quantum object decreases by the same value $\mu_q B$: that is,

$$\left(U_q\right)_1 = \left(U_q\right)_2 = U_q - \mu_q B. \qquad (9.16)$$

Using equalities (9.5), (9.7)–(9.8), (9.10)–(9.11) (at T=0), and (9.16), we obtain equality (9.2). However, according to Eqs (1.36), (1.44), and (2.14), the force $\mathbf{F}_r$ of the electric dipole-dipole interaction of the quantum objects of the Cooper pairs decreases and the pairs may be destroyed, which is then followed by the vanishing of the superfluid and/or superconductive property of the medium.

2nd case. Quantum objects create Cooper pairs in the *s*-state, that is, their spins, and, consequently, spin dipole magnetic moments are oriented in mutually opposite directions. (It should be noted that the Cooper pairs of most superconductors consist of quantum objects in the *s*-state.) In a magnetic field, taking into account the action of moment **M** (Eq. [9.14]), the energy of the quantum objects changes with different signs by value $\mu_q B$: that is,

$$\left(U_q\right)_1 = U_q - \mu_q B\,, \qquad (9.17)$$

$$\left(U_q\right)_2 = U_q + \mu_q B\,. \qquad (9.18)$$

According to Eqs (1.36), (1.44), and (2.14), the force of the electric dipole-dipole interaction of the quantum objects of the Cooper pairs decreases and the pairs may be destroyed. Thus, in this case, the superfluid (or superconductive) property of the medium may vanish.

Let us consider this case in detail for a superconductor with a Cooper pair consisting of electrons ($\mu_q = \mu_B$), and determine the dependence of the total electric dipole moment $\left(d_v\right)_t$ of the Cooper pair on the value of induction B of the magnetic field. Using Eqs (9.5), (9.7)–(9.8), (9.10)–(9.11) (at T=0), and (9.17)–(9.18), the value of the total electric dipole moment $\left(d_v\right)_t$ of the Cooper pair is determined to be

$$\left(d_v\right)_t = \left| \frac{\mu_B\left(U_q - \mu_B B\right)}{c\,p_q} - \frac{\mu_B\left(U_q + \mu_B B\right)}{c\,p_q} \right| = \frac{2\,\mu_B^2 B}{c\,p_q}\,. \quad (9.19)$$

Using Eq. (9.19), let us determine the expression for the critical value of the electric dipole moment $\left(\mathbf{d}_v\right)_t^c$ through the critical value of the magnetic induction $B = B_{c0}$ at which the superconductivity vanishes at T=0:

$$\left(d_v\right)_t^c = \frac{2\,\mu_B^2 B_{c0}}{c\,p_q}\,. \quad (9.20)$$

From Eqs (9.13) and (9.20), the expression for momentum p_q is as follows:

$$p_q = \frac{\left(U_q + kT_c\right)\sqrt{2m_e kT_c}}{2B_{c0}\mu_B}\left(1 + \sqrt{1 + \left(\frac{2B_{c0}\mu_B}{U_q + kT_c}\right)^2}\right). \quad (9.21)$$

Nonzero magnetic field at nonzero temperature

Let us consider Cooper pairs consisting of electrons in the *s*-state. In a magnetic field with induction B at nonzero speed y_p (according to Eq. [9.8], at nonzero temperature) and taking into account the action of moment **M** (Eq. [9.14]) the energies of the electrons in the pair respectively equal:

$$\left(U_q\right)_1 = U_q + kT - \mu_B B\,, \quad (9.22)$$

$$\left(U_q\right)_2 = U_q + kT + \mu_B B\,. \quad (9.23)$$

By using Eqs (9.5), (9.7)–(9.8), (9.10)–(9.11) (at T=0), and (9.22)-(9.23) the maximum value of the total electric dipole moment $\left(d_v\right)_t$ of the Cooper pair is determined to be

$$\left(\mathbf{d}_v\right)_t = \frac{\mu_{\rm B}\left(U_q + kT - \mu_{\rm B}B\right)}{c\left|\mathbf{p}_q + \mathbf{y}_p m_e\right|^2}\left(\mathbf{p}_q + \mathbf{y}_p m_e\right)$$

$$+\frac{\mu_{\rm B}\left(U_q + kT + \mu_{\rm B}B\right)}{c\left|-\mathbf{p}_q + \mathbf{y}_p m_e\right|^2}(-\mathbf{p}_q + \mathbf{y}_p m_e).$$

Assuming that $\mathbf{p}_q \uparrow\uparrow \mathbf{y}_p$ and using Eq. (9.8) the latter equation may be represented in the following form:

$$\left(d_v\right)_t = \left|\frac{\mu_{\rm B}\left(U_q + kT - \mu_{\rm B}B\right)}{c\left(p_q + \sqrt{2m_e kT}\right)} + \frac{\mu_{\rm B}\left(U_q + kT + \mu_{\rm B}B\right)}{c\left(-p_q + \sqrt{2m_e kT}\right)}\right|. \quad (9.24)$$

In the case of

$$U_q + kT > \mu_B B\,, \quad (9.25)$$

using Eq. (9.24) the value of $\left(d_v\right)_t$ may be represented in the following form:

$$\left(d_v\right)_t = \left|\frac{\mu_{\rm B}\left(U_q + kT\right)}{c}\frac{2\sqrt{2m_e kT}}{p_q^2 - 2m_e kT}\right| + \left|\frac{\mu_{\rm B}^2 B}{c}\frac{2p_q}{p_q^2 - 2m_e kT}\right|.$$

Using the latter equation let us determine the expression for the critical value of electric dipole moment $\left(\mathbf{d}_v\right)_t^c$ through the critical value of magnetic induction $B = B_{cT}$ (at which superconductivity vanishes at arbitrary temperature *T*).

$$\left(d_v\right)_t^c = \left|\frac{\mu_{\rm B}\left(U_q + kT\right)}{c}\frac{2\sqrt{2m_e kT}}{p_q^2 - 2m_e kT}\right| + \left|\frac{\mu_{\rm B}^2 B_{cT}}{c}\frac{2p_q}{p_q^2 - 2m_e kT}\right|. \quad (9.26)$$

9.2. The Dependence of the Critical Value of Magnetic Induction for a Superconductor on Temperature

To determine the dependence of the critical value of magnetic induction B_{cT} for a superconductor on temperature T the both sides of Eq. (9.26) are divided by $\left(d_v\right)_t^c$ and Eqs (9.13) and (9.20) are used. Then we have

$$\frac{B_{\mathrm{cT}}}{B_{\mathrm{c0}}}=\left(\frac{p_q^2-2m_ekT}{p_q^2}\right)$$
$$\square\left(1-\frac{\left(U_q+kT\right)\left(p_q^2-2m_ekT_c\right)}{\left(U_q+kT_c\right)\left(p_q^2-2m_ekT\right)}\left(\frac{T}{T_c}\right)^{1/2}\right), \qquad (9.27)$$

where B_{c0} is a critical value of magnetic induction at T=0.

In the case of

$$p_q \gg \sqrt{2m_ekT_c}\,, \qquad (9.28)$$

Eq. (9.27) may be rewritten in the following form:

$$\frac{B_{\mathrm{cT}}}{B_{\mathrm{c0}}}=\left(1-\frac{\left(U_q+kT\right)}{\left(U_q+kT_c\right)}\left(\frac{T}{T_c}\right)^{1/2}\right). \qquad (9.29)$$

A comparison of the theoretical and experimental data

The following equation is used for pure metals in the theory of superconductivity (Bardeen 1957):

$$U_q \approx 3.5kT_c\,. \qquad (9.30)$$

In this case, Eq. (9.29) is transformed as

$$\frac{B_{\mathrm{cT}}}{B_{\mathrm{c0}}}\approx\left(1-\frac{7}{9}\left(\frac{T}{T_c}\right)^{1/2}-\frac{2}{9}\left(\frac{T}{T_c}\right)^{3/2}\right). \qquad (9.31)$$

It follows from the experimental data that the following equation agrees well with the results of experiments:

$$\left(\frac{B_{\mathrm{cT}}}{B_{\mathrm{c0}}}\right)_{\mathrm{ex}} = \left(1-\left(\frac{T}{T_c}\right)^2\right). \qquad (9.32)$$

Let us compare the data obtained from Eqs (9.31) (which was obtained theoretically) and (9.32) (which was obtained in experiments) using, for example, the data for a superconductive pure metal, lead (*Pb)*: T_c =7.19K, B_{c0} =803 G (Corson 1999). In this case, $\sqrt{2m_e kT_c}$ =1.3445537·10^{-26} kg·m/s; according to Eq. (9.30), U_q =3.47277·10^{-22} J; and, according to Eq. (9.21), p_q =10^{-21} kg·m/s. Consequently, the Conditions (9.25) and (9.28) introduced in the deduction of Eq. (9.29) are justified in this case.

For a comparison of data obtained from Eqs (9.31) and (9.32), let us introduce the following factor *K:*

$$K = \left(\left(B_{cT} / B_{co}\right)_{\mathrm{ex}} - B_{cT} / B_{co}\right) / \left(B_{cT} / B_{co}\right)_{\mathrm{ex}}.$$

We obtained the following: at *T*=0 *K*=0; at $T = T_c$ *K*=0; and at $0 < T < T_c$ $K = 0 \div 0.4$.

Thus, the concept that superconductivity vanishes if the total electric dipole moment of the spin vortices created by the quantum objects constituting the Cooper pair exceeds the critical value, allows one to deduce theoretically the expression (9.31), while in the contemporary studies of superconductivity the analogous expression (9.32) is only obtained experimentally (Matthias 1963).

9.3. The Expulsion of a Magnetic Field from a Superconductor

The effect takes place in the case where the superconductor is exposed to an external magnetic field with induction $B < B_c$ at $T < T_c$ (B_c and T_c are the values of the induction of a magnetic field and the value of the temperature under which the superconductive properties vanish, respectively), and in the case where the superconductor is exposed to a magnetic field with induction B at $T > T_c$, the superconductor will be cooled down to the temperature of $T < T_c$ after that (the so-called Meissner–Ochsenfeld effect [Meissner and Ochsenfeld 1933]). This effect does not contradict the properties of physical vacuum consisting of QOs.

In the model of a physical vacuum consisting of QOs, magnetic field is determined by characteristics of the vacuum, see Eqs (4.7) and (4.9). According to Eqs (4.3)–(4.4), from equalities (9.1)–(9.2) it follows that the total spin and total electric dipole moment of QOs that constitute the physical vacuum in Cooper pair's location equals zero, which may influence the possibility of magnetic interactions in the physical vacuum.

Note. The physical phenomena that arise due to the action of the spin supercurrents between the spin vortices created by the quantum objects that take part in the phenomena may be absent in superconductive or superfluid media, because the quantum objects in these media form pairs with the total spin of the spin vortices created by the quantum objects of a pair equal to zero. For example, the quantum correlation and interaction between two parallel uncharged metal plates (the so-called Casimir effect and the Casimir-Lifshitz effect) are such phenomena.

CHAPTER TEN

THE EFFECT OF BIOLOGICALLY ACTIVE SUBSTANCES IN ULTRA-LOW DOSES AND LOW-INTENSITY PHYSICAL FACTORS ON BIOLOGICAL SYSTEMS

The following abbreviations are used in this chapter:

BAS—Biologically Active Substance
BS—Biological System
ULD—Ultra-Low Dose
NMR—Nuclear Magnetic Resonance
NP—Nanoparticle

10.1. The Effect of BAS in ULD on BS

10.1.1. The Properties of the Effect of BAS in ULD on BS

Ultra-low doses have concentrations of 10^{-13}M or lower. Note that the introduction of a substance in doses of 10^{-12} – 10^{-13}M into an organism will result in about 10 down to 1 molecules of the substance contained in a cell. That is, at concentrations of less than 10^{-13}M there will be, from the point of view of classical physics, no molecules from the substance in a cell. The levels of biological organization at which the action of BAS in ULDs is revealed are quite various: from macromolecules, cells, organs, tissues to plants and animals.

The features of the effects of BAS in ULDs on BS are as follows (Burlakova 1994):

1. The kinetic paradox: the effect of a BAS in ULD on a cell or an organism is strongest when the latter contains the same substance but in doses that are some orders of magnitude greater than the ULD used.

It is possible that Hahnemann's law of similars (*similia similibus curantur*) (Hahnemann 1796) can be seen as a consequence of the kinetic paradox.

