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Spin Supercurrent as a "Strange" Radiation in Low-Energy Nuclear Reactions

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Abstract The numerous experiments in which the features of Low-Energy Nuclear Reactions (LENR) were researched show that the emergence of new chemical elements in the reactions are accompanied by a radiation that has been detected on nuclear photographic plates located outside of the work chamber. Besides interactions between the radiation with various materials and absence of shielding by electromagnetic and molecular screens, it is characterized by other properties as well: nonmagnetic and nonelectric nature, the accompaniment by electromagnetic radiation, magnetization of nonmagnetic materials, etc. However, the nature of the radiation is left unknown, therefore this radiation is referred to as "strange" radiation. With the aim of determining the physical nature of "strange" radiation the properties of such process as spin supercurrent are analyzed in this work. The spin supercurrent emerges between objects having precessing spin and tends to equalize the respective characteristics of the spins (angles of precession and angles of deflection); that is, it transforms the angular momentum associated with spins. 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. The comparison of the properties of spin supercurrent with properties of "strange" radiation allows us to conclude the following: the spin supercurrent may be the physical process which accompanies Low-Energy Nuclear Reactions and called as "strange" radiation. From conducted investigations it follows that spin supercurrent does not only accompany Low-Energy Nuclear Reactions but it may stimulate the accomplishment of these reactions as well.

Keywords: *strange radiation, spin supercurrent, low-energy nuclear reactions, spin, virtual photons*

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1. Introduction

Traditionally, the history of research of cool nuclear fusion, or more precisely, Low-Energy Nuclear Reactions (LENR) starts from the experiments by M. Fleischmann and S. Pons. In March 1989, they demonstrated a device, which in the process of electrolysis of deuterium-dioxide, with the use of palladium cathode, released the energy exceeding several times the input energy and, besides, emitted neutrons [1]. It was taken to be doubtless for a long time that such processes were possible only under very high temperatures (million and billion degrees), since the fusion of nuclei in these processes was prevented by that their charges had the same sign.

The technique of experiments on cold nuclear fusion, which became already conventional, consists in saturation by hydrogen (deuterium) of substances capable to actively occlude such a gas. For example, nickel in interaction with hydrogen converts into copper, ferrum, cobalt, and zinc. To this end, besides mere holding in hydrogen atmosphere, the use is made of electrolysis or electric gas discharge [2,3]. The results of the studies of electrical explosions of foils made of super-pure materials in water pointed to the emergence of new chemical elements.

In these experiments an additional finding was the appearance of a "strange" radiation accompanying the transformation of chemical elements; the high-energy radiation has been detected on nuclear photographic plates located outside of the explosion chamber. (The term "strange" radiation was used in a paper by L. Urutskoev with co-workers [3]).

The properties of this "strange" radiation are considered in this work in detail, and it is shown that these properties are analogous to the properties of spin supercurrent emerging between objects having spin; the spin supercurrent transfers the angular momentum between spins of these objects.

The first works introducing the process of transfer of angular momentum in descriptions of physical phenomena were works by J. C. Maxwell describing a model of luminiferous ether in 1861-1873 [4]. In hundred years, the investigation of process of transfer of angular momentum was continued (with taking into account the quantum object characteristic opened in the 20th century, - spin) by M. Vuorio in 1976 [5], A. Borovic-Romanov in 1989 [6], Yu. Bunkov in 2009 [7], V. Dmitriev and I. Fomin in

2009 [8]. In these investigations the process of transfer of angular momentum is called "spin supercurrent".

The features of action of spin supercurrent let us to explain not only the features of "strange" radiation accompanying LENR but also a possibility of the accomplishment of nuclear fusion, the main operation in LENR.

Thus, it is possible that LENR and the "strange" radiation are the result of the action of the same process: spin supercurrent.

The following Sections are presented in this work below: Section 2, with a brief description of properties of objects between which spin supercurrent emerges (it will be shown that virtual photons may be such objects); Section 3, with a brief description of properties of spin supercurrent; Section 4, with a detailed comparison of properties of "strange" radiation with the properties of spin supercurrent.

2. The Properties of Virtual Photons

The experimental fact that spin supercurrent is not shielded by molecular screens may witness that it propagates in a "finer" physical medium (the physical vacuum) than the molecular one. It can be possible provided spin supercurrent emerges between virtual photons created by quantum objects.

