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Compensation of Coulomb Interaction of Nuclei in Low-Energy Nuclear Reactions

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ABSTRACT
The aim of this article is to show that compensation of Coulomb interaction for subsequent implementation of nuclear fusion (for example, between coaxial protons in nickel-hydrogen reactor) is a result of interaction of virtual photons created by these protons.

Besides the compensation of Coulomb interaction, the concept of virtual photons can explain the following properties of the Low-Energy Nuclear Reactions: the formation of so-called "nuclear molecules"; "mass defect"; the radiation of electromagnetic oscillation and ball lightning; the generation of spin supercurrent. It is shown that the properties of spin supercurrent are analogous to many properties of radiation of nuclear reactor.

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Introduction

Feynman's hypothesis of virtual photons

In 1949, Nobel Prize winner R. Feynman developed a diagram of force fields in which electric and magnetic interactions were accomplished by so-called virtual photons [1]. The properties of virtual photons were similar to those of photons performing the propagation of electromagnetic oscillation as well, in particular, virtual photons have spin $\mathbf{S}_v$ precessing with frequency $\boldsymbol{\omega}_v$, magnetic $\mathbf{B}_v$ and electric $\mathbf{E}_v$ components. According to [2] and [3]:

$$\mathbf{S}_v \perp \mathbf{B}_v, \qquad (1)$$

$$\mathbf{S}_v \uparrow\downarrow \mathbf{E}_v. \qquad (2)$$

According to Feynman's hypothesis, the virtual photon consists of electric oppositely charged virtual particles, that is, it is characterized by electric dipole moment $\mathbf{d}_v$. The electric dipole is created in the area whose size is equal to wavelength $\lambda\!\!\!^{-}_q$ of wave function of quantum object creating the virtual photon.

In quantum mechanics, $\lambda\!\!\!^{-}_q$ is determined by momentum p_q of quantum object [4]:

$$\lambda\!\!\!^{-}_q = \hbar / p_q. \qquad (3)$$

Thus, the electric dipole moment of virtual photon is determined as:

$$d_v = q_v \lambda\!\!\!^{-}_q , \quad (4)$$

where q_v is the electric charge of virtual particle constituting the virtual photon.

As electric component $\mathbf{E}_v$ of virtual photon is related to its dipole moment $\mathbf{d}_v$, it follows from Condition (2):

$$\mathbf{d}_v \uparrow\uparrow \mathbf{S}_v \quad (5)$$

In 2020, the investigation by H. Li and others [5] was conducted supporting the hypothesis of Feynman: "We report the quantized superfluid vortex filaments induced by the axial flow effect". Really, the superfluid medium in investigation by H. Li characterized by intrinsic angular momentum is similar to the physical vacuum characterized by "zero-point energy" [6]. Thus, it follows from the investigation by H. Li that the motion (at velocity **u**) of quantum object that occurs during decay of photon (being a spin vortex) can be followed by "quantized superfluid vortex filaments", in particular, by another spin vortex – by virtual photon. Consequently, the following relation exists: $\boldsymbol{\omega}_v \sim \mathbf{u}$. where $\boldsymbol{\omega}_v$ is the frequency of precession of spin of emerging spin vortex (of virtual photon), ω_v is determined by energy U_q of moving quantum object:

$$\omega_v = U_q / \hbar . \quad (6)$$

According to the updated experimental data [2]:

$$\boldsymbol{\omega}_v \uparrow\uparrow \eta \mathbf{u}, \quad (7)$$

$$\eta = \begin{cases} 1, \text{ for positively charged quantum object} \\ -1, \text{ for negatively charged quantum object} \end{cases} ; \quad (8)$$

One of the main properties of spin vortex is the precession motion (with frequency $\boldsymbol{\omega}_v$) of its spin $\mathbf{S}_v$. According to the properties of gyroscopes [7], moment $\mathbf{M}_v$ causing the precession motion of spin $\mathbf{S}_v$ satisfies the condition:

$$\mathbf{M}_v = \boldsymbol{\omega}_v \times \mathbf{S}_v . \quad (9)$$

The schematic image of virtual photon is given in Figure 1.

