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The Non-Electromagnetic Action of Photons on Biological Systems. Spin Supercurrent

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Abstract

The paper aims at showing that there is a physical process that might account for the non-electromagnetic action of photons on biological systems.

An analogy is shown between the effects of low-intensity electromagnetic radiation and the effects of biologically active substances in ultra-low doses on biological systems and also the features of quantum correlation of photons. The analogy may be due to the same physical mechanism underlying the phenomena. It is of importance that quantum correlations of photons are effected by non-electromagnetic forces.

A comparison is drawn between the features of quantum correlations in such quantum macrosystem as superfluid ^{3}He-B and the experimentally established properties of quantum correlations of photons.

It is shown that quantum correlations (and, consequently, the effects of low-intensity electromagnetic radiation on biological systems) may be due to spin supercurrents, whose properties are like those of spin supercurrents emerging between spin structures in superfluid ^{3}He-B, the spin supercurrents being of non-electromagnetic nature.

It is shown that the non-electromagnetic action of photons on a biological system may be performed by spin supercurrents emerging between the spin structures produced by the photons and biological system in the physical vacuum. The spin supercurrent speed may exceed that of light, because the spin supercurrent is not accompanied by the birth of a mass, as it is in the motion of a body (the relativistic increase in mass) or in the motion of photon (the kinetic mass of photon), and therefore has no inertial properties.

Keywords: Ultra-low doses; Non-electromagnetic action of photon; Low-intensity electromagnetic radiation; Quantum correlations; Spin supercurrent; Superfluid physical vacuum

Abbreviations

BS: Biological System; HPD: Homogeneously Precessing Domain.

Introduction

There is a number of phenomena that are indicative, expressly or by implication, of non-electromagnetic action of light on bodies, including biological systems. Let us discuss such phenomena.

The action of low-intensity electromagnetic radiation on a biological system (BS)

Electromagnetic radiation is referred to as a low-intensity radiation if its flux density is less than 1 μW/cm^2 [1,2].

Figure 1 shows the difference Y between the normalized blood clotting time for test group rats (exposed to an alternating electromagnetic field) and that for control group rats (not exposed to the alternating electromagnetic field) against the amplitude of magnetic field strength *H*. The frequency *f* of the electromagnetic field is 5 Hz. Helmholtz coils were used to produce the field [3].

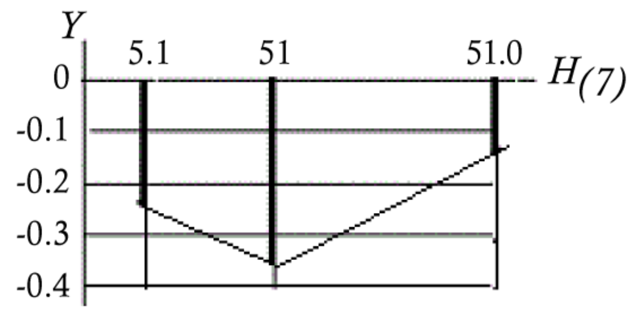

Figure 1: The difference *Y* between the normalized blood clotting time for test group rats and that for control group rats (not exposed to the alternating electromagnetic field) against the amplitude of magnetic field strength *H*. The frequency *f* of the field is 5 Hz.

Figure 2 shows the results of the experiment where test group rats were exposed to a low-frequency alternating electromagnetic field, in particular the difference *A* between the normalized erythrocyte count in the blood of test group rats and that of control group rats (not exposed to the alternating magnetic field) against the amplitude of

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magnetic field strength *H*. The frequency *f* of the magnetic field is 10 Hz [3].