2. A change in the sensitivity (generally, an increase) of the BS with respect to a subsequent exposure to the same BAS in ULD.

3. Dependence of the "sign" of the effect (inhibition or stimulation) on the initial state of the BS being treated.

4. An increase in side effects on an increase in the dose.

5. A non-monotonic, polymodal (oscillatory) dose-response (or dose-effect) dependence. In most cases, activity maxima are observed within definite ranges of doses, which are separated by so-called "dead zones". In some cases, the same effects are produced by doses of BASs differing in 5 to 8 orders of magnitude. There are also cases where a change in the "sign" of the effect is observed in the dose dependence.

6. The effect of a BAS in ULD may not be shielded by molecular substances.

There are a great number of works where the explanation of some of the effects of ULD is based on quantum mechanics concepts, such as quantized fluctuations and quantum coherence (quantum non-locality) or "singularities" in the physical vacuum (Milgrom 2006, Hankey 2009). However, there are no works drawing an analogy between the features of the effects of ULDs on BS and the features of a real physical process.

This section shows that there is a physical process in nature, which could underlie the effects of BAS in ULDs on BS and determine the above features of this effect (see also Boldyreva 2011 and 2013a, Boldyreva L. and Boldyreva E.

2012a). This process is the spin supercurrent that arises between the spin vortices created by the quantum objects that constitute BAS in ULDs, on the one hand, and by the quantum objects that constitute BS, on the other.

The characteristics of the spin vortices created by the quantum objects of BAS and BS are shown in Fig. 10-1. $\mathbf{S}_{BAS}$ and $\mathbf{S}_{BS}$ are the spins, $\boldsymbol{\omega}_{BAS}$ and $\boldsymbol{\omega}_{BS}$ are the spins' precession frequencies, β_{BAS} and β_{BS} are the deflection angles, α_{BAS} and α_{BS} are the precession angles relative to a reference line (r.l.), and $\left(I_{ss}\right)_z$ is the spin supercurrent component aligned with axis **z**.

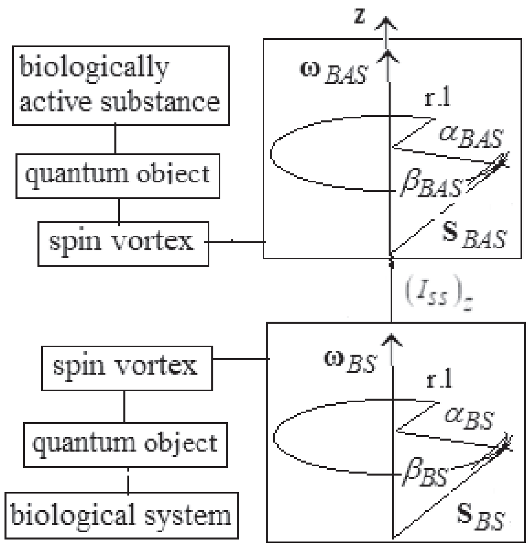


Fig. 10-1. The characteristics of spin vortices created by the quantum objects of BAS and BS: $\mathbf{S}_{BAS}$ and $\mathbf{S}_{BS}$ are the spins, $\boldsymbol{\omega}_{BAS}$ and $\boldsymbol{\omega}_{BS}$ are the precession frequencies, β_{BAS} and β_{BS} are the deflection angles, α_{BAS} and α_{BS} are the precession

angles relative to a reference line (r.l.), and $\left(I_{ss}\right)_z$ is the spin supercurrent component aligned with axis **z.**

In the case where the precession frequencies are aligned with axis **z**, the spin supercurrent component aligned with axis **z**, $\left(I_{ss}\right)_z$, may be determined to be

$$\left(I_{ss}\right)_z = -\left(g_1\right)_s \Delta\alpha - \left(g_2\right)_s \Delta\beta \ , \qquad (10.1)$$

where $\left(g_1\right)_s > 0$ and $\left(g_2\right)_s > 0$ are coefficients that are respectively dependent on coefficients g_1 and g_2 which were introduced in Section 2.2.1 (see Eq. [2.20]); $\Delta\alpha = \alpha_{BAS} - \alpha_{BS}$, $\Delta\beta = \beta_{BAS} - \beta_{BS}$ (Borovic-Romanov et al. 1989, Bunkov 2009, Dmitriev and Fomin 2009). Spin supercurrents tend to make the respective precession characteristics (precession and deflection angles) of the spins of interacting spin vortices equal. According to (2.32), the condition for the respective precession and deflection angles of the interacting BS and BAS to become equal, that is, for the effective action of spin supercurrent the following must hold:

$$\left|\boldsymbol{\omega}_{BAS}\right| - \left|\boldsymbol{\omega}_{BS}\right| \to 0 \,. \qquad (10.2)$$

Note. According to Eq (2.20), the effectivity of the interaction of spin vortices by means of a spin supercurrent depends not only on the difference between the values of the precession frequencies of spins of those spin vortices but also on the mutual orientation of their precession frequencies. For example, at a crossed mutual orientation, the interaction is missing (Klyshko 1994). However, in this work, only the difference between the values of the precession frequencies of the spins of these spin vortices will be considered.

10.1.2. Analogies Between the Properties of the Effect of BAS in ULDs on BS and the Properties of a Spin Supercurrent

Let us consider the above-mentioned properties of the effect of a BAS in ULD on a BS.

1. The kinetic paradox.

The effect of BAS in ULD on BS is most pronounced if the difference $\Delta\omega = \omega_{BAS} - \omega_{BS}$ meets Condition (10.2). Evidently, this is the case if the BAS's substance is contained in the BS in a sufficiently high dose. Then, among the values of the spin's precession frequencies of the spin vortices produced by the BS's quantum objects there will be a value close to ω_{BAS}.

2. A change in sensitivity (generally, an increase) of the BS with respect to a subsequent exposure to the same BAS in ULD.

The sensitivity of BS to the action of BAS is determined by difference $|\omega_{BAS} - \omega_{BS}|$: with its decreasing the sensitivity increases. As follows from Condition (2.25), after the action of a BAS in a ULD on a BS the spin's precession frequencies of the spin vortices created by the quantum objects of a BS and a BAS acquire values (respectively ω'_{BS} and ω'_{BAS}) satisfying the following condition:

$$|\omega_{BAS} - \omega_{BS}| > |\omega'_{BAS} - \omega'_{BS}|. \qquad (10.3)$$

By the subsequent exposure of a BS to the same BAS in ULD, taking into account Condition (10.3), the difference between the precession frequencies characterizing BS and BAS will satisfy the condition $|\omega_{BAS} - \omega'_{BS}| \le |\omega_{BAS} - \omega_{BS}|$. That is, the sensitivity of BS to a subsequent exposure to the same BAS in ULD is not decreased. However, this conclusion is only justified under the condition of the absence of “phase slippage” during the action of a BAS in ULD on a BS (see Section 2.2.1).

3. Dependence of the “sign” of the effect (inhibition or stimulation) on the initial state of the BS being treated.

According to Eq. (2.25), the action of spin supercurrents may result in a change in the precession frequencies of the interacting spin vortices. According to Eq. (1.2) for the photon and Eqs (1.32)–(1.33) for the virtual photon, the energy of the spin vortex associated with its precessing spin is proportional to the frequency of the precession. The “sign” of the change in the energy of each of the interacting spin vortices, as a result of action of spin supercurrent, is determined by the direction of the spin supercurrent between these vortices. Thus, the character (“sign”) of the effect of a BAS in ULD on a BS is determined by the direction of the spin supercurrent between the BS and the BAS. According to Eq. (10.1), the direction of the spin supercurrent between the spin vortices is determined by the difference in the precession angles $\alpha_{BAS} - \alpha_{BS}$ and the deflection angles $\beta_{BAS} - \beta_{BS}$ of the spins of these vortices. Consequently, at the beginning of the action of a spin supercurrent, its direction will be determined by the initial values of the precession angle and the deflection angle characterizing BS: respectively $\left(\alpha_{BS}\right)_0$ and $\left(\beta_{BS}\right)_0$.

4. An increase in side effects due to an increase in the BAS dose.

An increase in the dose of a BAS in ULD leads to appearance of several precession frequencies characterizing the BAS. When fulfilling Condition (10.2), a number of these BAS precession frequencies in ULD may effectively act on different BSs at the same time.

5. A non-monotonic, polymodal dose-response (or dose-effect) dependence.

An example of non-monotonic dose-effect dependence is shown in Fig. 10-2: the dependence of human mortality (caused by leukemia) on the value of the equivalent dose *d* of ionizing radiation (Yablokov 2002).

The curve is based on the data collected under E. Burlakova's guidance (Burlakova et al. 1999). With regard to the death rate *K*, the ratio of the number of deaths per 100000 person-years to the number of deaths caused by the equivalent dose *d* of about 23 mSv is used (the equivalent dose is a dose of radiation that takes into account the specificity of the action of any type of ionizing radiation on a human biological tissue on the basis of weighted radiation factors.) It is noteworthy that there is a range of values of *d* (at about 75 mSv), where the magnitude of *K* is less than that for the background value of *d* (about 2 mSv). It may be said that ultra-low doses of ionizing radiation in this range have a therapeutic effect.

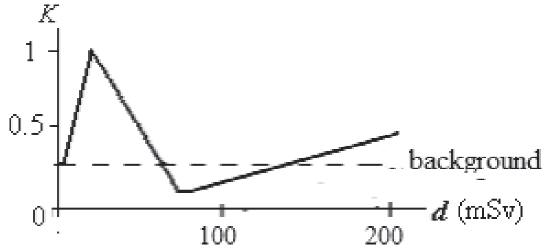


Fig. 10-2. The type of dependence of human mortality (caused by leukemia) on the equivalent dose *d*. *K* is the ratio of the number of deaths per 100000 person-years caused by arbitrary value of *d* to the number of deaths at *d*~23 mSv.

The nonmonotonic character of the effects of BAS in ULDs on BS shown in Fig. 10-2 is analogous to the type of dependence of the spin supercurrent on the precession angle (phase) under the phase slippage (see Fig. 2-5).

6. In the book by P. Bellavite and A. Signorine "The Emerging Science of Homeopathy" (Bellavite and Signorine 2002), we find that: "There is some preliminary evidence demonstrating a homeopathic effect not only of solutions but also of closed ampoules containing solutions and placed in contact with the system to be regulated (human or animal)."

This striking phenomenon, if confirmed, could be explained by property 8 (Section 2.2.1) of the spin supercurrent. Actually, whatever material the ampoule is made from, it is still a molecular substance. Spin supercurrents, through which the solution and "the system to be regulated" interact, propagate in a "finer" physical medium (the physical vacuum) than the molecular one. Therefore, spin supercurrents may not be shielded by molecular substances.

Thus, all of the above-mentioned features of the effects of ULD of BAS on BS are analogous to the properties of the spin supercurrents arising between the spin vortices created by the quantum objects that constitute BAS in ULD, on the one hand, and BS, on the other.

Let us consider the case where BAS is not used in an ultra-low dose. This means that the BAS creates a great number (w) of spin vortices in the physical vacuum. In this case, if the precession frequencies of the spins of the spin vortices are aligned with $\boldsymbol{\omega}_{BS}$, then the total spin supercurrent I_{sum} is determined to be $I_{sum} = \sum_{i=1}^{w} I_i$, where I_i is the spin supercurrent between the spin vortex created by the quantum object of BS, on the one hand, and the arbitrary i-th spin vortex created by the quantum object of BAS, on the other. While using Eq. (10.1): $I_{sum} = -\sum_{i=1}^{w} \left((g_1)_s \, \Delta\alpha_i + (g_2)_s \, \Delta\beta_i \right)$, where $\Delta\alpha_i$ and $\Delta\beta_i$ are the difference in the precession angles and the difference in deflection angles, respectively, for the spin vortices in question. If all the values and signs of $\Delta\alpha_i$ and $\Delta\beta_i$ are respectively equiprobable and $w \to \infty$, then

$$I_{sum} \to 0 . \tag{10.4}$$

In terms of the model of the effects of BAS on BS discussed in the present work, Condition (10.4) means that spin supercurrents cease to be the predominating factor that governs its effects and the latter will be determined by other physical factors. Thus, the spin supercurrent determines the action of BAS on BS only when BAS is used in ULD.