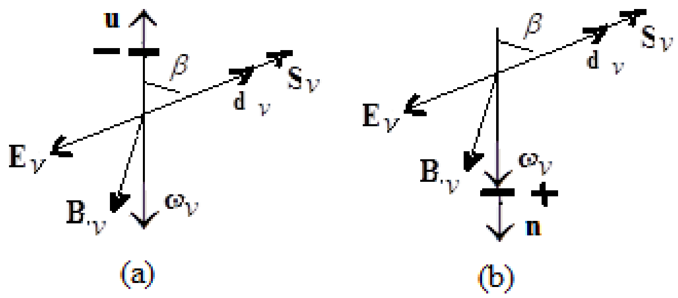

Figure 1: Schematic image of virtual photon (variant (a) - created by negatively charged quantum object; variant (b) - created by positively charged quantum object). $\boldsymbol{\omega}_v$ is frequency of precession of spin $\mathbf{S}_v$; $\mathbf{E}_v$ and $\mathbf{B}_v$ are electric and magnetic components, respectively; $\mathbf{d}_v$ is electric dipole moment; **u** is velocity of virtual photon; β is angle of deflection.

The angle β is the angle between spin ($\mathbf{S}_v$) and the direction opposite to the frequency ($-\boldsymbol{\omega}_v$); according to [2]:

$$\sin\beta = u / c , \quad (10)$$

where c is the speed of light; **u** is the velocity of virtual photon, or, which is the same thing, the velocity of quantum object creating the virtual photon. At u=c the properties of virtual photon will be identical to the properties of photon; thus, the radiation of photon may take place. (It is possible that this phenomenon determines the effect of Cherenkov [8]).

The meaning of the concept of virtual photons is that it explains as well the following properties of the Low-Energy Nuclear Reactions: the formation of so-called "nuclear molecules"; "mass defect"; the radiation of electromagnetic oscillation and ball lightning; the generation of spin supercurrent.

This article contains the following sections.

1. The Determination of Electric Dipole Moment of Virtual Photons Created by Quantum Objects.
2. Interaction of Protons by Means of Electric Dipole-Dipole Interaction of Virtual Photons Created by These Protons.
3. The "Mass Defect".
4. The Formation of Nuclear Molecules.
5. The Destruction of Virtual Photons.
6. The Spin Supercurrent in Low-Energy Nuclear Reactions.

1. The Determination of Electric Dipole Moment of Virtual Photons Created by Quantum Objects

1.1. The electric dipole moment of virtual photon created by electron

The electron may emerge, for example, as a result of decay of photon in electric field of heavy nucleus [4]. Based on the results of experiments conducted by Kaufmann [9] on the deflection of beta-rays emitted by radium, which showed that the mass of electron m_e is purely of an electromagnetic nature, we assume that the same is valid for the virtual particles that constitute the virtual photon created by electron, that is, the following holds:

$$2q_{ve} / m_{ve} = e / m_e, \tag{11}$$

where e and m_e are the electric charge and mass of electron, respectively; m_{ve} is the mass of virtual photon created by electron; q_{ve} is charge of virtual particle constituting virtual photon. From the expression (11) with the use of expression for Bohr magneton $\mu_B = e\hbar / (2m_e c)$, we have:

$$q_{ve} = \mu_B m_{ve} c / \hbar. \tag{12}$$

As, according to Feynman's hypothesis, the properties of virtual photon are similar to the properties of photon, the mass of virtual photon m_v will be defined similar to the kinetic mass of photon: $m_{ph} = U_{ph} / c^2$, where U_{ph} is photon energy, c is the speed of light. Consequently, the mass of virtual photon will be defined as:

$$m_v = U_q / c^2, \tag{13}$$

where U_q is the energy of quantum object creating the virtual photon.

Solving together Eqs (3)-(4), (12) and taking into account that in this case a quantum object is an electron: that is, the designation U_q is replaced by U_{qe}, we obtain:

$$d_{ve} = \mu_B U_{qe} / (p_{qe} c). \tag{14}$$

If energy U_{qe} equals kinetic energy: $U_{qe} = m_e u^2 / 2$, then, using the expressions for U_{qe} and for electron momentum $p_{qe} = m_e u$ in Eq. (14), d_{ve} can be presented as:

$$d_{ve} = \mu_B u / (2c). \tag{15}$$

In electric field $\mathbf{E}_n$, the moment $\mathbf{M}_e$ will act on the virtual photon as on an electric dipole:

$$\mathbf{M}_e = \mathbf{d}_{ve} \times \mathbf{E}_n. \tag{16}$$

For concretization of the expression for $\mathbf{M}_e$, let us consider the electron in a hydrogen atom. As in this case $u \ll c$, it follows from Conditions (5), (7)-(9): $\mathbf{d}_{ve} \uparrow\uparrow \mathbf{u}$. Using the latter Condition and expression (15) in equation (16), we obtain for electron: $|\mathbf{M}_e| = |\mu_B (\mathbf{u} \times \mathbf{E}_n) / (2c)|$. The expression for $\mathbf{M}_e$ is the same as for the maximum value of the spin-orbit interaction energy U_{s-o} of the electron in a hydrogen atom:

$$(U_{s-o})_{\max} = |\mu_B (\mathbf{u} \times \mathbf{E}_n) / (2c)|, \tag{17}$$

which was derived by L. Thomas based on the general requirements of relativistic invariance [10].