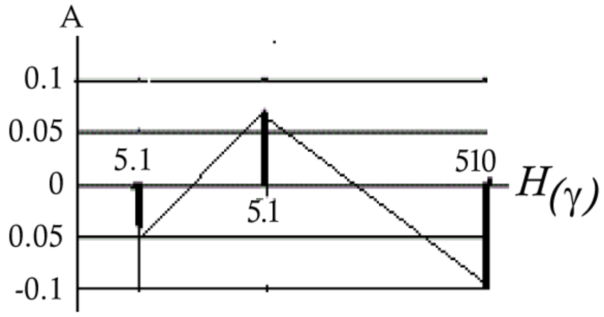

Figure 2: The difference *A* between the normalized erythrocyte count in the blood of test group rats and that in the blood of control group rats (not exposed to the alternating magnetic field) against the amplitude of magnetic field strength *H*. The frequency *f* of the field is 10 Hz

One more phenomenon characteristic of the action of ultra-low doses of irradiation is the type of dependence of human mortality (caused by leukemia) on the equivalent dose *d* of irradiation (including the ϒ-radiation of cesium-137) (Figure 3). The curve is based on the data collected under E. Burlakova's guidance [2,4]. As 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 of about 23 mSv is used.

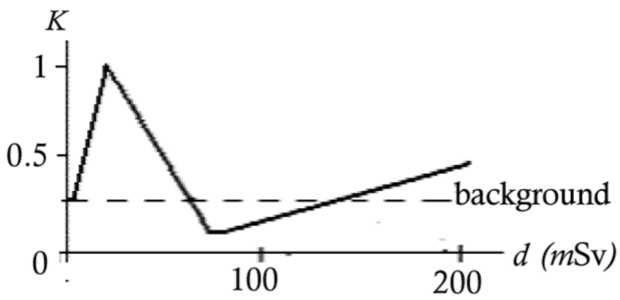

Figure 3: The type of dependence of human mortality (caused by leukemia) on the equivalent dose *d* (including the ϒ-radiation of cesium-137). *K* is the ratio of the number of deaths per 100000 person-years caused by arbitrary value of equivalent dose *d* to the number of deaths caused by the equivalent dose of about 23 mSv

As is shown by the above data, in the action of low-intensity electromagnetic radiation on BS the "dose-effect" (or "dose-response") dependence is non-monotonic. In some cases, the same effects are produced by low-doses differing in 5 to 8 orders of magnitude. There are also cases (an example is shown in Figure 2) where a change in the "sign" of the effect is observed in the dose dependence. Let us compare the above cases of "dose-effect" dependence with similar cases of dependence in the action of biologically active substances in ultra-low doses on BS.

Figure 4 shows the type of variation of the content of protein p53 with mice of F1 line as a function of dose *D* of the injected antioxidant phenosan [5,6]. The value $D = 10^{14}$ mole/kg corresponds to an ultra-low dose.

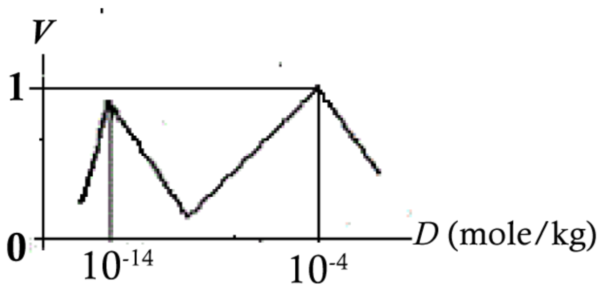

Figure 4: The type of dependence of the content of protein p53 with mice of F1 line as a function of dose *D* of the injected antioxidant phenosan

Figure 5 shows the dependence of normalized toxicity rate T/T' ($T=T'$ at d=9 nm)of silver nanoparticles (AgNP) in experiments with *E.coli* [7] on the nanoparticle size d. The conclusion was made that AgNP interaction with bacteria [8,9] cannot be reduced to the action of Ag^+ ions in equivalent concentrations. Therefore there are grounds to assume that the biological action of silver NPs can be effected through the mechanism different from that of Ag^+ ions (that is, it is not due to electric forces).