10.2. The Effect of Low-Intensity Physical Factors on BS

10.2.1. The Effect of Low-Intensity Electromagnetic Radiation on BS

Electromagnetic radiation is referred to as low-intensity radiation if its flux density is less than 1 μW/cm^2 (Burlakova 1994). Electromagnetic radiation consists of quantum objects (photons), which are spin vortices in a physical vacuum consisting of QOs. Consequently, they may interact with the spin vortices created by BS's quantum objects by means of a spin supercurrent. Thus, the same physical process underlies the action of both an ULD of BAS and low-intensity electromagnetic radiation on a BS (Boldyreva 2015b). Section 1.1.1 showed that the frequency ω_{ph} of a photon equals the frequency of the precession of its spin. Consequently, by analogy with BAS in ULD, the condition of the effective action of electromagnetic radiation on BS is as follows:

$$\omega_{ph} - \omega_{BS} \to 0 . \tag{10.5}$$

The experiments conducted prove this theoretical conclusion: the character of the obtained results is in accordance with the properties of the spin supercurrent. As an example, the action of a low-intensity magnetic field on the erythrocyte count in the blood of rats will be considered. Fig. 10-3 shows the difference *A* between the erythrocyte count in the blood of the test group rats and the blood of the control group rats (not exposed to the magnetic field), divided by the erythrocyte count in the blood of control group, against the magnetic field strength *H*. The frequency *f* of the magnetic field is 10 Hz (Makeev and Temuryanz 1982). The dependence is non-monotonic.

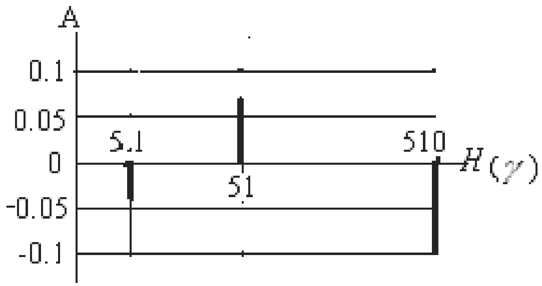


Fig. 10-3. The effect of a magnetic field on the characteristics of rat blood. *A* is the difference between the erythrocyte count in the blood of the test group rats and the control group rats (not exposed to the magnetic field), divided by the erythrocyte count in the blood of control group, against the magnetic field strength *H*. The frequency *f* of the magnetic field is 10 Hz.

Like in the experiments referred to by P. Bellavite and A. Signorine (Bellavite and Signorine 2002), the spin supercurrents in this case will pass through various shielding screens including electromagnetic screens. That is, we will have a paradoxical situation: the action of electromagnetic radiation on BS is affected through the electromagnetic screens.

10.2.2. The Effect of Field-Free Magnetic Vector Potential on BS

Section 4.4 gave the principle of the action of field-free magnetic vector potential. The magnetic vector potential affects the characteristics of the spin vortices created by quantum objects in the physical vacuum (Boldyreva 2019b). Thus, the effect of magnetic vector potential on BS may be similar to that of BAS in ULD or of low-intensity electromagnetic radiation. There is experimental evidence of the therapeutic action of field-free magnetic vector potential on BS.

In the experiment described below, a device consisting of permanent magnets of 150 mT magnetic induction arranged in a form of torus was used as a source of magnetic vector potential with the maximum value equal to $3.5 \cdot 10^{-4}$ T·м, while magnetic field **B**=0 (Fig. 10-4) (Trukhan 2009).

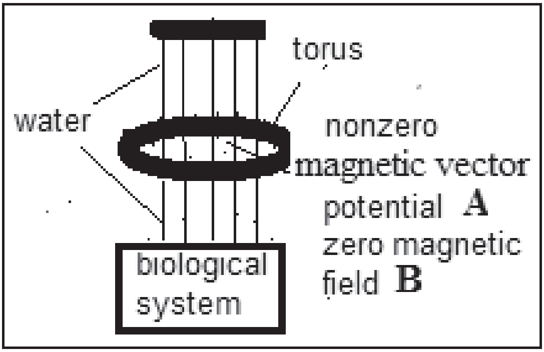


Fig. 10-4. Experimental setup. The water passes through the torus center in the region of zero magnetic field **B** and nonzero magnetic vector potential **A** to the BS.

Two types of studies were carried out in the experiment:
1) the "indirect" (i.e., with the use of an intermediate medium) action of field-free magnetic vector potential on BS;

2) the “direct” action of field-free magnetic vector potential on BS.

The first type of study. Distilled water was passed through the torus center (“exposed” water); the “exposed” water dwell time in the region of vector potential was as great as 40-50 msec. Then the water was added to the solution with preincubated infusoria *Spirostomum ambiguum* in the experimental sample. The relative change in the motion activity index (MAI) of the experimental infusoria sample with respect to that of the control infusoria sample was evaluated. In the control sample, the solution with infusoria was supplemented with the same volume of “unexposed” water: i.e. water that had not passed through the region of the field-free magnetic vector potential. The experiments show that the values of MAI (as a number of intersections of a marker line by infusoria for 5 minutes) for the experimental samples are greater than those for the control samples by a factor of 1.5. Thus, the results of the experiment suggest that the water passed through the region of field-free magnetic vector potential changes the characteristics of the BS.

The second type of study (Novoseletskiy et al. 2004). The effect of the field-free magnetic vector potential on the extent of lysis (cell destruction) in the lymphocyte suspension. Lymphocytes were extracted from human venous blood using the standard technique of flotation in the density gradient. The suspension of the lymphocytes at 20–25ºC was exposed to the field-free magnetic vector potential for 60 minutes. After the exposition, the lysis extent changed in comparison with the control value (6%) of the suspension not exposed to the potential. It is noteworthy that the 900 min long exposition did not result in a difference in the lysis extent (Fig. 10-5).

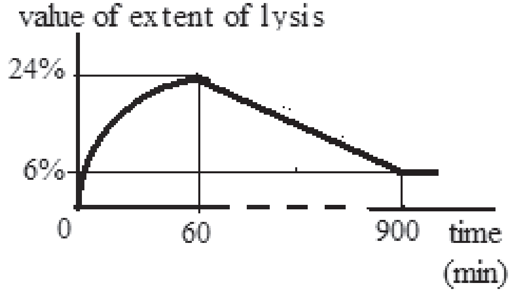


Fig. 10-5. The extent of lysis in the suspension of lymphocytes vs. the duration of the exposition of the suspension in the region of the field-free magnetic vector potential (900 min).

The results of the discussed experiments support the validity of the supposition (4.10) about the influence of the magnetic vector potential on the characteristics of the spin of spin vortices. In the first type of study, this potential influences the characteristics of the spins of the spin vortices created by the quantum objects of water, and then the interaction of these vortices with the spin vortices created by the quantum objects of a BS takes place. In the second type of study, this potential directly influences the characteristics of the spins of the spin vortices created by the quantum objects of a BS.

The cessation of the influence of a magnetic vector potential over time is similar to the property of a spin supercurrent. From the definition of the spin supercurrent, Eq. (2.20), it follows that, if the differences between the angles of precession and between the angles of the deflection of interacting spin vortices become equal to zero (as a result of the action of the spin supercurrent), the spin supercurrent ceases.

10.2.3. The Effect of a BAS in ULD on a BS Through "Information" Matrices

In Section 10.2.2, the case where the magnetic vector potential influences a BS by an indirect method was considered: magnetic vector potential–water–BS. Essentially, the intermediate substance, water, is an information matrix in this case.

According to a considered model of influence of a BAS in ULD on a BS by means of a spin supercurrent, the action of information matrix on the BS may be represented by the following schema (Fig. 10-6). I_{BAS-im} is the spin supercurrent between the spin vortices created by the quantum objects of a BAS, on the one hand, and the spin vortices created by the quantum objects of the information matrix, on the other. I_{im-BS} is a spin supercurrent between the spin vortices created by the quantum objects of an information matrix, on the one hand, and the spin vortices created by the quantum objects of a BS, on the other.

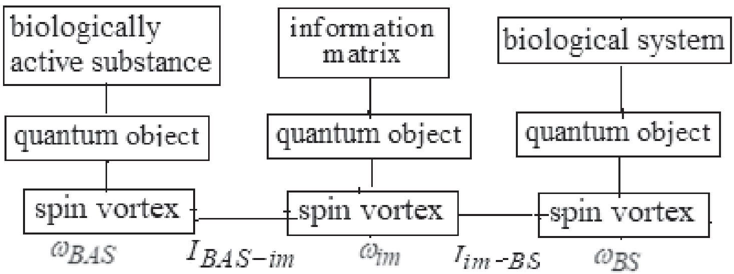


Fig. 10-6. A diagram showing the use of an information matrix in the action of a BAS in ULD on a BS. I_{BAS-im} and I_{im-BS} are spin supercurrents; and ω_{BAS}, ω_{im}, and ω_{BS} are the frequencies of the precession of the spins in spin vortices discussed here.

According to Eq. (2.25), as a result of the action of a spin supercurrent I_{BAS-im}, the following takes place: $\left|\omega_{BAS}-\omega_{im}\right|>\left|\omega'_{BAS}-\omega'_{im}\right|$, where ω_{im} is the precession frequency characteristic of the spin of the spin vortex created by the quantum object of an information matrix; ω'_{BAS} and ω'_{im} are the frequencies of the precession of spins of respective spin vortices after the action of a spin supercurrent I_{BAS-im}. Let us assume that the difference $\omega_{im}-\omega'_{im}$ is connected with ω_{BAS} and introduce the following denotation:

$$k_{BAS-im}=\left(\omega_{im}-\omega'_{im}\right)/\,\omega_{BAS}. \qquad (10.6)$$

As a result of the action of a spin supercurrent I_{im-BS}, the following takes place: $\left|\omega'_{im}-\omega_{BS}\right|>\left|\omega''_{im}-\omega'_{BS}\right|$, where ω''_{im} and ω'_{BS} are the values of the frequencies of the precession of respective ω'_{im} and ω_{BS} after the action of a spin supercurrent I_{im-BS}. Using (10.6), the latter inequality may be written in the following form: $\left|\omega_{im}-k_{BAS-im}\omega_{BAS}-\omega_{BS}\right|>\left|\omega''_{im}-\omega'_{BS}\right|$. Thus, the information matrix may take part in the transfer of the characteristics of BAS (in particular, the values of precession frequencies) to BS.

The information matrix may be a light beam. The light beam, in particular laser beam, passing through a BAS may be modulated by frequency ω_{BAS}. When meeting Condition (10.5), such a light beam may act on a BS like a BAS in ULD (Gariaev 2015).

10.2.4. The Quantum Correlations Between BSs

The theoretical aspects of quantum correlations were analyzed in Section 2.2.2. Let us consider an example illustrating the possibility of correlation between BSs. In 1991, Yu Tyagotin carried out the following experiment. Cells grown in the same medium (mice cells containing normal splenocyte chromosomes) were divided into two parts. After that, one of the parts was placed in noxious conditions. As a result, not only the cells of that part perished, but also the cells of the other part that were in favorable conditions (Tyagotin 1993). It should be noted that, as both parts of the cells were grown in the same medium, the condition (2.32) holds for the frequencies of the precession of the spins of the spin vortices created by both parts of cells. Thus, according to the principles of quantum mechanics, the transmission of diseases from one BS to another is possible by the means of quantum correlations.

The conducted experiment suggests that the probability of the transmission of diseases must also be high for identical twins, since Condition (2.32) must hold in this case. Indeed, the investigation of a great number (~500) of identical twins showed that only almost 40% of all diseases have a genetic component even though identical twins share 100% of their genetics. The following special notation was introduced: Twin Correlation (Lakhani 2019).