It should be noted that the possibility of explanation of spin – orbit interaction of electron in a hydrogen atom (Eq. (17)) can serve as a proof of validity of expression for electric dipole moment of virtual photon created by the electron (Eq. (15)).

1.2. The electric dipole moment of virtual photon created by proton

A proton like an electron has an electric charge and can occur during the decay of photon [11], that is, it has an electromagnetic nature. Consequently, it can be assumed that expression (11) deduced for electron can be similar to an analogous expression for proton as well: $2q_{vp}/m_{vp} = e/m_p$, where q_{vp} is electric charge of the virtual particle that makes up the virtual photon with mass m_{vp}; m_p is mass of the proton. Using in the latter equation the expression for nuclear Bohr magneton $\mu_N = e\hbar/(2m_p c)$, we have:

$$q_{vp} = \mu_N m_{vp} c/\hbar. \qquad (18)$$

Based on equation (13), the expression for mass m_{vp} of virtual photon created by proton can be written as:

$$m_{vp} = U_{qp}/c^2, \qquad (19)$$

where U_{qp} is the energy of proton creating the virtual photon. Then, solving together Eqs (3)-(4) and (18)-(19), we obtain the expression for electric dipole moment of proton:

$$d_{vp} = \mu_N U_{qp}/(p_{qp} c). \qquad (20)$$

If energy U_{qp} of proton (with mass m_p and speed u) equals kinetic energy: $U_{qp} = m_p u^2$, then, using the expressions for U_{qp} and for proton momentum $p_{qp} = m_p u$ in Eq. (20), d_{vp} can be presented as:

$$d_{vp} = \mu_N u/(2c). \qquad (21)$$

Besides using the expressions for kinetic energy of U_{qp} and Eq. (19) in Eq. (18), the following expression for q_{vp} can be derived:

$$q_{vp} = \mu_N m_p u^2/(2c\hbar). \qquad (22)$$

2. Interaction of Protons by Means of Electric Dipole-Dipole Interaction of Virtual Photons Created by These Protons

Using equation (21), let us consider the electric dipole - dipole interaction of virtual photons created by protons with velocities $\mathbf{u}_1$ and $\mathbf{u}_2$ ($\mathbf{u}_1 \rightarrow\rightarrow \mathbf{u}_2$, $u_1 = u_2 = u$). The schematic image of virtual photons created by protons in this case, taking into account Figure 1, is presented in Figure 2:

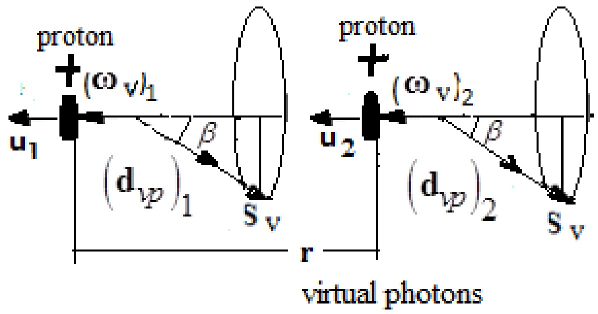

Figure 2: The schematic image of the protons interacting by means of virtual photons created by these protons. $(\mathbf{d}_{vp})_1$ and $(\mathbf{d}_{vp})_2$ are the electric dipole moments of the virtual photons; $(\boldsymbol{\omega}_v)_1$ and $(\boldsymbol{\omega}_v)_2$ are the frequencies of precession of spins $\mathbf{S}_v$; $\mathbf{u}_1$ and $\mathbf{u}_2$ are the velocities of protons; r is the distance between protons; β are the angles of deflection.