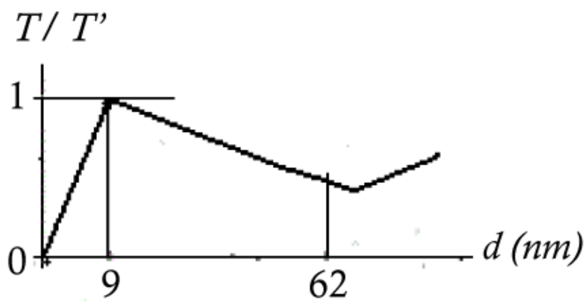

Figure 5: The type of dependence of normalized toxicity rate T/T' ($T=T'$at d=9nm) on the nanoparticle size *d*.

The non-monotonic "dose-effect" dependence (shown in Figures 1-5) is not the only similarity between the features of the effects of low-intensity electromagnetic radiation on BS and the effects of biologically active substances in ultra-low doses on BS. There are other analogies [1,10-13]: a change in sensitivity (generally, an increase) of the BS with respect to a subsequent exposure to ultra-low dose; dependence of the "sign" of the effect (inhibition or stimulation) on the initial state of the BS being treated; disappearance of side effects with a decreased dose (while retaining its activity). The analogies suggest that the effects of low-intensity electromagnetic radiation on BS and those of biologically active substances in ultra-low doses on BS may be due to the same physical mechanism. Since the action of biologically active substances in ultra-low doses on BS is performed by non-electric and non-magnetic forces, the action of low-intensity electromagnetic radiation on BS is likely to be of non-electromagnetic nature too.

The main difficulty in determining the physical mechanism accounting for the effects of ultra-low doses is the low concentration of the substance introduced. The ultra-low doses are taken to be those with concentrations of 10^{13}M or lower [1]. Note that 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 to be 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 of the substance in a cell. This accounts for the difficulty of explaining the effects on the basis of modern physics, in particular, on the basis of the laws of statistical physics.

Quantum correlations of photons

The phenomenon of quantum correlation can be explained by the following example. Let two photons *a* and *b* at the output of a beam splitter, which are described by the same wave function (that is, they have the same frequency and phase), move in different directions and interact with different BS. Photon *a* is directed, depending on the position (1 or 2) of switch *P,* either towards BS A_1 or BS A_2; photon *b* is directed towards BS *B.* Since in quantum mechanics any interaction results in a reduction of wave function, two different interactions of photon *a* with BS may result in two different states of photon *b*, that is, the properties of photon *b* will depend on which BS photon *a* interacts with. Thus the biological systems irradiated by the photons emitted by the same source appear to be connected with each other by quantum correlations of the photons.

The following properties of quantum correlations were determined in the experiments. Quantum correlations take place:

1) For quantum entities having either zero rest mass (e.g. photon) or nonzero rest mass [14].

2) Independent of the distance between the detectors; this was established over distances of the order of 10 km [15].

3) Not only in the process of simultaneous detection of both photons, but also in the case of different times of traveling of the photons from their sources to the detectors. That is quantum correlation takes place between the photon interacting with a detector and the photon which has not yet reached its detector and is found in the physical vacuum [16].

4) Quantum correlations have a non-electromagnetic nature.

There are experimental data [17] that quantum correlations may take place between the photons that have the same frequency, but have been emitted by different sources.

Note that the effects of ultra-low doses on BS and quantum correlations have some similar features:

1. They take place for quantum entities having either zero rest mass (e.g. photon) or nonzero rest mass;

2. They are caused not by electric or magnetic forces;

3. They do not present a cooperative effect, that is, they take place between single quantum entities (between two photons in Figure 6), not between ensembles of quantum entities.