It was shown in Section 2.2.2 that quantum correlations are performed by a spin supercurrent. In order to prove that a spin supercurrent may transmit disease, let us consider a particular example: change in the energy characteristics (the temperature) of a BS2 at a change in the temperature of a BS1 (Boldyreva 2019c). Let us introduce the following denotations: $(\omega_1)_0$, $(\alpha_1)_0$, and $(\beta_1)_0$ are the frequency of precession, the angle of precession, and angle of deflection, respectively, characterizing a spin vortex produced by a quantum object that constitutes BS1, before an increase in temperature; $(\omega_2)_0$, $(\alpha_2)_0$, and $(\beta_2)_0$ are similar characteristics of the spin vortex produced by a quantum object that constitutes BS2 before an increase in temperature. (For simplicity, it is supposed that BS1 and BS2 contain one quantum object each). It is suggested that in the initial state the spin supercurrent is absent because the following equalities hold:

$$(\omega_2)_0 = (\omega_1)_0,\ (\alpha_2)_0 = (\alpha_1)_0,\ (\beta_2)_0 = (\beta_1)_0. \qquad (10.7)$$

Let us assume that the temperature of BS1 increases by Y degrees at $t=\tau$. In this case, the energy of BS1 changes by value kY (k is the Boltzmann constant) and, according to Eqs (1.32)–(1.33), the precession frequency characterizing BS1 changes by $kY/\hbar$: that is, at $t=\tau$, this frequency (denote it as $(\omega_1)_\tau$) equals

$$(\omega_1)_\tau = (\omega_1)_0 + kY/\hbar. \qquad (10.8)$$

If the energy $\hbar(\omega_1)_\tau$ connected with frequency $(\omega_1)_\tau$ of spin vortex equals the kinetic energy of quantum object creating this spin vortex, then, according to Eqs (1.54) and (10.8), the angle of deflection of BS1 at $t=\tau$, $(\beta_1)_\tau$, equals

$$\begin{aligned}(\beta_1)_\tau &= \arcsin(u/c)\\ &= \arcsin\left(\sqrt{2\left(\hbar(\omega_1)_0 + kY\right)\Big/m_q}\;/\;c\right),\end{aligned} \qquad (10.9)$$

where m_q and u are respectively the mass and speed (at $t=\tau$) of BS1's quantum object, c is the speed of light.

Let us determine the spin supercurrent $(I_{ss})_{\tau+\Delta\tau}$ performing the transmission of the disease from BS1 to BS2 in arbitrary time $t=\tau+\Delta\tau$, supposing that in time interval

$\tau \div \tau + \Delta\tau$ the changes in the precession frequencies and the deflection angles of BS1 and BS2 were negligible as a result of action of spin supercurrent. (Due to equalities (10.7) the spin supercurrent equals zero in time interval $0 \div \tau$ and, consequently, the values of the precession frequencies and the deflection angles of BS1 and BS2 do not change during this interval). Thus the following holds:

$$\left.\begin{array}{l}(\omega_1)_{\tau+\Delta\tau} = (\omega_1)_\tau, \ (\omega_2)_{\tau+\Delta\tau} = (\omega_2)_\tau = (\omega_2)_0, \\ (\beta_1)_{\tau+\Delta\tau} = (\beta_1)_\tau, \ (\beta_2)_{\tau+\Delta\tau} = (\beta_2)_\tau = (\beta_2)_0.\end{array}\right\} \quad (10.10)$$

Using Eqs (2.23)-(2.24), (10.8) and (10.10) one may determine the precession angles of BS1 and BS2 at $t = \tau + \Delta\tau$ (before the action of spin supercurrent):

$$(a_1)_{\tau+\Delta\tau} = (a_1)_0 + \tau(\omega_1)_0 + \Delta\tau \cdot \left((\omega_1)_0 + kY/\hbar\right), \quad (10.11)$$

$$(a_2)_{\tau+\Delta\tau} = (a_2)_0 + \tau(\omega_2)_0 + \Delta\tau \cdot (\omega_2)_0. \quad (10.12)$$

In accordance with definition (Eqs [10.1]), spin supercurrent $(I_{ss})_{\tau+\Delta\tau}$ is determined as:

$$(I_{ss})_{\tau+\Delta\tau} = \Big[(g_1)_s\left((\alpha_1)_{\tau+\Delta\tau} - (a_2)_{\tau+\Delta\tau}\right) + (g_2)_s\left((\beta_1)_{\tau+\Delta\tau} - (\beta_2)_{\tau+\Delta\tau}\right)\Big].$$

According to Eq. (2.20), if $(\mathbf{I}_{ss})_{\tau+\Delta\tau} > 0$ then the spin supercurrent is directed from BS1 to BS2.

From inequalities (2.21)–(2.22), it follows that the difference between precession angles $\Delta\alpha$ and that between deflection angles $\Delta\beta$ of BS1 and BS2 after the action of the current must satisfy the conditions:

$$|\Delta\alpha| \le \left|(\alpha_1)_{\tau+\Delta\tau} - (a_2)_{\tau+\Delta\tau}\right|, \quad (10.13)$$

$$|\Delta\beta| \le \left|(\beta_1)_{\tau+\Delta\tau} - (\beta_2)_{\tau+\Delta\tau}\right|. \quad (10.14)$$

Using Eqs (10.7)–(10.12) we have: $\left|\left(\alpha_1\right)_{\tau+\Delta\tau}-\left(a_2\right)_{\tau+\Delta\tau}\right|=\Delta\tau kY$ and $\left|\left(\beta_1\right)_{\tau+\Delta\tau}-\left(\beta_2\right)_{\tau+\Delta\tau}\right|=$ $=\left|\arcsin\left(\sqrt{2\left(\hbar\left(\omega_1\right)_0+kY\right)/m_q}\,/\,c\right)-\left(\beta_2\right)_0\right|.$

From these expressions it follows: the Conditions (10.13)–(10.14) are fulfilled provided temperature's difference between BS1 and BS2 becomes, in particular, less than *Y*.

Thus, two processes may exist simultaneously between two biological systems as a result of the action of spin supercurrent: disease transmission from an ill organ to a healthy organ and an inverse process that has a therapeutic effect.

10.2.5. The Effect of Cavity Structures on BS

There is much evidence for the influence of cavity structures (pyramids, empty honeycombs, porous materials, bundles of long tubes, and others) on BS. Examples of such influence are considered in detail in Section 6.2. It has also been shown that the cavity structure's effect on BS may be accomplished by a spin supercurrent (see Section 6.1 and [Boldyreva 2013b]).

10.2.6. The Effect of Metal Nanoparticles on BS

The main applications of metal nanoparticles (NPs) in medicine are targeted drug delivery, treatment, diagnosis, monitoring, and control of diseases. In spite of the extensive studies undertaken to establish the mechanism of the action of NPs, particularly metal NPs, on BS, it seems that many points remain unclear. Meanwhile, without a clear understanding of the processes underlying the biological effects of metal NPs one can hardly hope to give well-founded recommendations for the safe application of metal NPs in medicine (Egorova 2010).

As follows from recent studies, the medical effect of compound metal NPs on the cell of a biological organism is not determined in many cases by the action of the metal ions. For example, with regard to the toxic effect of AgNP, NPs cannot be reduced to the action of Ag+ ions in equivalent concentrations; this conclusion was made in studies on the AgNP interaction with bacteria (Egorova 2010) and fish embryos (Asharani et al. 2008). Therefore, there are grounds to assume that the biological action of silver NPs can be realized through a different mechanism than that of Ag+ ions (that is, it is not due to electric forces).

This Section shows that many features of the effects of metal NPs on BS in drug delivery and the treatment of diseases are similar to the properties of a spin supercurrent arising between the spin vortices created by quantum objects that constitute NPs, on the one hand, and BS, on the other (see also Boldyreva 2014a).

1) There is a nonmonotonic dependence of the efficacy of the NPs' action on a BS on the size of NPs. For example, experiments with *E. coli* established the nonmonotonic dependence of the toxic effect of silver NPs on NP size (Egorova 2010, Lok et al. 2007). Fig. 10-7 shows the type of dependence of the normalized toxicity rate $T_r / T_r^{'}$, ($T_r = T_r^{'}$ at $d = 9nm$) on NP size d.

Fig. 10-7. The type of dependence for the normalized toxicity rate $T_r / T_r^{'}$, ($T_r = T_r^{'}$ at $d = 9$ nm) on the NP size d.

The nonmonotonic "size-effect" dependence is analogous to the dependence of the spin supercurrent on the difference in precession angles of interacting spin vortices if the phase slippage effect takes place (see property 5, Section 2.2.1).
2) The efficacy of NPs depends on their form. For example, in experiments on the action of AgNP NPs on *E. coli* (Egorova 2010, Pal et al. 2007), it was found that the toxic action of AgNP depended on their form: triangular particles were more active than spherical ones.

As shown in Section 6.1 (Eq. [6.1]), the special energy properties of the form of ambient bodies (cavity structures) are due to the emergence of spin supercurrents in them.
3) There are two methods of drug targeting: active targeting using external physical factors (for example, a magnetic field or heating) and passive targeting where drug delivery is performed due to the properties of the medication and/or the drug carrier (Sato et al. 2013). It is known (Zhang et al. 2009) that the NPs of precious metals are used as drug carriers in passive targeting.

Different metals may perform passive targeting on different biological organs. For example, gold nanoshells may selectively diagnose cancer cells (Mozafari 2006), depending on the nanoshell's size and charge (Allen and Cullis 2004). Note that metals whose NPs effectively "adhere" to certain organs have to be present in the organism before the introduction of NPs. For example, iron ions are known to be present in the form of reserve protein ferritin in the spleen; silver is contained in the brain, liver, kidneys, and bones; and gold is found in the blood.

There are ways of amplifying the adhesion effect and increasing the number of cases where it can take place. For example, hyperthermia in tumor cells seems to induce modifications in the cell surface receptor molecules and this means that tumor cells are more readily recognized by killer cells (Multhoff et al. 2005).

It is experimentally established that the adhesion of metal NPs (particularly colloid metal NPs) to the cell surface is not to be due to electrostatic forces (Oberdorster et al. 2005). That is, there is a possibility of an interaction of NPs and BS by other types of interaction, in particular, through spin supercurrents. Let us substantiate this supposition.

As the action of a spin supercurrent tends to equalize both the precession and deflection angles of the spins of interacting spin vortices (see Eqs [2.21]–[2.22]) then, while fulfilling Condition (10.2), as a result of action of this current the spins of interacting spin vortices ($\mathbf{S}_1$ and $\mathbf{S}_2$, respectively) will be oriented in the same direction: that is, $\mathbf{S}_1 \rightarrow\rightarrow \mathbf{S}_2$. According to Condition (1.41), electric dipole moments ($\mathbf{d}_1$ and $\mathbf{d}_2$, respectively) of these spin vortices also will be oriented in the same direction: $\mathbf{d}_1 \rightarrow\rightarrow \mathbf{d}_2$.

In this case, there are two types of forces between the quantum objects that produced the vortices: 1) a pseudomagnetic attractive force acting between the quantum objects with oriented spins (see Section 2.4); 2) an electric dipole-dipole attractive force. Due to the fact that non-electrostatic forces determine the adhesion of metal NPs to the cell surface, it follows that the pseudomagnetic force is predominant.

From this point of view, the use for targeting NPs of metals which are already contained in the cells under study and the hyperthermia in tumor cells should be looked upon as a search for methods that fulfill Condition (10.2), i.e. the condition of the equality of the frequencies of the precession of the spin vortices produced by the quantum objects that constitute the NP, on the one hand, and those of spin vortices produced by the quantum objects that constitute the diseased organ, on the other. Fulfilling Condition (10.2) (due to the action of spin supercurrent) also means fulfilling Condition (2.36): i.e., the condition for the action of pseudomagnetic force.

> *Note*. From the point of view of possibility of fulfilling Condition (10.2) Fe NPs are the most desirable as they have "free" electrons' spins that may take any direction. Consequently, spin supercurrent in this case may accomplish affective equalizing the spin characteristics of spin vortices created by Fe NPs and objects affected.

4) The medical action of NPs is determined by their intrinsic properties and does not depend significantly on the presence of a protective shell. For example, conclusions have been drawn by the researchers in terms of the medical effect of AgNP NPs (Egorova 2010:253): "Antimicrobial effect of AgNP is clearly expressed not only in water medium, but also in studies of solid materials with NPs deprived of their protective shell."

The independence of the action of NPs on a BS of the existence of the NPs' protective shells is similar to the property of a spin supercurrent: the independence of both molecular and electromagnetic screening (Property 8, Section 2.2.1).

5) It is an experimental fact that 3D NPs, which are spiral shaped, deform and even unwind the spiral when penetrating a DNA molecule. One example of such NPs are fullerenes (computer simulations have shown that fullerenes, namely, spherical C60 molecules, are potentially dangerous to DNA molecules [Zhao et al. 2005]). Another example is dendrimers: 3D and higher generation dendrimers have a form which is similar to a sphere (Nanjwade et al. 2009).

The observed results of action of 3D NPs may be a consequence of spin supercurrent effect. The spin supercurrent is distinct from other physical processes, most notably, in that it transforms angular momentum due to equalizing the respective angles of the precession and deflection of the spins of spin vortices created by interacting quantum object.

The possibility of transforming angular momentum allows one to use 3D NPs against viruses. Let us consider it in detail.

The nanoparticles against viruses.