The attractive force F_a acting between virtual photons created by protons in this case (Figure 2) is determined by expression [12]:

$$F_a = 6(d_{vp})_1 (d_{vp})_2 \cos^2\beta / r^4, \qquad (23)$$

where $\left(d_{vp}\right)_1 \cos\beta$ and $\left(d_{vp}\right)_2 \cos\beta$ are the projections of electric dipole moments of interacting protons on directions $\mathbf{u}_1$ and $\mathbf{u}_2$, respectively; r is the distance between protons. Besides force F_a, force F_b acts between protons. Here $F_b = 3\left(d_{vp}\right)_1\left(d_{vp}\right)_2 \sin^2\beta / r^4$, where $\left(d_{vp}\right)_1 \sin\beta$ and $\left(d_{vp}\right)_2 \sin\beta$ are the projections of electric dipole moments of interacting protons on the directions perpendicular to $\mathbf{u}_1$ and $\mathbf{u}_2$, respectively. But, as the projections of electric dipole moments perform precession motion and if $\left(\boldsymbol{\omega}_v\right)_1 \neq \left(\boldsymbol{\omega}_v\right)_2$, the average result of action of force F_b equals zero.

According to experiments by D.S. Baranov, V.N. Zatelepin and others [13], the object (they call it "dark hydrogen") providing the fusion of nuclei has size 10^{-11}-10^{-12}cm. According to Figure 2, this experimental fact means that the above-mentioned size is the size of virtual photons created by interacting protons and it follows from Eq. (4) that we may assume the following value of wavelength of proton:

$$\lambda\!\!\!^{-}_q \approx 10^{-12}\,\text{cm}. \tag{24}$$

Then, according to wavelength's definition (Eq. (3)), the proton speed is determined as:

$$u = 6.3\cdot 10^8\, cm/s. \tag{25}$$

Let us consider the force F_a of electric dipole-dipole interaction of protons. According to Eqs (21) and (24)-(25), and assuming that $r=\lambda\!\!\!^{-}_q$, the force F_a in Eq.(23) can be determined as:

$$F_a = \frac{6\cdot\mu_N^2 u^2}{4c^2 \lambda\!\!\!^{-}_q{}^4} = 1.7\ 10^{-2}\text{dyne}. \tag{26}$$

Repulsive Coulomb force F_q between two like charged protons with charges e is determined as:

$$F_q = e^2/\lambda\!\!\!^{-}_q{}^2 = 2.3\ 10^5\ \text{dyne}. \tag{27}$$

Using Eqs (24)-(27), let us determine the value F_a/F_q when there is no compression of chain of interacting protons:

$$F_a/F_q = 1.7\cdot 10^{-2}/2.3\cdot 10^5 \approx 7.3\cdot 10^{-8}. \tag{28}$$

It follows from Eq. (28) that in this case the force F_a cannot compensate the Coulomb interaction between the protons. In order to solve the problem, attempts have been made for creating a coaxial sequence of protons in nickel-hydrogen reactor, see Figure 3 [14].

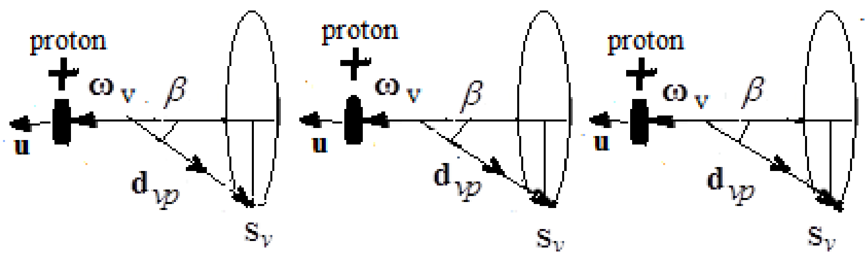

Figure 3: The sequence of protons. $\boldsymbol{\omega}_v$ are frequencies of precession of spins $\mathbf{S}_v$; $\mathbf{d}_{vp}$ are electric dipole moments of virtual photons created by protons; β are angles of deflection; $\mathbf{u}$ are the velocities of protons.

If similar chain did not solve the problem of compensation of Coulomb interaction, compression of the chain of protons was used. The result of those attempts was a change in the structure of charged virtual particles that make up the interacting virtual photons: the size of these virtual photons is reduced to a value $r < \lambda_q$, see Figure 4.