According to Feynman's model [9], 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, the so-called virtual particles. This pair is also called a "virtual photon" since it is like a photon transfers electric and magnetic interactions, and, like a photon, it has a spin $\mathbf{S}_v$, energy U_v and electric component $\mathbf{E}_v$ which are determined similar to the analogous characteristics of photon (according to [10,11], photon's electric component $\mathbf{E}$ and spin $\mathbf{S}$ are related as $\mathbf{S} \uparrow\downarrow \mathbf{E}$), that is:

$$\mathbf{S}_v \uparrow\downarrow \mathbf{E}_v, \quad (1)$$

$$U_v = \hbar\omega_v, \quad (2)$$

where $\boldsymbol{\omega}_v$ is the frequency of precession of $\mathbf{S}_v$. As, according to Feynman's model, a virtual photon consists of electric unlike charged virtual particles, one of virtual photon's characteristics is electric dipole moment $\mathbf{d}_v$, $\mathbf{E}_v$ is the electric field of this dipole and taking into account Eq. (1) and [12] the following holds:

$$\mathbf{S}_v \uparrow\uparrow \mathbf{d}_v. \quad (3)$$

The orientation of virtual photon's spin $\mathbf{S}_v$ is associated with the orientation of spin $\mathbf{S}_q$ of quantum object that created this virtual photon. According to reference [11], for free-moving quantum object, at the speed much less than the speed of light, the following holds:

$$\mathbf{S}_v \uparrow\downarrow \mathbf{S}_q. \quad (4)$$

As an example, the characteristics of virtual photons between which spin supercurrent $(I_{ss})_z$ may emerge are given in Figure 1: α_1 and α_2 are the angles of precession, β_1 and β_2 are the angles of deflection, $\boldsymbol{\omega}_1$ and $\boldsymbol{\omega}_2$ are the precession frequencies oriented along axis $\mathbf{z}$; $\mathbf{S}$ is spin; $\mathbf{E}_1$ and $\mathbf{E}_2$ are electric components; $\mathbf{d}_1$ and $\mathbf{d}_2$ are electric dipole moments.

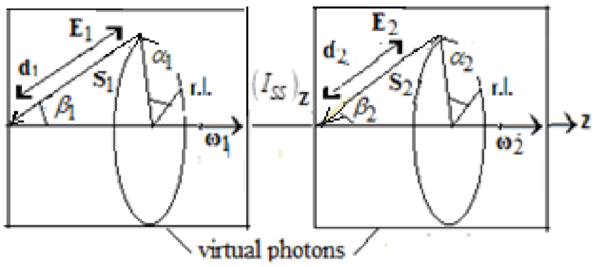

Figure 1. The characteristics of virtual photons. $(I_{ss})_z$ is a spin supercurrent between virtual photons. α_1 and α_2 are the angles of precession, β_1 and β_2 are the angles of deflection; $\boldsymbol{\omega}_1$ and $\boldsymbol{\omega}_2$ are the precession frequencies oriented along axis $\mathbf{z}$; $\mathbf{S}_1$ and $\mathbf{S}_2$ are spins, r.l. is a reference line. $\mathbf{E}_1$ and $\mathbf{E}_2$ are electric components; $\mathbf{d}_1$ and $\mathbf{d}_2$ are electric dipole moments

The angles of precession and deflection, frequencies of precession of virtual photons' spins (Figure 1), according to Eq. (2) and references [11,12] are determined by the expressions:

$$\alpha_1 = U_1 t / \hbar, \quad (5)$$

$$\alpha_2 = U_2 t / \hbar, \quad (6)$$

$$\beta_1 = \arcsin \sqrt{2U_1 / m_1} / c, \quad (7)$$

$$\beta_2 = \arcsin \sqrt{2U_2 / m_2} / c, \quad (8)$$

where U_1 and U_2 are energies, m_1 and m_2 are masses respectively of quantum objects creating these virtual photons, c is the speed of light, t is arbitrary time.

3. The Properties of Spin Supercurrent

The considered properties of spin supercurrent are based on the data obtained in experiments with superfluid ^{3}He-B [6,7,8].

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

$$(I_{ss})_z = -b_1(\alpha_2 - \alpha_1) - b_2(\beta_2 - \beta_1), \quad (9)$$

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

2) According to Eq (9), the spin supercurrent tends to equalize the respective characteristics of the spins of interacting virtual photons. Consequently, as a result of the action of spin supercurrent between two virtual photons presented in Figure 1, the following inequalities will take place:

$$\left|\alpha_1-\alpha_2\right|\geq\left|\alpha_1^{'}-\alpha_2^{'}\right|, \quad (10)$$

$$\left|\beta_1-\beta_2\right|\geq\left|\beta_1^{'}-\beta_2^{'}\right|, \quad (11)$$

where $\alpha_1^{'}$ and $\alpha_2^{'}$ are the values of the precession angles of the spins of respective virtual photons after the action of spin supercurrent; $\beta_1^{'}$ and $\beta_2^{'}$ are the values of the deflection angles of the spins of respective virtual photons after the action of spin supercurrent.