The main properties of viruses (they replicate inside the cell of all type of life forms, from animals and plants to microorganisms; have the shape from simple helical and icosahedral forms to more complex structures; are surrounded by a protective protein “coat”; have very small size equal to the one-hundredth the size of most bacteria) determine the properties of the physical process that may influence viruses.
The comparative analysis of the properties of spin supercurrent and viruses shows that the spin supercurrent may effectively influence viruses, that is this current is able to change the viruses’ characteristics.

1. The viruses consist of one of the types of nucleic acid (DNA-deoxyribonucleic acid or RNA-ribonucleic acid), that is, viruses are quantum objects creating spin vortices in a physical vacuum consisting of QOs.
The spin supercurrent emerges between spin vortices created by any quantum objects: electrically charged and neutral, magnetized and non-magnetized, constituting a living and non-living system.

2. The viruses are surrounded by a protective protein “coat”.
The action of spin supercurrent is not shielded by electromagnetic and molecular screens.

3. The viruses have the shape from simple helical and icosahedral forms to more complex structures.

The spin supercurrent transforms angular momentum and, consequently, as a result of its action the change in the form of interacting objects may take place.

Consequently, one of the methods of influencing viruses is to change their form, for example, to deform and even unwind their helical forms (Boldyreva 2021a).

Thus, the features of the interaction of a NP with a BS are determined by the action of the spin supercurrents produced between the spin vortices created by the NP's quantum objects, on the one hand, and the spin vortices created by the BS's quantum objects, on the other. Consequently, according to Condition (10.4) (Section 10.1.2), the fact that NPs have a small size is of fundamental importance for effective action of spin supercurrent on viruses.

10.3. The Combined Action of Low-Intensity Physical Factors (Including BAS in ULD) and Intensive Physical and Chemical Factors in Medicine

Intensive physical and chemical factors used in medicine refer, in particular, to intensive radiotherapy and chemotherapy, which are effective remedies for a lot of diseases and nearly all malignant tumors. However, these remedies have the disadvantage of negatively affecting healthy organs. One of the ways to minimize this negative effect is the precise delivery of remedies to the diseased organ. Another method is decreasing the doses of radiation and chemical agents due to their combined action with low-intensity physical factors (Boldyreva 2017b). It was shown in the previous sections that such factors are BAS in ULD, infralow frequency magnetic fields, the field-free magnetic vector potential, information matrices, the quantum correlation of quantum objects, the cavity structure effect, and the NP effect. The effect of all of the above-mentioned factors on a BS takes place due to their action (in particular, by spin supercurrent) on the spins of the spin vortices created by the quantum objects that constitute the BS.

BAS in ULD (including those used in homeopathy)

Studies have shown that the use of BAS in ULD increases the sensitivity of BS to subsequent exposure to intensive physical and chemical factors (Fiedler and Kipen 1997). This allows one to achieve a positive therapeutic effect by using lower doses of intensive factors. For example, a complex mix of preparations (in homeopathic doses), such as *hydrastis*, *chamomilla ipecacuanha*, *nux vomica*, *condurango*, and *carbo vegetabilis*, combined with intensive radiotherapy and chemotherapy can heal serious diseases of the lymphatic system. Whereas, in contrast, only using intensive factors in greater doses may result in complete irreversible disability for the whole organism.

Infralow frequency electromagnetic field

The BS's high sensitivity to low-frequency, low-intensity electromagnetic fields makes the combined use of these fields and intensive physical and chemical factors a reasonable method of treatment in medicine. For example, studies have shown the advisability of using low-intensity γ-radiation in doses of ~10cGy and less at the first stage of treating oncological diseases (esophageal cancer, breast cancer, or carcinoma of lung) and using irradiation in a therapeutic dose of 1.9Gy at the second stage. In such a multistage treatment, cancer growth inhibition and the tumor's degradation were much more pronounced than when low-dose pre-radiation had not been performed (Little 1990).

The field-free magnetic vector potential

As shown in Section 10.2.2, the field-free magnetic vector potential may influence the properties of BS, in particular when performing therapeutic actions. Consequently, it is possible to increase the therapeutic action of the remedies used by a patient, if the remedies are exposed to a field-free magnetic vector potential with definite therapeutic properties.

The quantum correlation

Based on the property of quantum correlations (Section 2.2.2), the following recommendations for nursing care can be given. It is desirable that the preparation of food and care are performed by a patient's healthy relative. The energy characteristics of quantum objects that constitute the patient's diseased organ may be similar to their relative's identical organ. In this case, quantum correlations are possible between the same organs of the diseased person and his/her healthy relative. Thus, a correction (healing) of the diseased organ may take place. However, there is a possibility that the patient can "infect" the relative, although the "disease" may be absolutely noncontagious from the standpoint of medical science (see Section 10.2.4 for more detail).

Cavity structures

In Section 6.2, much evidence was provided of the specific influence exerted on BSs by ambient bodies that have a cavity structure (empty honeycombs, mesh structures, porous materials, bundles of tubes, pyramids, and so on). It is recommended that cavity structures should be used in addition to the application of intensive physical and chemical factors. Besides, it is useful to follow definite recommendations concerning the forms of the room where the patient resides. The patient's bed should not be placed in a corner of the room or in a very narrow room. The ceiling above the bed should not be bent inwards, as it is better for it to be dome shaped like in religious buildings. If the ceiling is flat, then a canopy can be arranged over the bed. (It should be noted that pharaohs and emperors' sleeping places were in the center of room under a canopy.) The following method of self-healing may be used: laying the palms of the hands on a problem area of the body so that the fingers of one hand are at angle to the fingers of the other hand, thus forming a grate (Section 6.2, Fig. 6-14(d)).

Nanoparticles

It is known that in passive targeting with the use of NPs active biological substances can penetrate deeply into the tissue. Consequently, NPs can be used for the precise delivery of chemical remedies to the diseased organ. For example, gold nanoshells may selectively diagnose cancer cells (Mozafari 2006) (see Section 10.2.6 for more detail).

10.4. A Theoretical Approach to the Selection of a BAS in ULD for Effective Action on a BS

The term "effective action" means that, as a result of the action of a BAS in ULD on a BS, the respective characteristics of the spins in the spin vortices created by quantum objects of BAS in ULD and BS become identical. The most pronounced effect in the action of BAS in ULD on BS takes place while Condition (10.2) holds. Consequently, when selecting a BAS in ULD for effective action on a BS it is necessary to know the precession frequencies, ω_{BAS} and ω_{BS}, of the spins in the spin vortices created by the quantum objects that constitute the BAS in ULD and the BS in the physical vacuum.

This section considers some methods for determining the precession frequencies of the spins of spin vortices (see also ([Boldyreva 2018a]) on the basis of: 1) data of the energy levels of the quantum objects that constitute BS and BAS; 2) the determination of the frequencies of photons that are effectively acting on BS; and 3) the use of the spin vortex spin's spin-flip effect, which is initiated by the action of the alternating electric field (the spin-flip effect takes place when the varied frequency of the electric field equals the precession frequency of the spin).

10.4.1. The Determination of the Precession Frequencies of the Spins of Spin Vortices Created by Quantum Objects while Analyzing Their Energy Levels

According to Equality (1.33), the spin precession frequency ω_v of a spin vortex (virtual photon) created by a quantum object is the frequency of its Schrodinger's wave function and, according to Eqs (1.32)–(1.33), this is related to the energy U_q of the quantum object:

$$\omega_v = U_q / \hbar . \tag{10.15}$$

Generally, a quantum object is characterized by energy levels: $\left(U_q\right)_1, \ldots, \left(U_q\right)_i, \ldots, \left(U_q\right)_n, \ldots,$ ($\left(U_q\right)_0$ is the zero level). A diagram of the energy levels of a quantum object is shown in Fig. 10-8. From Eq. (10.15), it follows that the possible values of spin precession frequencies—$\left(\omega_v\right)_1, \ldots, \left(\omega_v\right)_i, \ldots, \left(\omega_v\right)_n$––that characterize the spin vortex created by the quantum object are, respectively, equal to $\left(\omega_v\right)_1 = \left(U_q\right)_1 / \hbar, \ldots,$ $\left(\omega_v\right)_i = \left(U_q\right)_i / \hbar, \ldots, \left(\omega_v\right)_n = \left(U_q\right)_n / \hbar$.

Thus, generally, a BS and a BAS are characterized by a spectrum of the possible values of the spin precession frequencies of the spin vortices created by the quantum objects that constitute the BS and the BAS.

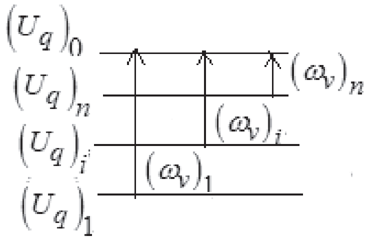


Fig. 10-8. The energy levels of a quantum object: $(U_q)_1,\ldots,$ $(U_q)_i,\ldots,$ $(U_q)_n$, $(U_q)_0$. ($(U_q)_0$ is the zero level); $(\omega_v)_1,\ldots,$ $(\omega_v)_i,\ldots,$ $(\omega_v)_n$ are the spectrum of the possible values of the spin precession frequencies of the spin vortices (virtual photons) created by a quantum object. The arrows show the transitions between the energy levels.

According to Eq. (10.15), the spin precession frequency $(\omega_{BS})_i$ of a spin vortex created by a quantum object of energy $(U_{BS})_i$ that constitutes BS is determined to be $(\omega_{BS})_i = (U_{BS})_i / \hbar$. Similarly, the spin precession frequency $(\omega_{BAS})_i$ of the spin vortex created by a quantum object of energy $(U_{BAS})_i$ that constitutes the BAS is determined to be $(\omega_{BAS})_i = (U_{BAS})_i / \hbar$.

Therefore, in order to determine the possible frequencies of the spin precession of the quantum vortices produced by the BAS's and the BS's quantum objects, it is necessary to know the magnitudes of the quantum objects' energy levels.

10.4.2. The Determination of the Precession Frequencies of the Spins of Spin Vortices Created by Quantum Objects of BS While Analyzing the Effect of Photons on BS

As follows from Section 1.1.1, the spin precession frequency of the spin vortex constituting the photon is equal to the photon frequency ω_{ph}. From the comparison of conditions (10.2) and (10.5), it follows that the effect of the BAS in ultra-low doses on a BS can be replaced by the effect of low-intensity photon beams if the following equality is true:

$$\omega_{ph} = \omega_{BAS} . \qquad (10.16)$$

(It should be noted that the effect on BS of photons that do not belong to a low-intensity electromagnetic radiation may be performed mainly by electric and/or magnetic photon components.)

It is worth noting that essentially the same approach (equality [10.16]) was used by Paracelsus, an outstanding physician and philosopher in the 15th century (Hartmann 1887), for treating some diseases. For example, Paracelsus thought that a disease whose symptoms were like those of anemia (in terms of modern medicine) could be cured by radiation from Mars. This conclusion was based on the fact that this type of disease was treated by iron-containing preparations of red color and Mars is a reddish color, which accounts for the name “red planet”. (Note that the color of the planet is due to the presence of iron oxide on its surface.)

According to Condition (10.5), by analyzing the action of photons on the BS, one may determine the precession frequencies of the spins in the spin vortices created by the quantum objects that constitute the BS.

The determination of the photon frequency meeting condition (10.5) can be performed by two methods: 1) the analysis of the characteristics of photons on which the BS exerts effective action; and 2) the analysis of the state of the BS on which the photon acts.

Method 1. The photon beam under study passes at a small distance from the BS (for example, in experiments described in [Sargsyan et al. 2010] the distance was 10–15mm). The amplitude and frequency modulation of the photon beam are measured. The experiments show that the BS impacts the photon beam, and the character of the impact depends on the state of the BS. By varying the photon frequency, one may determine the frequency at which the impact on the photon beam is most pronounced for the given state of the BS.

Method 2. The BS is irradiated by a photon beam and its state is analyzed. For example, electric signals from different points of the BS and acupuncture points' electric resistance are measured (Nakatani 1953). The frequency of the photons varies in these experiments and the frequency is determined to be where the reaction of the BS is most pronounced.

From the above, it follows that "color-therapy" is possible. Indeed, if any frequency ω_{ph} of an unabsorbed light beam that passes through the body (it is this frequency that determines the body's color) satisfies the Condition (10.5), then the color of the body is able to exert an effective action on a nearby BS.