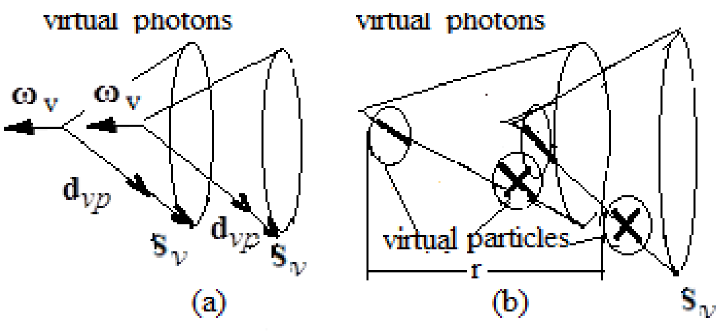

Figure 4: The schematic image of spatial overlap of virtual photons created by a pair of protons. Variant (a): spatial overlap of virtual photons with the indication of characteristics of virtual photons: $\boldsymbol{\omega}_v$ are the frequencies of precession of spins $\mathbf{S}_v$; $\mathbf{d}_{vp}$ are electric dipole moments. Variant (b): the annihilation of virtual particles under spatial overlap of virtual photons. ⊖ and ⊕ are electrically charged "virtual particles" in virtual photons.

There are two consequences of spatial overlap of virtual photons: the emergence of force not being repulsive between quantum objects creating these virtual photons, that is $F_a \geq F_q$, and the "mass defect". Let us consider these consequences in detail.

The attractive force between virtual photons in case of spatial overlap of virtual photons

As shown in Figure 4, the attractive force between virtual photons in this case should be determined by equation: $F_a = q_{vp}^2 / r^2$, where r is the distance between spatially separated electrically charged virtual particles. Thus, in this case F_a is a force between charges q_{vp}, not between electric dipoles $\mathbf{d}_{vp}$. With using expression for q_{vp} (Eq. (22)) force F_a is determined as:

$$F_a = \left(\mu_N m_p u^2 / (2c\hbar)\right)^2 / r^2 = 3.1\ 10^{-27}/r^2 \text{ dyne}. \quad (29)$$

Let us determine repulsive force F_q between protons taking into account that due to annihilations of virtual particles in virtual photons the distance between protons may decrease by almost half (up to the value $\lambda_q / 2$). Then, repulsive force F_q is determined as:

$$F_q = 4e^2 / \lambda_q^2 = 4 \cdot \left(4.8 \cdot 10^{-10} / 10^{-12}\right)^2 = 9.2 \cdot 10^5 \text{dyne}. \quad (30)$$

The distance r in equation (26) can be found from equality: $F_a = F_q$. Then from Eqs (29) and (30) we obtain: $r = 5.8\ 10^{-17}$cm.

The comparison of results of investigation of proton chain before compression and after compression

Characteristics / Modes	distance between virtual photons /distance between protons	F_a / F_q
before compression	$\lambda_q / \lambda_q = 1$	$7.3\ 10^{-8}$
after compression	$r/(\lambda_q/2) \approx 0.8\ 10^{-4}$	1

2. The "Mass Defect".

The partial annihilation of virtual particles in virtual photons results in the decrease of total mass of considered pair of virtual photons, that is:

$$(m_v)_t < (m_v)_1 + (m_v)_2,$$

where $(m_v)_1$ and $(m_v)_2$ denote masses of virtual photons before the annihilation; $(m_v)_t$ is the total mass of virtual photons after annihilation. Thus, the inequality $r < \lambda\!\!\!^{-}_q$ is accompanied by the mass loss of interacting virtual photons; the value $\Delta m_v = (m_v)_t - (m_v)_1 - (m_v)_2$ is called as "mass defect".

If as a result of annihilation each of the interacting virtual photons loses one electrically charged virtual particle (see Figure 4), the mass of each of virtual photons is reduced by half. Thus, the total "mass defect" will be equal to initial mass of virtual photon m_v. According to Eq. (19), the energy of proton U_{qp} is related to "mass defect".

4. The Formation of "Nuclear Molecules"

The dipole - dipole interaction may result in creation of molecules from nuclei (so-called "nuclear molecules" [13]).

For example, well-known "capture" of electron by proton can be carried out with using dipole-dipole interaction of virtual photons created by electron and proton, see Figure 5. In this case Coulomb attractive force F1 between proton and electron: $F1=e^2/(r1)^2$ is balanced by repulsive force F2 of dipole-dipole interaction of virtual photons created by proton and electron: $F2 = 6(\mathrm{d}_{vp})_1 \cdot (d_v)_2 \cos^2\beta / (r1)^4$. That is, the size of the resulting pair of electron-proton is determined as $r1 = \sqrt{6(\mathrm{d}_{vp})_1 \cdot (d_{ve})_2 \cos^2\beta / e^2}$.