3) From the experiments with superfluid ^{3}He-B it follows that the speed of spin supercurrent theoretically equals infinitude, at least:

$$y_{ss} >> c \quad (12)$$

As superfluid ^{3}He-B is a quantum system described by a single wave function, the angles of precession and deflection of precessing spins of ^{3}He atoms are the angles of orientation of the spin part of order parameter of the quantum system. Therefore, at emergence of differences in the values of the respective angles, a process that tends to equalize these values has to emerge in the system. In accordance with the principles of quantum mechanics, this process must be dissipation-free and have infinite speed y_{ss} (otherwise the system ceases to be described by a single wave function). Due to the classical association between mass and energy, the dissipation-free means inertia-free; the latter deletes the contradiction between expression (12) and the second postulate of Special Relativity holding only for inertial systems: “In any inertial frame of reference, light propagates isotropically, independent of the motion of its source, and the speed of light is equal to absolute constant *c*.” [13].

4) The effectivity of the action of spin supercurrent between the “interacting spins” 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.

5) The spin supercurrent is not an electric or magnetic process and if it propagates in a “finer” physical medium (the physical vacuum) than the molecular one, then it may not be screened by electromagnetic and molecular screens.

6) The effectivity of action of spin supercurrent may decrease at an increase in the number of interacting virtual photons. Let us assume, for example, that one virtual photon with precession frequency $\boldsymbol{\omega}_{ex}$ interacts with a great number (w) of virtual photons. If the precession frequencies of the spins of all virtual photons are aligned with $\boldsymbol{\omega}_{ex}$, 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 virtual photons created by the quantum object having frequency $\boldsymbol{\omega}_{ex}$, on the one hand, and the arbitrary i-th virtual photon created by another quantum object, on the other hand. Using Eq. (9), we obtain $I_{sum}=-\sum_{i=1}^{w}\left(b_1\Delta\alpha_i+b_2\Delta\beta_i\right)$, where $\Delta\alpha_i$ and $\Delta\beta_i$ are the difference in the precession angles and the difference in deflection angles, respectively, for the arbitrary i-th virtual photon in question. If all the values and signs of $\Delta\alpha_i$ and $\Delta\beta_i$ are respectively equiprobable and $w\to\infty$, then:

$$I_{sum}\to 0. \quad (13)$$

7) The spin supercurrent belongs to the category of pseudomagnetic interaction of spins [14,15]. The following phenomena are explained by pseudomagnetic interaction: the precession of spin of moving quantum objects relative to the direction of substance’s spin polarization; light polarization twisting when passing light through a magnetized medium (the effect of Faraday [16]); ferromagnetism in which pseudomagnetism appears as a force creating domains from electrons with spins oriented in one direction. Thus. pseudomagnetic interaction includes not only a moment acting on spins (spin supercurrent) but a force $\mathbf{F}_{pm}$ acting on spins as well. The character of a pseudomagnetic interaction is, in many aspects, analogous to that of magnetic interaction; 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. Based on the analogy between magnetic and pseudomagnetic interactions, the following can be supposed: if spins $\mathbf{S}_1$ and $\mathbf{S}_2$ of any objects are oriented as:

$$\mathbf{S}_1\to\to\mathbf{S}_2, \quad (14)$$

F_{pm} is determined to be:

$$F_{pm}=\left|\phi_{pm}(S_1,S_2)\right|q_1q_2/\left|q_1q_2\right|, \quad (15)$$

where $\phi_{pm}\left(S_1,S_2\right)$ is a function of the characteristics of 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, if $F_{pm}<0$, the force is repulsive.

4. Comparison of the Properties of “Strange” Radiation with Properties of Spin Supercurrent

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 in the physical vacuum. The characteristics of spins (frequency of precession, angle of deflection) of virtual photons are determined by the energy of quantum objects creating these virtual photons, see Eqs (5)-(8). Consequently, 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. Then, according to Eqs. (9) and (5)-(8), spin supercurrent arises between virtual photons (see Figure 1) and at arbitrary time *t* it is determined as:

$$\begin{aligned}\left(I_{ss}\right)_z^t &= -b_1t\left(U_2-U_1\right)/\hbar \\ &-b_2\left(\arcsin\sqrt{2U_2/m_2}/c-\arcsin\sqrt{2U_1/m_1}/c\right).\end{aligned} \quad (16)$$

Let us compare the properties of spin supercurrent with characteristics of LENR (including those of "strange" radiation), see [2,3,17,18,19,20,21].