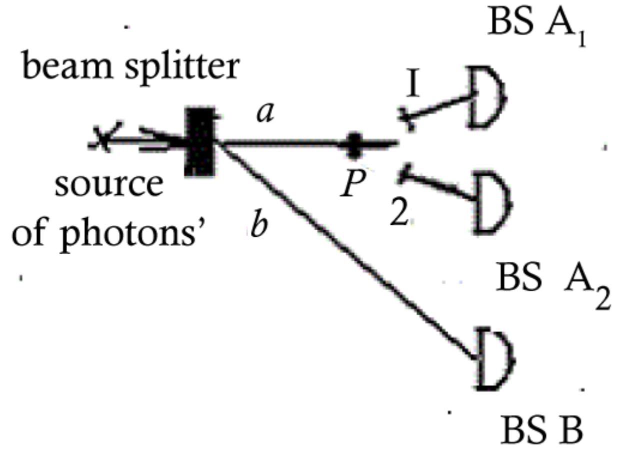

Figure 6: Photon *a* arrives at either BS A_1 or BS A_2 depending on the position of switch P (1 or 2), photon *b* arrives at BS B.

Both phenomena, the quantum correlation and the action of ultra-low doses (including the action of low-intensity electromagnetic radiation) on BS, may be assumed to be caused by the same physical mechanism.

Theoretically, quantum correlations occur instantaneously, and the only explanation based on the classical cause-and-effect relationship might be the introduction of unknown "superluminal" (non-electromagnetic) forces between quantum entities. The only obstruction to "legalization" of such forces is the relativity postulate according to which the speed of transmission of energy (signal) cannot exceed the speed of light [16].

Note. There is the Copenhagen interpretation of quantum correlations, but it does not consider in principle the processes taking places between the quantum entities in the physical vacuum. At the same time the above third property of quantum correlations suggests that quantum correlations take place specifically in the physical vacuum.

Using as an example the quantum correlations in such quantum macrosystem as superfluid ^{3}He-B it is shown in this paper that there is a physical process responsible for quantum correlations, namely, spin supercurrent. Thus the non-electromagnetic action of photons on BS may be effected by spin supercurrents arising in the physical vacuum. The spin supercurrent speed may exceed the speed of light, because spin supercurrent is not accompanied by the birth of a mass, as it is in the motion of a body (the relativistic increase in mass) or in the motion of photon (the kinetic mass of photon), and therefore has no inertial properties.

Materials and Methods

The properties of quantum correlations in superfluid ^{3}He-B

The superfluid ^{3}He-B consists of atoms having spin. One of the properties of superfluid ^{3}He–B is that areas with coherently precessing spins of ^{3}He atoms, the so-called homogeneously precessing domains (HPDs), may exist there. Examples of HPDs are given in Figure 7;

these HPDs are characterized by spin *S* and by respective precession angles α_1 and α_2, nutation angles β_1 and β_2, precession frequencies ω_1 and ω_2, and energies U_1 and U_2, the energies being dependent on the characteristics of the respective spin structures:

$U_1 = f(S, \omega_1, \beta_1)$, (1)

$U_2 = f(S, \omega_2, \beta_2)$. (2)

Since superfluid ^{3}He-B is a quantum system, the HPDs produced in it are quantum entities too. The precession and nutation angles determine the spin part of the order parameter for superfluid ^{3}He–B and there are processes that tend to make equal the respective characteristics of the spin part of the order parameter throughout the whole volume of the superfluid. Such processes in superfluid ^{3}He–B are spin supercurrents [18-20], that is, quantum correlations are effected in this quantum system by spin supercurrents. The value of spin supercurrent *J* between two HPDs is proportional to differences in their precession angles and nutation angles (α_1 - α_2 and β_1 - β_2 in Figure 7).

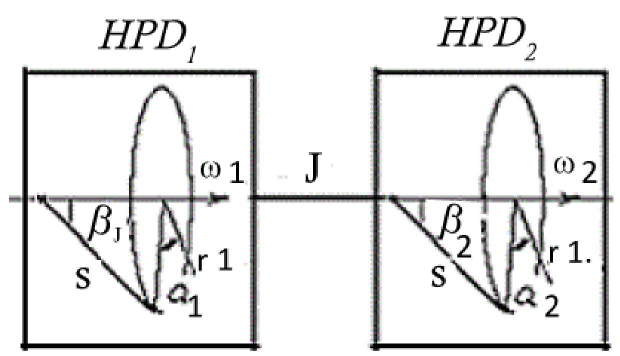

Figure 7: Spin structures HPD_1 and HPD_2 : ω_1 and ω_2 are precession frequencies, α_1 and α_2 are precession angles, β_1 and β_2 are nutation angles, S is spin; r.l. is the reference line, J is spin supercurrent

