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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 $\lambda\!\!\!^{-}$ for particles: $\lambda\!\!\!^{-} = \hbar / p$. 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.

The structure of the figure number – the number of the Chapter, dash, and the number of the figure in the Chapter.

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,

$$\mathbf{S}_{ph} \perp \mathbf{c} . \qquad (1.4)$$

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,

$$\boldsymbol{\omega}_{ph} \| \mathbf{c}. \qquad (1.5)$$

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:

$$\mathbf{S}_{ph} \uparrow\downarrow \mathbf{E}_{ph} . \qquad (1.6)$$

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 $\mathbf{p}_{ph}$.

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

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

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

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

$$\beta = \pi / 2 . \quad (1.9)$$

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

$$\mathbf{S}_{ph} \uparrow\uparrow \mathbf{d}_{ph} . \quad (1.10)$$

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

$$d_{ph} = q_{ph} \lambda\!\!\!^{-}_{ph} . \quad (1.11)$$

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 $\left|\left(r_{ph}\right)_{-}-\left(r_{ph}\right)_{+}\right|=\lambdabar_{ph}$ (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.

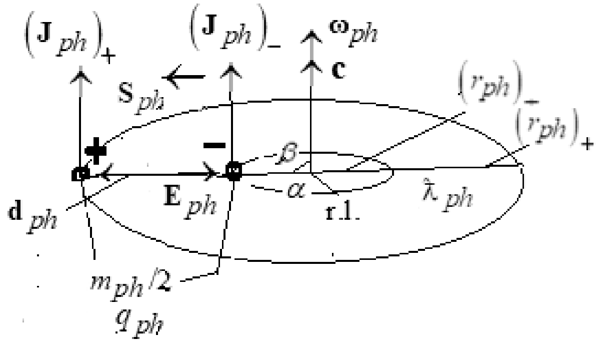

Fig. 1-1. The characteristics of the right-hand photon. $\boldsymbol{\omega}_{ph}$ is the frequency of the precession of spin $\mathbf{S}_{ph}$; $\mathbf{d}_{ph}$ is the electric dipole moment; $\mathbf{E}_{ph}$ is the electric component; $\mathbf{c}$ is the photon's velocity; $\lambdabar_{ph}$ is the 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 $\left|\sqrt{\frac{2\cdot(J_{ph})_+}{m_{ph}\cdot\omega_{ph}}}-\sqrt{\frac{2\cdot(J_{ph})_-}{m_{ph}\cdot\omega_{ph}}}\right|=\lambda\!\!\!^{-}_{ph}$, 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