1) A spin supercurrent does not arise between quantum objects creating virtual photons having total zero spin (for example, between Cooper pairs, as the virtual photons created by quantum objects constituting the pair have total zero spin. The most probable is the emergence of a spin supercurrent in substances that have "free" quantum objects, such as in metals containing "free" electrons.

It is in accordance with the properties of chemical elements involved in LENR: the elements used in these reactions, i.e. nickel, lithium, palladium are metals; hydrogen has one electron.

2) The spin supercurrent is not an electric and is not a magnetic process.

It is an experimental fact that "strange" radiation is neither a magnetic nor an electric process.

3) Spin supercurrent is capable to magnetize nonmagnetic materials, since it influences virtual photons' spins, and according to Eq. (4), the spins of quantum objects producing these virtual photons. (The spin of quantum object, in turn, is associated with its magnetic moment [12].)

The magnetization of nonmagnetic substances by "strange" radiation was observed in many experiments.

4) According to Eqs (10)-(11), spin supercurrent changes the characteristics of spins of virtual photons between which it emerges, which results in $\partial \mathbf{S} / \partial t \neq 0$ and, according to Eq. (1), in $\partial \mathbf{E} / \partial t \neq 0$. The latter inequality may initiate the emergence of electromagnetic oscillations [12]. Thus, spin supercurrent may be accompanied by appearance of electromagnetic oscillations.

It has been experimentally detected that "strange" radiation is accompanied by electromagnetic oscillations.

5) According to the properties of spin supercurrent, Eq. (12), the speed of spin supercurrent is greater than the speed of light. More precise value of speed of spin supercurrent can be obtained in studies of quantum correlations, as it has been shown by Boldyreva [11,22] that quantum correlations are accomplished by spin supercurrent. Experiments exist [23] in which it is shown that the speed of quantum correlations is greater by factor of $\sim 10^4$ than the speed of light.

The experiments conducted show that the "strange" radiation accompanying cold nuclear fusion has the speed exceeding the speed of light by factor of $\sim 10^3$.

6) By definition spin supercurrent transforms angular momentum (angles of precession and deflection), consequently, the emerging tracks on the surface of various materials may have a vortex form.

According to experimental observations, the tracks created by "strange" radiation may have a vortex form. The schematic image of tracks created by "strange" radiation and having a vortex form is given in Figure 2 [21].

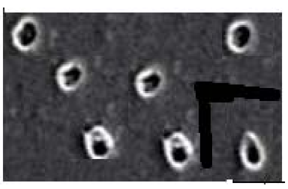

Figure 2. The schematic image of tracks created by "strange" radiation and having a vortex form

(As the characteristics of the tracks speak for the existence of angular momentum in "strange" radiation the hypothesis that "strange" radiation may be α or β radiation must be excluded).

7) 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 may result in appearance of periodically repeating jumps in density [11,24].

In many experiments with LENR the twin-tracks on the surface of various materials often emerge. The example of possible track's structure is given in Figure 3 [20].

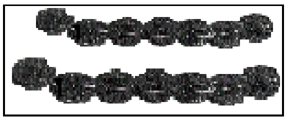

Figure 3. The possible structure of twin-tracks in experiments with LENR

8) Spin supercurrent is not shielded by electromagnetic and molecular substances. The exclusion may take place while passing spin supercurrent through the substances containing a great number of quantum objects creating virtual photons with nonzero total spin.

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, excluding the cases of using a multi-layered aluminum foil for screening.

9) At passing of spin supercurrent through the substances containing a great number of quantum objects creating virtual photons with nonzero total spin the following may take place: (1) the disappearance of spin supercurrent due to the emergence of the situation described by Eq. (13); (2) the scattering of spin supercurrent due to the interaction of virtual photons created by quantum objects participating in nuclear reaction with virtual photons created by quantum objects of substances in question.

It was found experimentally that multi-layered aluminum foil has the screening effect on "strange" radiation.

10) As shown in works [11,25], spin supercurrent may affect biological systems. For example, the action of the biologically active substances in ultra-low doses on a biological system is accomplished by spin supercurrent.

As shown in works [21,26] "strange" radiation 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 (n) of nucleated cells in the bone marrow of mice and the influence on the peripheral blood cell composition [26].

11) 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, Eqs (2) and (5)-(8). Thus, the action of spin supercurrent, see Eq. (16), while equalizing the values of the 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 substance consisting of the quantum objects.

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

12) Let us show that spin supercurrent (under the name "strange radiation") does not only accompanies LENR but it may stimulate this process as the action of spin supercurrent may result in the emergence of attractive forces between like charged nuclei of different atoms.