Using Eqs (5), (10), (15), (21), we obtain the following expression for r1:

$$r1 = \sqrt{6 \cdot \mu_N \cdot \mu_B \cdot u^2 \left(1 - u^2/c^2\right)^2 / \left(4c^2 e^2\right)}$$

$$= \sqrt{1.2 \cdot 10^{-28}} \approx 1.1 \cdot 10^{-14} cm$$

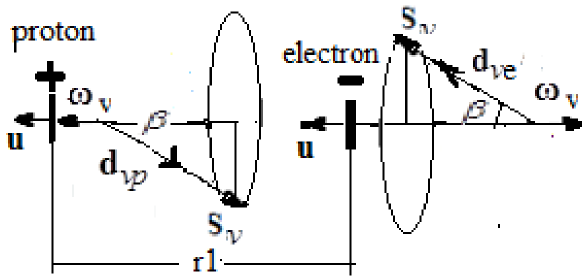

Figure 5: The schematic image of virtual photons created by proton and electron. $\boldsymbol{\omega}_v$ are the frequencies of precession of spins $\mathbf{S}_v$; $\mathbf{d}_{vp}$ and $\mathbf{d}_{ve}$ are electric dipole moments of the proton and the electron, respectively; **u** are velocities of proton and electron; β are angles of deflection.

In Figure 6 is shown the example of a complex of four protons in which between any two protons an attractive force between virtual photons created by these protons acts.

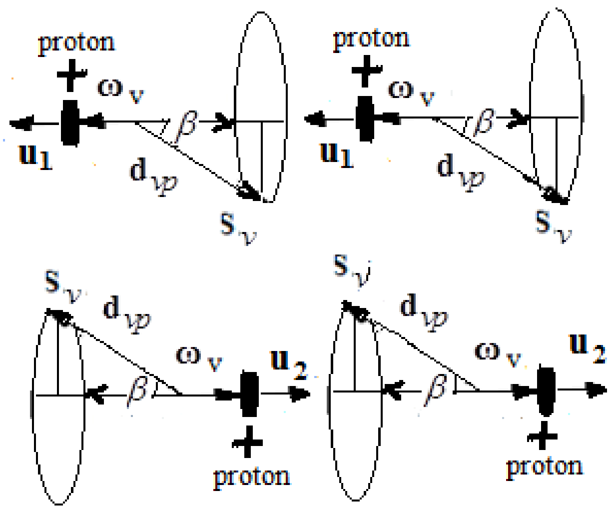

Figure 6: Schematic image of virtual photons created by 4 protons. $\mathbf{u}_1$ and $\mathbf{u}_2$ are velocities; $\boldsymbol{\omega}_v$ are frequencies of precession of spins $\mathbf{S}_v$; $\mathbf{d}_{vp}$ are electric dipole moments; β are angles of deflection.

5. The Destruction of Virtual Photons

There are a few types of destruction of virtual photon.

1. Cherenkov effect: transformation of virtual photon in photon at speed of nuclei equal to *c* [8]. The visible Cherenkov radiation is bright blue $(4.5\cdot 10^{14} Hz - 5.1\cdot 10^{14} Hz)$. The major part of Cherenkov radiation is posted in the ultraviolet spectrum ($7.5\cdot 10^{14} Hz - 3.\cdot 10^{16} Hz$).
These data are in accordance with results of work [13].

2. Analogous to decay of photon in electric field of heavy nucleus into oppositely charged objects (for example, an electron and positron) [4], the separation of virtual photon in electric field **E** into oppositely charged "virtual particles" (as Feynman called them) takes place. These "virtual particles" radiated by nuclear reactor are observed in experiments and classified in some works as "ball lightning" [15] (Figures 7-8).

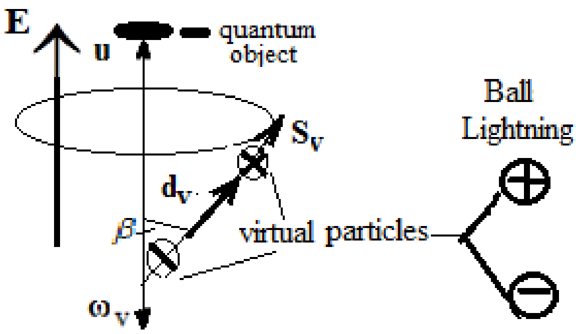

Figure 7: The results of decay of virtual photon created by quantum object into ball lightning. **E** is electric field strength; **u** is velocity of quantum object; $\boldsymbol{\omega}_v$ is frequency of precession of spin $\mathbf{S}_v$; $\mathbf{d}_{vp}$ is electric dipole moment of quantum object; β is angle of deflection.

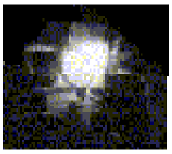

Figure 8: The type of ball lightning emerging during LERN (the size: several cm).