There exists such a phenomenon in ^{3}He–B as phase slippage. At a certain difference in precession angles, $\Delta\alpha_c$, for two HPDs there takes place a precession phase slippage, or phase drop, by 2πn (n=1, 2…). The critical spin supercurrent J_c corresponds to $\Delta\alpha_c$ [19]. Figures 8a and 8b show examples of the character of dependence of normalized spin supercurrent J/J_c between two HPDs with respective precession frequencies ω_1 and ω_2 ($\omega_1 \upuparrows \omega_2$) on the hypothetical difference in the precession angles, Δφ, which is defined as $\Delta\varphi = (\omega_1-\omega_2)t$, t being time. Up to the value of Δφ equal to $\Delta\alpha_c$, the hypothetical difference is equal to the precession angles difference determining the spin supercurrent, Δα, that is, Δφ= Δα. On the curves the line 1-1 corresponds to the change in the supercurrent in the process of phase slippage, the 2π phase slip taking place. In Figure 8a we have $\Delta\alpha_c = \pi$. In Figure 8b $\Delta\alpha_c \approx 3\pi$ [18].

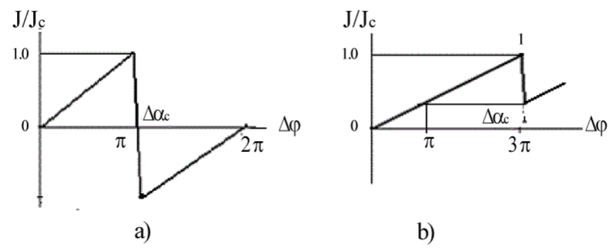

Figure 8: Versions of dependency of the normalized spin supercurrent J/ J_c on the hypothetical difference in the phases of precession, Δφ. Up to point Δφ= $\Delta\alpha_c$, Δφ=Δα.The phase slippage is shown by line 1-1. The 2π phase slippage is taking place. Version a) $\Delta\alpha_c = \pi$; version b) $\Delta\alpha_c \approx 3\pi$

Generally, the determination of time dependency of the magnitude of the spin supercurrent between two regions with precessing spins is a difficult problem, because the speed of transmission of information of the existence of a gradient of the order parameter is, in theory, infinite, and the speed of the spin supercurrent is finite [19]. Besides, a possibility of phase slippage should be taken into account. One of the conditions for the respective precession and nutation angles of interacting HPDs to become equal is the following:

$\Delta\omega \to 0$, (3)

where Δω is the difference between the precession frequencies of interacting HPDs.

Results

Comparison of the properties of quantum correlations and those of spin supercurrents in superfluid ^{3}He-B

According to postulates of quantum mechanics, quantum entities (including photons) produce virtual particles in the physical vacuum. The spin of those particles is the same as for the real particles. Hence it follows that 1) the virtual particle spin has no definite direction, and by the magnitude of spin the magnitude of its projection onto a preferential direction is meant; this can be interpreted as a precession of the spin about the preferential direction; 2) spin correlations can take place.

Thus the spin structures produced by the biologically active substances, photons and the target biological systems as consisting of quantum entities are characterized by respective frequencies of precession, precession angles and nutation angles, the total spin S_s and energy U_s

$U_s = S_s \omega_s$, (4)

where ω_s is the frequency of precession of spin in the structure consisting of virtual particles. Spin correlations may take place between these spin structures.

In this section it will be shown that under the assumption that the properties of these spin correlations are analogous to those of spin supercurrents in superfluid ^{3}He-B, the properties of quantum correlations mentioned in Introduction can be explained on the basis of the properties of spin supercurrents between spin structures in superfluid ^{3}He-B.

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Correlations take place between quantum entities with zero or non-zero rest mass.