10.4.3. The Use of Spin-Flip Effect for Determining the Frequencies of the Precession of the Spins of Spin Vortices

The method is based on the possibility of the spin-flip effect (the spin inversion) of the precessing spin of the spin vortex under the action of the alternating electric field. The method is similar to the one used in the spin-flip effect in nuclear magnetic resonance (NMR). Fig. 10-9 illustrates the NMR method (McKinstry 1986). The nucleus' spin $\mathbf{S}_n$ (we accept that $\mathbf{S}_n$ is oriented along the nucleus' magnetic moment $\boldsymbol{\mu}_n$

as it takes place in a proton) precesses in the magnetic field of constant induction **B** with frequency $\mathbf{\Omega}_B$. In the magnetic field of induction **b** rotating with frequency $\mathbf{\Omega}_b$, $\mathbf{b} \perp \mathbf{\Omega}_B$, the spin-flip effect may take place under the following condition:

$$\mathbf{\Omega}_B = \mathbf{\Omega}_b . \qquad (10.17)$$

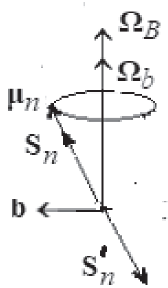


Fig. 10-9. A diagram illustrating NMR. $\mathbf{\Omega}_B$ is the frequency of the precession of spin $\mathbf{S}_n$, $\mathbf{S}'_n$ is the inverse direction of the nucleus spin, **b** is the magnetic induction, $\mathbf{\Omega}_b$ is the frequency of rotation of **b**, and $\boldsymbol{\mu}_n$ is the nucleus spin magnetic moment.

A spin-flip in a spin vortex produced by a quantum object may be performed in the following way: the quantum object creating this spin vortex (the spin of the latter precesses with frequency $\boldsymbol{\omega}_v$) is placed in the region of electric field **E** rotating with frequency $\boldsymbol{\omega}_E$. Under the action of moment $\mathbf{M} = \mathbf{d}_v \times \mathbf{E}$, the precession of electric dipole moment $\mathbf{d}_v$ relative to **E** emerges. According to Eq. (1.41), the spin $\mathbf{S}_v$ is connected with this dipole moment. The inversion of moment $\mathbf{d}_v$ and, consequently, of spin $\mathbf{S}_v$ takes place under the following conditions (Sedov 1971–1972): $\mathbf{E} \perp \boldsymbol{\omega}_v$ and

$$\boldsymbol{\omega}_v = \boldsymbol{\omega}_E . \qquad (10.18)$$

Fig. 10-10 illustrates the spin-flip effect of spin $\mathbf{S}_v$ precessing with frequency $\boldsymbol{\omega}_v$. In Fig. 10-10, the direction of the spin after the inversion is shown by vector $\mathbf{S}_v^{'}$. As the inversion of the spin is accompanied by the inversion of $\mathbf{d}_v$, then, knowing the frequency $\boldsymbol{\omega}_E$ at which the generation of the electric impulse caused by inversion of $\mathbf{d}_v$ takes place, and using Eq. (10.18), it is possible to determine ω_v.

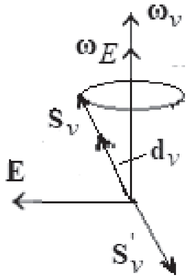


Fig. 10-10. A diagram illustrating the inversion of the spin vortex's spin. $\boldsymbol{\omega}_v$ is the frequency of the precession of the spin $\mathbf{S}_v$, $\boldsymbol{\omega}_E$ is the frequency of the rotation of **E.** $\mathbf{d}_v$ is the electric dipole moment of the spin vortex, and $\mathbf{S}_v^{'}$ is the inverse direction of $\mathbf{S}_v$.

The following differences exist between NMR and the spin-flip effect of the spin vortex's spin: 1) in NMR the spin of the quantum object is investigated but not the spin of the spin vortex created by the quantum object; 2) in NMR the spin-flip effect is caused by an alternating magnetic field, and not by an alternating electric field as in the spin-flip effect of the spin vortex's spin; and 3) NMR is accompanied by the generation of a magnetic pulse since the quantum object has the spin magnetic dipole moment, the spin vortex has the electric dipole moment, and its spin-flip effect is accompanied by the generation of an electric pulse.

Note. As shown in Section 4.4 the magnetic vector potential affects the characteristics of spin vortices created by quantum objects in the physical vacuum. This feature of magnetic vector potential may account for its using for spin's inversion instead of alternating electric field (Boldyreva 2018a).

10.5. Long-Range Frequency Coherence in BS

A spin supercurrent arises not only between the spin vortices created by quantum objects that constitute a BAS, on the one hand, and the spin vortices created by the quantum objects that constitute a BS, on the other hand, but also between the spin vortices created by the quantum objects that constitute the same BS. If a change in the spin characteristics of a spin vortex (for example, the vortex having spin precession frequency ω_1) created by a quantum object of BS takes place, then the action of the spin supercurrent may lead to similar changes in other spin vortices created by the other quantum objects that constitute the same BS. The changes will be most pronounced for the spin vortex whose spin precession frequency ω_2 satisfies condition (2.32): i.e., $\omega_1 - \omega_2 \to 0$. From this point of view, it may be said that the so-called long-range frequency coherence (Fröhlich 1988) of BS at frequency ω_1 takes place. (The size of the area of coherency at any frequency depends on the properties of the BS).

In such a way a change in one organ of BS may spread onto adjacent or distant organs, with the most pronounced changes occurring in organs that have similar functions to the organ where the initial changes occurred (for these organs Condition (2.32) must be fulfilled). We may suppose that, for example, metastases emerging from neoplasms may spread in this way. One of the ways of halting the spread of the changes in spin characteristics is the use of an external action on the spins. The spin-flip effect can be used in such an action. The inversion of spin in the spin-flip effect results in changes in the spin deflection angle (by π) and the spin precession angle. The change in the deflection angle affects coefficients g_1 and g_2 in Eq. (2.20) that determine the value of the spin supercurrent. A considerable change in the precession angle, according to the properties of spin supercurrent (Section 2.2.1, property 5), may cause a phase slipping and, as a result of this, a change in the sign of the spin supercurrent. Thus, the spin flip may cause a change in the spin supercurrent both in terms of magnitude and direction; consequently, it may be used for ceasing the spread of the metastases that emerge from neoplasms.

Chapter Eleven

Physical Aspects of Some Magic Rites

Researchers of magic rites can be divided into two groups: those who look upon these rites as being caused by people's ignorance (for example, the well-known anthropologist E. Tylor [Tylor 1871]), and those who think that their origin lies in the existence of certain physical processes in nature. It is known that the great mathematician and philosopher, Pythagoras, and his followers treated magical rites quite seriously (Dorandi 2013). Albert Einstein wrote the following in a letter to Dr. Herman Peisach about the rituals that are aimed at searching for underground water and buried ores, etc., which are often performed with the use of some type of dowsing rod (Einstein 1946): "I know very well that many scientists consider dowsing as a type of ancient superstition. According to my conviction this is, however, unjustified. The dowsing rod is a simple instrument which shows the reaction of the human nervous system to certain factors which are unknown to us at this time."

The famous anthropologist, James George Frazer, was the first person to use the properties of the physical vacuum to explain some peculiarities of magic rites, in particular those of contagious magic, which is based on the belief that things that have once had contact with each other could continue interacting after they have been separated. With regard to the physical principles which could underlie contagious magic, Frazer wrote, "things act on each other at a distance through a secret sympathy, the impulse being transmitted from one to the other by means of what we may conceive as a kind of invisible ether" (Frazer 1823).

This work shows that the physical vacuum consisting of QOs may be such a "kind of invisible ether". With this aim in mind, based on the properties of the physical vacuum (see Section 4.1) and the properties of the spin supercurrent (see Section 2.2.1) emerging in this physical vacuum, the following "miracles" performed by both ancient and contemporary magicians ("psychics") will be considered (see also, Boldyreva 2018e):

1) the selective mental influence on remote bodies (living and non-living);
2) locating hidden cavity structures (for example, underground water and underground caves), including dowsing;
3) the structuring of space around the psychic: the production of periodically repeating areas characterized by an increase in the energy radiated by the psychic (ancient people called these areas "magic rings" or "charmed rings", which allegedly protect the person against malicious influence);
4) the ability to change the psychic's weight (in particular, levitation);
5) the ability to become invisible;
6) the transmutation of the system of chemical elements (alchemy);
7) obtaining information about a non-living person.

11.1. Selective Mental Influence on Remote Objects (Contagious Magic)

Under James George Frazer's classification, two types of magic exist (Frazer 1823): (1) homeopathic magic based on the principle of similars ("*similia similibus curantur*") (see also [Hahnemann 1796]); and (2) contagious magic based on the belief that "the things which have once been in contact with each other continue to act on each other at a distance after the physical contact has been severed", and that the distance between the things being interacted was of no importance. For example, there was custom among primitive peoples to thoroughly hide baby teeth that had fallen out, severed hair, nails, or pieces of food, so that whoever had possession of them could not use his/her ill will against their former owner. In Australia, there was a custom of stealing one's enemy's things (e.g. a garment) in order to beat them soundly or roast them in a fire with the aim of doing harm to the enemy. It is clear that cases of remote mental influence by contemporary psychics on various physical bodies must also be classified as contagious magic for the following reasons: first, the "establishing the contact" stage is necessary for a successful psychic to influence a body; and, secondly, the efficiency of this influence does not depend on the distance as it is not taken into account when performing contagious magic rites.

Besides the direct contact with the body of future influence or with the things connected to the body, "establishing contact" by magicians or contemporary psychics may be performed at a distance. The second method may be realized in a number of ways. For example, the fabrication of the so-called "doll" was practiced, to which the enemy's peculiars were mentally ascribed and then harm was done to the "doll". The psychic can also "tune" his or her own organism in such a way that the maximum effect can be achieved when influencing the body. In ancient times, magicians used narcotic substances for that purpose, and the Pythia of the Delphian oracle made predictions being exposed to a noxious vapor located in the temple (Parke and Wormell 1956). Even now, shamans in Siberia wind themselves up for psychomotor agitation with "shamanic dances".

The method of “tuning” is most often used in experiments with contemporary psychics. For example, in experiments conducted by V. Kartsev (Kartsev 2002), a psychic found at small distance that his influence over mice was most effective when he played a “garmonika” (a type of button accordion). After that, the psychic effectively influenced mice at a distance of 30 km using such a method. The famous psychic, E. Dubitskiy, described his method of tuning for cancer treatment (the treatment was conducted successfully by Skype from Moscow to New York) in the following way: “the mental materialization of ‘elementary’ particles (electrons, protons, neutrons) and directing the beam to the target, on which cancer cells have been placed mentally”. In other experiments, in order to change the temperature of a semiconductor inside a microcalorimeter, E. Dubitskiy used the following mental images: the compression of atoms and changes in their speeds (Dubitsky 2002). A unique psychic, A. Vdovin, cured multiple sclerosis over the phone imagining that he was a snake squirming inside the body of the patient and eating the bacteria covering the nerves. The psychic S. Soloviov influenced a micro-teslameter G-79 (which measures magnetic induction) at a distance of about 15 km while imagining that the “rays stretched from his hands to the sensor” (Dulnev 2002).

Let us analyze the particulars of a psychic’s mental influence on remote bodies (see also Boldyreva and Sotina 2002a and 2002b) and compare them with the properties of a spin supercurrent (Section 2.2.1) (Boldyreva 2018e).

1) *The necessity of establishing contact*

This feature is in accordance with property 5 of the spin supercurrent: the effective interaction of spin vortices in a physical vacuum consisting of QOs by means of a spin supercurrent takes place under Condition (2.32), that is under the equality of the precession frequencies of the spins of interacting spin vortices. Consequently, establishing contact is necessary for equalizing the precession frequencies of the spins of the spin vortices created by the quantum objects that constitute the psychic's organism, on the one hand, and the spins of the spin vortices created by the quantum objects that constitute the body being influenced, on the other.

Note that, according to Eq. (2.20), the effectiveness of the interaction of the spin vortices by means of a spin supercurrent depends not only on the difference between the values of the precession frequencies of the spins of these spin vortices but on the mutual orientation of their precession frequencies. For example, there is no interaction at a crossed-over mutual orientation. It is possible that, at the stage of establishing contact, the correction of the mutual orientation of the precession frequencies of the spins of the spin vortices created by the quantum objects that constitute the psychic's organism and the body being influenced takes place.