6. The Spin Supercurrent in Low-Energy Nuclear Reactions

Besides the electric dipole - dipole interaction, the spin supercurrent, transferring the angular momentum between spins of virtual photons, can emerge between virtual photons. As opposed to electric dipole - dipole interaction occuring, in general, inside a working camera, the spin supercurrent can emerge both between virtual photons created by quantum objects only of working camera and between virtual photons created by quantum objects of working camera and environmental objects.
Note. The investigations of spin supercurrent were conducted from 1976; in 2008 Yu. Bunkov, V. Dmitriev and I. Fomin were awarded the Fritz London Memorial Prize for the studies of spin supercurrents in superfluid ^{3}He-B [16-18].

6.1. The properties of spin supercurrent

The spin supercurrent emerges between objects having precessing spin and tends to equalize the respective characteristics of spins (angles of precession and angles of deflection); that is, the spin supercurrent transfers the angular momentum between spins of these objects (Figure 9).

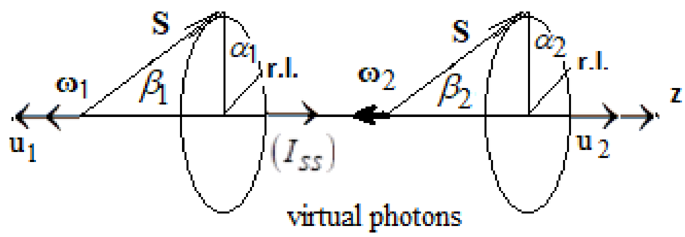

Figure 9: The schema of spin structures. $(I_{ss})_z$ is a spin supercurrent between virtual photons with the following characteristics: α_1 and α_2 are precession angles; β_1 and β_2 are deflection angles; $\boldsymbol{\omega}_1$ and $\boldsymbol{\omega}_2$ are precession frequencies oriented along axis z; **S** are spins; r.l. are reference lines; $\mathbf{u}_1$ and $\mathbf{u}_2$ are velocities.

1) The value of spin supercurrent $\left(I_{ss}\right)_z$ arising between virtual photons in the direction of the orientation (axis z) of their precession frequencies $\boldsymbol{\omega}_1$ and $\boldsymbol{\omega}_2$ (see Figure 9) is determined to be

$$\left(I_{ss}\right)_z = -b_1\left(\alpha_2-\alpha_1\right)-b_2\left(\beta_2-\beta_1\right), \tag{31}$$

where b_1 and b_2 are coefficients depending on β_1 and β_2; $b_1>0$, $b_2>0$.

Taking into account the relation between the angle of precession and frequency of precession:

$$\alpha = \omega t, \tag{32}$$

(where t is time) and using Eqs (6), (10) and (32), the Eq.(31) can be rewritten in the form:

$$\left(I_{ss}\right)_z = -b_1\left(U_2-U_1\right)t/\hbar - b_2\left(\arcsin\left(u_2/c\right)-\arcsin\left(u_1/c\right)\right). \tag{33}$$

As follows from the studies of properties of spin supercurrent in superfluid ^{3}He-B, the process should be dissipation-free (inertia free) and have infinite speed y_{ss} [19]:

$$y_{ss} \approx 10^4 c. \tag{34}$$

There is no contradiction between expression (34) and the second postulate of Special Relativity as this postulate is valid only for inertial systems [20].

As spin supercurrent is not an electric or magnetic process, it cannot be screened by electromagnetic screens.

It follows from Eq. (33) that the change in the energy of quantum objects (for example, at heating, electrolysis or in electric gas discharge) results in a change in the characteristics of virtual photons created by these objects and, consequently, spin supercurrent emerges. Let us compare the properties of spin supercurrent with characteristics of radiation of low energy nuclear reactors [21].

1) Spin supercurrent cannot occur between quantum objects creating some virtual photons with a total zero spin. Most likely is the occurrence of spin supercurrent in substances having 'free' quantum objects, for example, in metals containing 'free' electrons with nonzero total spin.

This property is in accordance with the results of experiment in which the abnormally high heat generation was obtained at nickel saturation with hydrogen, with addition of lithium. It should be noted that nickel and lithium, being metals, contain 'free' electrons; atom of hydrogen contains one electron [22].

2) It was found experimentally that in the process of cold nuclear fusion there were observed regions with reduced temperature [22].