Spin supercurrents may emerge in superfluid ^{3}He-B between any structures having spin. Consequently, quantum correlations may take place between any quantum entities producing spin structures with total nonzero spin in the physical vacuum. No matter by which type of quantum entities the spin structures have been produced: with zero or non-zero rest mass.

Note. Quantum correlations may not take place between quantum entities producing spin structures with total zero spin in the physical vacuum. For example, according to [21], there will be no quantum correlations in superconductors between Cooper pairs of electrons with s-pairing.

Correlations take place independent of the distance between the detectors.

Spin supercurrents in superfluid ^{3}He-B may emerge between any spin structures, independent of the distance between them.

Correlations take place between quantum entities not only at the moment of simultaneous registration of the entities.

Spin supercurrent arises between spin structures in superfluid ^{3}He-B instantly, in theory, after the emergence of differences in the precession angles or/and nutation angles of the structures, whether the difference is a result of an external action on one of the structures or on both ones simultaneously.

The quantum correlations may take place between photons of the same frequency, emitted by different sources.

The virtual particles produced by photons in the physical vacuum are converted into real particles (electron-positron pairs, proton-antiproton pairs), if the energy of the photon equals the total energy of the pair of real particles produced. This means that the energy of a pair of virtual particles, that is, the energy of the spin structure produced by the photon in the physical vacuum $\left(U_S\right)_{ph}$ is equal to the energy of photon, Uph:

$$\left(U_S\right)_{ph} = U_{ph}. \quad (5)$$

For the total spin of the pair of virtual particles produced by the photon, $\left(S_S\right)_{ph}$, we have:

$$\left(S_S\right)_{ph} = \hbar. \quad (6)$$

Taking Eq. (4) into account and comparing the well-known relation between energy Uph and photon frequency ωph, Uph = hωph with Eqs. (5) and (6), we obtain that the precession frequency in the spin structure produced by a photon in the physical vacuum $\left(\omega_S\right)_{ph}$ is equal to the photon frequency.

$$\left(\omega_S\right)_{ph} = \omega_{ph}. \quad (7)$$

According to Eq. (3), the efficacy of spin supercurrents in superfluid 3He-B is maximum if the interacting spin structures have equal precession frequencies. But according to (7) the frequency of precession in the spin structure produced by the photon in the physical vacuum is equal to the photon frequency. Thus, the main condition for the photons to be quantum-correlated, i.e. the equality of the photon frequency, is transformed into the condition of the equality of the precession frequencies in the spin structures created by the photons in the physical vacuum

Quantum correlations are effected by a process propagating at a superluminal speed.

The question arises whether the speed of spin supercurrent can exceed the speed of light in vacuum, c, which is a speed limit not only for light but for moving bodies with nonzero rest mass?

To answer the question let us discuss the phenomenon which is characteristic of both light and moving particles: the increase in mass. This quantity for the photon is equal to $\hbar\omega_{ph}/c2$ (c is the speed of light). With due account of (7), it may be assumed that the formation of the mass is associated with the spin precession frequency in the spin structure produced by the photon in the physical vacuum. According to postulates of quantum mechanics any quantum entities produce virtual particles in the physical vacuum; consequently any body as consisting of quantum entities produces a spin structure in the physical vacuum. It is shown in [21] that the additional mass of any moving body (the so-called relativistic increase in mass), Δm, is related to the precession frequency ω_m of the spin structure produced by the body by the following equation: $\Delta m = \hbar\omega_m/c^2$. Thus any moving object that produces a spin structure in the physical vacuum possesses inertial properties, and its speed, at least relative to the gravitational field (since the formation of mass is due to a process in the gravitational field), cannot exceed the speed of light in vacuum.