2) *Independence from distance*

The variation of the distance between the psychic and the influenced body did not affect the result. For example, in experiments by K. Korotkov in which the psychic influenced a gas-discharge detector (Korotkov 2002) the distance varied in the range of 0.5 m to several km, with the result being the same; in experiments by G. Dulnev in which the psychic influenced a micro-teslameter G-79 (Dulnev 2002) the distance varied in the range of 0.5 m to 15 km, with the similar result; and in experiments by G. Gurtovoy and A. Parkhomov (Gurtovoy and Parkhomov 1993, Parkhomov 2002) in which the psychic influenced a microcalorimeter, the distance varied in the range of 0.5 m to 2000 km, with the same result.

It should be noted that the independence from the distance rules out the hypothesis of the thermal or acoustic nature of a psychic's influence.

This feature is in accordance with property 6 of the spin supercurrent: the spin supercurrent arises between the spin vortices independent from the distance between them.

3) *Independence from the presence of electromagnetic screens*

Screening the object being influenced from electromagnetic radiation did not affect the result produced by the psychic and, in some cases, it made it even more distinct (Gurtovoy and Parkhomov 1993, Parkhomov 2002).

This feature of mental influence is in accordance with property 8 of the spin supercurrent: i.e., the spin supercurrent is not screened by electromagnetic screens.

4) *The ability to transmit information*

Psychics have demonstrated the ability to transmit information to the body. For example, while influencing a semiconductor noise generator (the source of *flicker noise*), the psychic could, on the one hand, suppress the signal at the generator's output at will, and, on the other, they could also produce a train of pulses (these experiments were conducted by A. Parkhomov [Parkhomov 2002]). While influencing the concentration of the gas emitted by the cucumber's slices (these experiments were conducted by H. Kokubo, et al. [Kokubo 2011]), the psychic could make their odor more distinct or suppress it.

This property is in accordance with the definition of spin supercurrent (Eq. [2.20]): the sign of the spin supercurrent and, consequently, the result of its action may change under a change in the characteristics of the spins of the spin vortices between which the spin supercurrent arises.

Based on the above analogies between the action of a psychic on remote bodies and the properties of a spin supercurrent (Section 2.2.1), the action of a psychic may be represented by the scheme analogous to that given in Fig. 10-1, which demonstrates the action of a biologically active substance on a biological system. In both cases, a spin supercurrent emerges between the spin vortices, which are created by quantum objects; in this case, they were created by quantum objects that constitute the psychic's organism, on the one hand, and the remote body, on the other hand.

11.2. Locating a Hidden Cavity Structure: Dowsing

Analysis of experimental evidence on locating underground water, and buried ores, etc. (sometimes performed with the use of some type of dowsing rod) makes it possible to specify the main features of locating (Betz 1995, Bondarenko 2002) and compare them with the properties of a spin supercurrent (Section 2.2.1). According to Condition (6.1), the energetic properties of a cavity structure are determined by the spin supercurrents existing in the cavity structure. Let us represent a spin supercurrent I_{ss} emerging in a cavity structure as three summands:

$$I_{ss} = \left(I_{ss}\right)_1 + \left(I_{ss}\right)_2 + \left(I_{ss}\right)_3, \qquad (11.1)$$

where $\left(I_{ss}\right)_1$ is the spin supercurrent between the spin vortices created by the quantum objects of the cavity wall substance, $\left(I_{ss}\right)_2$ is the spin supercurrent between the spin vortices created by the quantum objects of the substance contained in the cavity, and $\left(I_{ss}\right)_3$ is the spin supercurrent between the spin vortices created by the cavity wall substance, on the one hand, and the spin vortices created by the substance contained in the cavity, on the other.

Let us consider the following features of locating.

1) *The dependence of the effectiveness of locating on the form and the substance of a cavity structure (including a cavity wall substance and the substance contained in that cavity),*

The dependence of the effectiveness of locating on the form and the substance of the cavity structure under study may be explained using the properties of spin supercurrents $(I_{ss})_1$ and $(I_{ss})_2$ (Eq. [11.1]). It follows from Eq. (2.20) that the values of $(I_{ss})_1$ and $(I_{ss})_2$ are determined through coefficient g_1 and g_2 by the properties of the substance where the spin supercurrent emerges: that is, by the properties of the cavity wall substance and of the substance contained in the cavity, respectively. As shown in Section 6.1, the values of $(I_{ss})_1$ and $(I_{ss})_2$ depend on the structure's form.

2) *The dependence of the effectiveness of locating on the difference in the characteristics of the cavity wall substance and the substance contained in the cavity. In many cases, the effectiveness is highest when the substances are in different phase states: solid and liquid, solid and gas, etc.*

These properties may be explained by the following: the less difference between the respective characteristics of the cavity wall and the substance contained in the cavity structure, the less the spin supercurrent $(I_{ss})_3$, which is in accordance with Eq. (2.20). Thus, the probability of location of the cavity structure decreases.

3) *The dependence of the effectiveness of dowsing on the substance and form of the dowsing rod.*

The condition of the effective interaction of spin vortices by means of a spin supercurrent is Condition (2.32): the difference between the precession frequencies of the spins of interacting spin vortices must be negligible. Consequently, the substance of the rod or other auxiliary object similar to that being searched must be used to decrease the difference in the values of the spin precession frequencies that are characteristic of the system—dowser/dowsing rod, on the one hand, and the system—cavity structure/substance contained in it, on the other. For example, while searching a cavity containing oil it is useful to hold a vial with oil in one's hands (Bondarenko 2002).

It should be noted that, according to Eqs (2.21) and (2.22), the action of a spin supercurrent on spins is analogous to the action of a moment that changes the angles of the precession and the deflection of these spins. This may explain why in the course of locating with the use of a rod the latter *rotates* in the area of cavity structures.

4) *The negligible screening of the action of the cavity structure on the dowser and the rod. The dowser can detect underground water located 100 meters below the ground.*

According to the eighth property of the spin supercurrent (Section 2.2.1): the spin supercurrent is not screened by electromagnetic and molecular screens. However, the dissipation of this current is possible when it passes through the Earth's stratum.

Thus, the main properties of dowsing are described by the properties of a spin supercurrent.

11.3. The Structuring of Space by Psychics

In 2011, Japanese researchers, H. Kokubo, O. Takagi, and Y. Nemoto, conducted unique experiments on psychics' non-contact effect on bio-sensors. Cucumber slices were used as bio-sensors and the concentrations of the gas emitted by the slices were measured (Kokubo et al. 2011). The recurring zones of the increased concentrations of gas emitted by the slices were observed. The characteristics of the recurring zones (number, form, and thickness of zones; the distances between them) were determined by the psychic's ability to create these zones (the psychic was at the center of the circles). An approximate schematic picture of the observed recurring zones is shown in Fig. 11-1: the radius r of the external zone in these experiments was only limited by the size of the setup (r~250cm); and the thickness δ of the maximum concentration zone was ~15cm.

Fig. 11-1. Approximate schematic picture of observed recurring zones created by a psychic: r is the radius of external zone, and δ is the thickness of the maximum concentration zone.

The emergence of these recurring zones may be explained by the properties of the physical vacuum consisting of QOs and the properties of spin supercurrents. Any person may interact with the physical vacuum by means of the spin supercurrents arising between the spin vortices created by the quantum objects that constitute the person's organism, on the one hand, and the QOs that constitute the physical vacuum, on the other. (It must be taken into account that, according to Eqs. [4.2]-[4.3], spin vortices consist of QOs.) As shown in Section 7.1.3, the spin supercurrent may influence the density of the physical vacuum consisting of QOs. If the speed of the spin supercurrent is greater than the speed of the propagation of contraction in the vacuum, density jumps in the physical vacuum consisting of QOs emerge, which create recurring zones.

According to the experimental data, recurring zones created in the physical vacuum are not screened by molecular screens, which is in accordance with property 8 (see Section 2.2.1) of spin supercurrents.

According to Flack (2005), density jumps are accompanied by shock waves. Consequently, psychics are able to not only create recurring zones but also shockwaves. It is possible that the ability of some persons to destroy bricks with only a hand motion and without touching the bricks is due to their ability to create shockwaves.

Note. Similar recurring zones accompanied by elevated magnetic field strength were observed in experiments with rotating magnets conducted by S. Godin and V. Roshchin (Roshchin and Godin 1999 and 2000). These zones were like concentric cylindrical "walls" around rotating magnets and were arranged equidistantly. (Note that the magnetic field strength is proportional to the physical vacuum density, see Eq. [4.9].) The observed recurring zones are not shielded by molecular substances (for more detail, see Section 7.1.3).

11.4. Changes in Weight: Levitation

According to witness testimonies (one of the witnesses was Russian emperor, Alexander 1), Russian orthodox Saint Seraphim of Sarov (1759–1833) rose from the ground during a fervent prayer (Zander 1975). Shamans of Buryatia can hover for several seconds in the air at a height of 0.5m with 30 kg of metallic objects attached to them, after a 24-hour fast and dancing, including rotations. All of the shamans' rites include the rotation motion where, at the right-hand rotation, a decrease in weight may take place.

The phenomenon of decreasing weight is also observed in biological systems, in experiments with rotating bodies, and in a rotating magnetic field (for more details, see Section 7.2).

This phenomenon may be explained by the possibility of spin and, according to Condition (4.4), electric polarization of a physical vacuum consisting of QOs. In inhomogeneous electric field the force may act on quantum objects located in the area of polarized vacuum (in detail see Section 7.2).

11.5. Short-Term Invisibility

The magic items “Invisibility Cloak” (“Mantle of Invisibility”) and “Cap of Invisibility” occur frequently in folklore and fairy tales (Hansen 2004). However, these items do not only belong to myths and legends, as short-term invisibility is observed in nature. For example, upon exposing the cocoon of an ichneumon from the Ichneumonidae family, which belongs to the Bathyplectes anurus species (cocoon of a parasitic fly or wasp), to sunlight a short-term invisibility took place (Grebennikov 2006). In experiments conducted by J. Searl in 1940–1950 (Sandberg 1985 and 1987) with a rotating nonlinear magnetic field at the critical value of the speed of rotation the experimental setup began to rise and then disappeared.

The Gospel of Luke (New Testament: Gospel of Luke) states that when Nazarites “were filled with wrath” over Christ preaching in the synagogue and wanted to shove him off the mountain where the town was situated, “he passing through the midst of them went his way”. It is unknown how Christ passed “through the midst” of people “filled with wrath” but the possibility that he became invisible should not be excluded.

This phenomenon may be explained by the properties of a physical vacuum consisting of QOs (Section 5.4). This vacuum is a luminiferous medium, but at the QOs’ spins “freezing” (Eq. [5.33]) the electromagnetic oscillations could not spread in this vacuum. The “freezing” of QOs’ spins may take place, in particular as a result of the action of spin supercurrent emerging in the physical vacuum consisting of QOs (see also 7.1.5).

11.6. The Transmutation of the System of Chemical Elements: Alchemy

It has been known from ancient times that some people have the ability to perform transmutation on the system of chemical elements. Most of them have tried to convert any substance into gold; they are usually called “alchemists” (Ragai 1992). Most “alchemists” used the so-called philosophers’ stone (which may, in fact, be a powder or solution) to perform this. This elixir is supposed to help to perform the transmutation.

The possibility of the transmutation of the system of chemical elements is in accordance with the properties of spin supercurrent, see Section 2.2.1, and is explained by the interaction by means of the spin supercurrents of the spin vortices created by the quantum objects constituting the organism of “alchemist” with the spin vortices created by the quantum objects of the substance influenced. It is possible that the philosophers’ stone is used for the same purpose as a dowsing rod, see Section 11.2, which increases the effectiveness of the action of the spin supercurrent due to fulfilling Condition (2.32) between the interacting spin vortices.

11.7. Obtaining Information About a Non-Living Person

There is experimental data that substantiate the existence of the physical vacuum spin system’s “memory”. For example, the outstanding psychic, L. Korabelnikova, while identifying people by their belongings perceived the deceased as being alive for 9 days after their death (Korabelnikova gained great experience while rescuing people in town Spitak in Armenia, after the earthquake in 1988). It is possible that the belief commonly held by many peoples that the “soul” of a deceased person remains for some days on the Earth is based on the existence of this “memory”.

Similar phenomena can also be observed with cavity structures: for example, after removing a pyramid its properties may, for some days, be observed in the now empty place (Section 6.1).