According to Eqs (10)-(11), spin supercurrent equalizes the characteristics of spins of virtual photons between which it emerges. Consequently, a situation is possible when the spins (respectively $\mathbf{S}_1$ and $\mathbf{S}_2$) of these virtual photons (see Figure 1) will be oriented in one direction, $\mathbf{S}_1 \rightarrow\rightarrow \mathbf{S}_2$. According to Eq. (3), the similar holds for electric dipole moments (respectively $\mathbf{d}_1$ and $\mathbf{d}_2$) of the virtual photons:

$$\mathbf{d}_1 \rightarrow\rightarrow \mathbf{d}_2. \quad (17)$$

In this case, an electric dipole-dipole attractive force emerges between these virtual photons [12]. If the considered virtual photons created by quantum objects participated in nuclear reaction, then the attractive forces will act between the quantum objects and may cause nuclear fusion. It should be noted that "low-energy" nuclear reaction is accomplished due to attractive forces emerging between like charged nuclei of different atoms (cool nuclear fusion).

13) As the orientation of virtual photon's spin $\mathbf{S}_v$ is associated with the orientation of spin $\mathbf{S}_q$ of quantum object creating this virtual photon, see Eq. (4), the external magnetic field impose quantum objects influence not only the orientation of their spins $\mathbf{S}_q$ but spins of virtual photons created by them as well. The change in the characteristics of spins of virtual photons may: (1) make Conditions (14) and (17) wrong, which results in the disappearance of attractive force between the like charged quantum objects; (2) change the spin supercurrent existing between virtual photons.

According to experimental data the use of external magnetic field influences the characteristics of LENR.

5. Discussion

During the performance of LENR an analogue of ball lightning may emerge [20], see Figure 4. Later it can crumble into many small balls or discharge on high voltage wires.

The model of emergence of ball lightning based on the properties of virtual photons and spin supercurrent is considered in book by Boldyreva [11] in detail. According to this model, virtual photons consisting of two unlike charged virtual particles (according to the hypothesis by Feynman) are divided in an electric field of nucleus (or during electric gas discharge) into charged virtual particles having spin $\mathbf{S}_v / 2$ ($\mathbf{S}_v$ is virtual photon's spin). If spin supercurrent orients these spins in one direction, that is, Condition (14) is fulfilled, then, according to Eq. (15), an attractive pseudomagnetic force acts between like charged virtual particles producing the ball lightning.

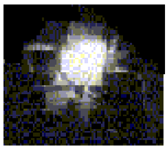

Figure 4. The type of ball lightning emerging during LERN (the size: several cm)

The ball lightning is of nonmagnetic nature, but it may magnetize other bodies due to the action of spin supercurrent between spins of ball lightning and virtual photons created by quantum objects of other bodies. That is, ball lightning may show the magnetic properties not being a magnetic object.

6. Conclusion

The properties of "strange" radiation accompanying LENR are explained by the action of spin supercurrent arising between virtual photons created by quantum objects participating in nuclear reactions, on the one hand, and virtual photons created by quantum objects of researched materials and/or registering devices, on the other hand. The spin supercurrent equalizes the angles of precession and deflection of precessing spins of interacting virtual photons, that is spin supercurrent transforms angular momentum.

It is shown in this work that the action of spin supercurrent explains the following properties of "strange" radiation accompanying LENR.

- The use of metals (nickel, lithium, palladium) for the performance of LENR.
- Nonelectric and nonmagnetic nature of "strange" radiation.
- The magnetization of nonmagnetic substances by "strange" radiation.
- The accompaniment of "strange" radiation by electromagnetic oscillations.
- The superlight speed of the "strange" radiation.
- The emergence of tracks having a vortex form on the surface of various materials.
- The emergence of twin-tracks on the surface of various materials.
- The observation of "strange" radiation in the regions adjacent to active zones of the reactor where the experiments were conducted, excluding the cases of using multi-layered aluminum foil for screening.
- The screening effect of multi-layered aluminum foil.
- The action of "strange" radiation on biological systems.
- The emergence of regions with reduced temperature in the process of cold nuclear fusion.
- The influence of external magnetic field on the characteristics of LERN.

The spin supercurrent (under the name of “strange radiation”) not only accompanies LENR but it may stimulate this process as the action of spin supercurrent results in the emergence of attractive forces (having pseudomagnetic nature) between like charged nuclei of different atoms.

Thus, the LENR and the “strange” radiation are results of action of the same process: spin supercurrent. It should be noted that this article is the first article where the role of spin supercurrent in LENR is studied.

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