The spin supercurrent arises between spin structures, but it does not produce the latter. Therefore, *spin supercurrent is not accompanied by the birth of a mass and thus does not possess any inertial properties. So its speed may be greater than the speed of light in vacuum.* A change in the characteristics of interacting spin structures results, according to equations (1)-(2), in a change of energy of the structures. *Consequently, the spin supercurrent transports energy between spin structures, but there is no mass associated with the energy, that is, the equation which relates energy E to mass m ($E=mc^2$) is not valid in this case.*

Thus the properties of quantum correlations mentioned in Introduction can be explained by the action of spin supercurrents emerging between the spin structures created by quantum entities in the physical vacuum [22]. The properties of spin supercurrent are similar to those of spin supercurrent emerging between spin structures in superfluid ^{3}He-B.

Discussion

I. In [21] it is shown that the spin precession frequency in the spin structure created by a biological system in the physical vacuum is determined by the energy of the biological system and may coincide with one of the frequencies of the intrinsic electromagnetic radiation of the system. In this case condition (3) – the condition of the effective action of light on the biological system – is transformed into the requirement of equality of the frequency of the irradiating light and the frequency of the intrinsic electromagnetic radiation of the biological object being irradiated. This can elucidate the long-lived principle of treatment of various diseases: “Like cures like.” Here are some well-known recommendations based on that principle: erysipelatous inflammation having red color is treated by application of red cloth; choledochitis by yellow cloth.

II. According to the properties of spin supercurrent, for the action of ultra-low doses on a biological system by spin supercurrents to be effective the condition (3) has to be met. Therefore, taking into account (7), the following conclusion can be drawn: *the action of a* *biologically active substance in ultra-low dose on a biological system can be replaced by the action of light whose frequency is equal to the spin precession frequency in the spin structure created by the biologically active substance in the physical vacuum.* It agrees with Paracelsus' views on treatment of diseases. The outstanding medieval physician and philosopher thought that light emitted by celestial bodies can cure certain diseases: for example, the disease whose symptoms are like those of anaemia should be cured by radiation of Mars. Note that in the modern medicine anaemia is treated by iron-containing preparations; and Mars is characterized by the presence of iron oxide on its surface, which accounts for the color of the planet: "red planet".

The converse is valid as well: *the therapeutic action of electromagnetic radiation on a biological system can be replaced by the action of a biologically active substance provided the spin precession frequency in the spin structure created by the substance in the physical vacuum is equal to the frequency of electromagnetic radiation*. There are a number of experiments where the properties of water were affected by low-intensity electromagnetic radiation [1] and then this water exerted the same therapeutic effect as the low-intensity electromagnetic radiation.

III. There is much evidence that in the periods of enhanced solar activity outbreaks of diseases (typhus, cholera, etc.) occurred most frequently [23]. Quite possible that epidemics burst out when in the spectrum of solar radiation there were frequencies equal to the spin precession frequencies in the spin structures created by bacterial agents of corresponding diseases in the physical vacuum.

IV. Assuming that the non-electromagnetic action of photons on a biological system is due to spin supercurrents, similar to those which emerge between spin structures in superfluid ^{3}He-B, we endow the physical vacuum with the properties of superfluid ^{3}He-B.

The validity of ascribing the properties of superfluid ^{3}He-B to the physical vacuum is substantiated in a number of works. For example, in [24] a possibility of laboratory simulation of cosmic string formation in the early Universe using superfluid ^{3}He was shown; in [25-27] there were revealed analogies between some properties of superfluid ^{3}He-B and gravitational properties of space. It was proved in [21,28] that if the physical vacuum had the properties of superfluid ^{3}He-B, the waves described by Maxwell's equations could propagate through the vacuum. The spin supercurrents similar to those which emerge between spin structures in superfluid ^{3}He-B may underlie the effects of cavity structures on biological systems [29].

Conclusion

It is shown in the paper that light may exert a non-electromagnetic action on biological systems through spin supercurrents similar to those which emerge between the spin structures in superfluid ^{3}He-B.

The spin supercurrent speed may exceed the speed of light, because the spin supercurrent is not accompanied by the birth of mass, as it is in the motion of a body ("relativistic" increase in mass) or in the case of photon (kinetic mass of photon), and consequently does not possess any inertial properties.

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