This phenomenon is due to the fact that the characteristics of virtual photon's spin (angles of deflection and precession, frequency of precession) are determined by the velocity (value, direction) and energy of quantum object creating the virtual photon. Thus, the action of spin supercurrent while equalizing the values of characteristics of virtual photons' spins equalizes as well the energy characteristics (in particular, the value and direction of velocity) of quantum objects creating these virtual photons. Consequently, the action of spin supercurrent suppresses the chaotic motion of quantum objects, which results in a decrease in the temperature of the substance consisting of the quantum objects.

3) The creation on the surface of various materials of a track having a vortex form (see Figure 10 [23]). This can be fulfilled by a process transforming angular momentum.

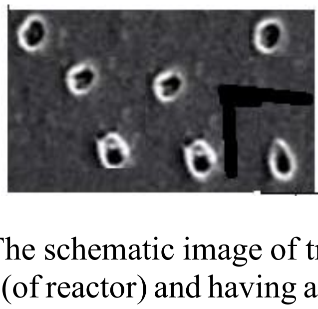

Figure 10: The schematic image of tracks created by radiation (of reactor) and having a vortex form.

4) In many experiments with Low Energy Nuclear Reactions the twin-tracks on the surface of various materials often emerge (see Figure 11 [24]).

If spin supercurrent causes the contraction of the medium where it spreads and the speed of spin supercurrent is greater than the speed of spreading this contraction, then the action of spin supercurrents can result in appearance of periodically repeating jumps in density [7].

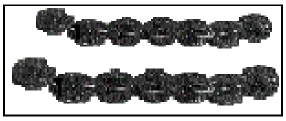

Figure 11: The possible structure of twin-tracks in experiments with reactor.

5) It was found experimentally that some of the phenomena accompanying cold nuclear fusion (for example, the emergence of optical radiation and abnormally high heat emission) were observed as well in the regions adjacent to active zones of the reactor where the experiments were conducted [24].
It is in accordance with the property of spin supercurrent: it is not shielded by electromagnetic and molecular substances.

6) As shown in works [23, 24], the radiation of reactor acts on a biological system. For example, the following phenomena took place in the conducted experiments with female mice of C57Bl/6 line aged 80 days: the change in the number of nucleated cells in the bone marrow of mice and the influence on the peripheral blood cell composition
This is in accordance with data about effective action of spin supercurrent on biological systems. For example, the action of biologically active substances in ultra-low doses on a biological system is accomplished by spin supercurrent [2,25].

7) It was experimentally discovered that multi-layered aluminum foil has the screening effect on radiation of reactor [15].
This is in accordance with the following property of spin supercurrent. At passing of spin supercurrent through the substances containing a great number of quantum objects creating virtual photons (with nonzero total spin), the scattering of spin supercurrent can take place.

8) The possibility of magnetization of nonmagnetic materials [15].
According to Eq. (1), the action of spin supercurrent on spin of virtual photons is simultaneously its action on the magnetic component of the virtual photon and consequently on magnetic properties of quantum object creating this virtual photon.

9) According to experimental data, the use of external magnetic field influences the form of track produced by nuclear reactor [26].
This phenomenon can be explained by magnetic properties of virtual photons created by nuclei constituting the reactor.

10) The aftereffect effect was observed, when tracks appear after switching off the reactor. The experiments consisted of the following: after foil explosion, the water and the remaining foil were poured in a cup of Petri and the film was put at a distance of 10 centimeters from the cup. It turned out that radiation could accumulate in the substance and get out of the substance (the film) within a few days after reactor shutdown [15].
This phenomenon is explained by virtual photon's gyroscopic properties conditioned by the existence of precessing spin.

5. Conclusion

1. The compensation of Coulomb interaction for subsequent implementation of nuclear fusion (for example, between coaxial protons in nickel-hydrogen reactor) is a result of electric dipole-dipole interaction of virtual photons created by the protons.

2. In interaction of virtual photons, the spatial overlap of virtual photons with oppositely oriented electric dipole moments can take place. This process is accompanied by a decrease in the total mass of these virtual photons. This effect is called "mass defect".

3. The creation of complexes of many nuclei (so called "nuclear molecules") using electric dipole-dipole interaction of virtual photons created by these nuclei is possible.

4. If the speed of virtual photon equals the speed of light, the transformation of virtual photon to photon takes place, that is, electromagnetic radiation (Cherenkov effect) emerges.

5. The decay of virtual photon into positively and negatively charged complexes can take place in electric field. These complexes are irradiated by reactor like ball lightning.

6. The spin supercurrent transferring the angular momentum can arise between virtual photons. The action of spin supercurrent can be carried out in two directions: production of "nuclear molecules" and taking part in reactor radiation.

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