This phenomenon may be explained by the properties of the physical vacuum, which consists of QOs (Section 7.4), and by the properties of spin supercurrents (Section 2.2.1). From Conditions (2.21)–(2.22), it follows that, as a result of the action of the spin supercurrent arising between the spin vortices created by the quantum objects that constitute a person's organism, on the one hand, and the QOs that constitute the physical vacuum, on the other hand, this vacuum "acquires" some of the properties of that person's organism. In the absence of disturbances, due to conservation of angular momentum connected with spins of QOs that constitute the physical vacuum these properties may remain unchanged for some time after removing the person or object from the region of their former location.

Conclusion to Chapter 11

The above "miracles" accomplished by both ancient and contemporary magicians (they are often called "psychics") are due to the processes taking place in a physical vacuum consisting of QOs. These processes are spin supercurrents that emerge between spin vortices (virtual photons) created by quantum objects that constitute a person's organism, on the one hand, and spin vortices (virtual photons) created by quantum objects that constitute the body being influenced or QOs that constitute the physical vacuum, on the other. Consequently, the ability of any person to accomplish a miracle is determined by his/her ability to control the characteristics of spins (orientation, precession frequency) of the spin vortices (virtual photons) created in the physical vacuum by the quantum objects that constitute the person's organism.

CONCLUSION

Listed below are a number of the phenomena that are explained in this work, which takes the following into account: 1) a quantum object creates a spin vortex in a physical vacuum consisting of quantum oscillators (QOs); and 2) spin vortices can interact by means of spin supercurrents.

It should be noted that many of these phenomena have not yet had any physical interpretation.

I. *Corpuscular-wave dualism*.

Any quantum object (the state of which is described by the wave function) can create a spin vortex having precessing spin in a physical vacuum consisting of QOs. If a spin vortex is created by a quantum object with non-zero rest mass it may also be called “virtual particles pair” or “virtual photon” (these names are used in Feynman’s diagram).

The characteristics of the spin precession in a spin vortex determine the characteristics of the wave function of the quantum object creating this spin vortex: the precession frequency of the spin equals the wave function frequency; the precession angle (phase) equals the wave function phase; and the size of the spin vortex as an electric dipole equals the wave function wavelength.

II. *Quantum correlations*.

The quantum correlations between quantum objects are performed by the spin supercurrents arising between the spin vortices created by interacting quantum objects in a physical vacuum consisting of QOs. The fact that the spin supercurrent is a process equalizing the order parameter in the quantum liquid described by a single wave function (for example, in superfluid ^{3}He-B) proves that the speed of spin supercurrent theoretically equals infinity. This explains the possibility of the correlations of photons emitted simultaneously and separated in space.

III. ***So-called "relativistic" mass of bodies*****.**

The "relativistic" mass of a body equals the sum of the masses of the spin vortices created by quantum objects that constitute the body. To an accuracy of u^2 / c^2 (u is the object's speed and c is the speed of light) the expression for this sum coincides with that for the "relativistic" mass m_r determined by the Lorentz transformation: $m_r = m_0\left(u^2 / \left(2c^2\right) + o\left(u^2 / c^2\right)\right)$, where m_0 is the body's rest mass and $o\left(u^2 / c^2\right)$ are summands of a higher order of smallness than u^2 / c^2.

IV. ***Inertial properties of a quantum object*****.**

Both summands of a quantum object's mass (rest mass and "relativistic" mass) are created in spin vortices. The rest mass is created in the spin vortex constituting the photon, whose decay results in the creation of this quantum object; the "relativistic" mass is created in the spin vortex produced by this quantum object. The value of every summand is determined by the precession frequency of the spin of a respective spin vortex. Thus, the inertial properties of the quantum objects may be explained by the "gyroscopic" properties of mass.

V. ***A change in the size of a system of electric charges set in motion with the system being in equilibrium only under the action of electrostatic forces (the Lorentz experiment).***

A change in the size of a system of moving electric charges may take place as a result of the electric dipole-dipole interaction of the spin vortices created by these moving electric charges.

Besides, the size of the system may decrease in the direction of motion, because the projection of the total spin of the spin vortices created by the system's quantum objects on velocity **u** of its motion is decreased by factor $\sqrt{1-u^2/c^2}$.

VI. ***The equalization of the speed of light in an inertial system.***

The speed of light is made equal to value c in an inertial system due to the interaction of the spin vortices that constitute the photons and the spin vortices created by the quantum objects that constitute the inertial system and which, in fact, determine its inertial properties.

The formula for the transformation of a photon's energy (from $\hbar\omega_{ph}$ to $\hbar\omega_d$) when it passes from one inertial system to another inertial system moving relative to the first one at velocity **v** is determined by the following expression: $\hbar\omega_d = \hbar\omega_{ph}(\mathbf{c}+\mathbf{v})^2/\left(2c^2\right)+\hbar\omega_{ph}/2$.

VII. ***Longitudinal and transverse Doppler effects.***

The above formula for the transformation of photon's energy when the photon passes from one inertial system to another inertial system moving relative to the first one at velocity **v** describes these effects.

VIII. ***The spin-orbit interaction of an electron in an atom*.**

Since the spin vortex is an electric dipole, the spin-orbit interaction of an electron in an atom is connected with the moment acting in the electric field of the atomic nucleus on the spin vortex created by the electron.

IX. ***Magnetic interactions*.**

Since the moving charged quantum object creates a spin vortex in a physical vacuum consisting of QOs, the electric current is a vortex line in the vacuum. Thus, the magnetic interaction of electric currents is, essentially, an interaction of the vortex lines created by these electric currents in a physical vacuum consisting of QOs. The following equation has been deduced: $\mathbf{B} = \boldsymbol{\upsilon}\sqrt{4\pi\rho}$, where **B** is magnetic induction, $\boldsymbol{\upsilon}$ is the velocity of the physical vacuum, and ρ is the density of the physical vacuum.

X. ***Equations describing the electromagnetic process with due account for quantum and gyroscopic properties of the latter.***

The electromagnetic process is a wave-vortex-spin process in a physical vacuum consisting of QOs. The following equations describing this process were deduced:

$$\partial\left(k_S \cdot \mathbf{S}\right)/\partial t = -curl\boldsymbol{\upsilon}, \quad \partial\boldsymbol{\upsilon}/\partial t = c^2 curl\left(k_{\mathbf{S}} \cdot \mathbf{S}\right),$$

where c is the speed of light; t is time; k_S is a factor of proportionality; $\boldsymbol{\upsilon}$ is a velocity of physical vacuum consisting of QOs; and **S** is the spin of an element of the volume of the physical vacuum.

Taking into account the equation $\mathbf{B} = \boldsymbol{\upsilon}\sqrt{4\pi\rho}$ deduced in the work and $\mathbf{E} = -c \cdot k_S \sqrt{4\pi\rho} \cdot \mathbf{S}$ (**B** is magnetic induction;

ρ is the density of the physical vacuum consisting of QOs; **E** is the strength of the electric field which arises as a result of electric polarization of these QOs), we obtain Maxwell's equations for electromagnetic oscillations:
$\partial\mathbf{E}/\partial t = c \cdot curl\mathbf{B}$, $\partial\mathbf{B}/\partial t = -c \cdot curl\mathbf{E}$,

XI. ***Antenna near-field effect: the existence of a superluminally propagating electromagnetic field near an antenna (an oscillating electric dipole).***

In the oscillating electric field near an antenna, a spin supercurrent arises that influences the spins of QOs that constitute a physical vacuum. As a result of a change in the QOs' spins, electromagnetic oscillation is created in the physical vacuum. Thus, the spin supercurrent is "accompanied" by electromagnetic oscillation and it can be said that an electromagnetic field propagates in the physical vacuum at the speed of spin supercurrent: that is, superluminally.

XII. ***The cosmic microwave background (CMB).***

The cosmic microwave background may be an electromagnetic emission that is ever-present in outer space due to the emergence of electromagnetic oscillations in nonlinear rotating magnetic fields created by planets, stars, and interstellar matter.

XIII. ***The "dark" energy.***

Certain properties of dark energy, such as positive density and negative pressure, are identical to those of the physical vacuum consisting of QOs. Besides, the physical vacuum may be classified as "dark" since light propagates in it as a process.

XIV. *Superfluidity and superconductivity.*

Superconductivity and superfluidity are the motions of Cooper pairs in a medium without viscosity. As quantum objects create spin vortices in the physical vacuum, the interaction between the spin vortices influences the character of motion of these quantum objects. The interaction of spin vortices created by quantum objects of Cooper pairs is negligible due to zero total spin and zero total electric dipole moment of the vortices.

The motions of Cooper pairs may be considered as superfluid until the total electric dipole moment of a pair does not exceed the critical value determined in this work. The experimentally proved dependence of the critical value of magnetic induction for a superconductor on the temperature was derived on the basis of this concept.

XV. *The expulsion of a magnetic field from a superconductor (the Meissner–Ochsenfeld effect).*

This effect takes place due to changes in the properties of a physical vacuum consisting of QOs at the location of the superconductor (the total spin and total electric dipole moment of QOs that constitute the physical vacuum in Cooper pair's location equal zero).

XVI. *The interaction of two parallel uncharged conducting plates (the Casimir effect and the Casimir-Lifshitz effect).*

This effect is due to the electric dipole-dipole interaction between the spin vortices created by quantum objects of one conducting plate and the spin vortices created by quantum objects of another conducting plate.

XVII. ***Changes in the weight of rotating bodies*.**

Changes in the weight of a rotating body could be associated with emergence of force acting in the electric field of the Earth on electrically polarized QOs that constitute a physical vacuum at the location of the rotating body. The electric polarization of QOs may be created by the rotating body as a result of the Barnett effect and as a result of action of spin supercurrent as well.

XVIII. ***The rotation of a body performing accelerated translational motion*.**

A body's accelerated translational motion results in a change in the orientation of the spins of spin vortices created by quantum objects that constitute the moving body. The change in the orientation of the spins of spin vortices means a change in the orientation of the spins of QOs that constitute a physical vacuum at the location of this body. This change of orientation of spins, that is, of angular momenta of QOs at the location of this body may result in the rotation of the body.

XIX. ***The emergence of energy at the rotation of nonlinear magnetic field.***

The rotating nonlinear magnetic field is accompanied by the generation of spin supercurrents in a physical vacuum consisting of QOs and, consequently, by the generation of energy connected with these supercurrents.

XX. ***The origin of ball lightning.***

Ball lightning may be a complex of like-charged particles created on the decay of QOs that constitute a physical vacuum. The repulsive electric force acting between like-charged particles is compensated for by the attractive force belonging to the category of pseudomagnetic interactions.

XXI. ***Transmutation of the system of chemical elements*.**

The changes in the elemental and isotopic composition of a complex of reacting molecules may be a result of the interaction (electric dipole-dipole or by means of spin supercurrents) of the spin vortices created by the quantum objects that constitute the system of reacting molecules.

XXII. ***The effect of nanoparticles (NPs) on a biological system (BS).***

The effect of NPs on a BS may be performed by spin supercurrents arising between the spin vortices created by the quantum objects that constitute NPs, on the one hand, and the spin vortices created by the quantum objects that constitute the BS, on the other.

XXIII. ***The effect of ultra-low doses (ULD) of biologically active substances (BAS) on a biological system (BS).***

The effect of BAS in ULD on a BS is due to the spin supercurrent arising between the spin vortices created by the quantum objects that constitute the BAS, on the one hand, and the spin vortices created by the quantum objects that constitute BS, on the other.

XX1V. ***The properties of form (cavity structures): generation of energy, glowing, short-term invisibility, changes in weight, and post-action (the action of cavity structures on objects after the removal of the cavity structure).***

The phenomena connected with the form (for example, a cavity structure) of bodies are caused by the action of spin supercurrents that arise between the spin vortices created by the quantum objects that constitute the cavity structure substance. The post-action of cavity structures, that is, the "memory" of the physical vacuum consisting of QOs, is connected with the non-zero time of recovery of the characteristics of QOs' spins after their change (due to the gyroscopic properties of spins).

XXV. ***Physical aspects of some magic rites, particularly the selective mental influence on remote bodies, dowsing, levitation, alchemy, and so-called "magic rings".***

Many "miracles" accomplished by both ancient and contemporary magicians (currently, they are often referred to as "psychics") are due to the processes taking place in a physical vacuum consisting of QOs. In particular, these processes may be spin supercurrents arising between the spin vortices created by the quantum objects that constitute the magician's organism, on the one hand, and the spin vortices created by the quantum objects that constitute the body being influenced or the QOs that constitute the physical vacuum, on the other.

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