

# **Chapter 10**

## **Long-Range Frequency Coherence in a Biological System**


One of the founders of quantum mechanics E. Schrödinger studying the physical aspect of functioning of a living organism developed the following conclusion [1]: “The living organism seems to be a macroscopic system which in part of its behavior approaches to that purely mechanical (as contrasted with thermodynamic) conduct to which all systems tend, as the temperature approaches absolute zero and the molecular disorder is removed.”

That the behavior of a living organism is similar to behavior of systems in which the molecular disorder is removed let us to suppose that the same physical process functions both in a living organism and in the systems. It follows from Schrödinger’s conclusion that the effectivity of this process depends on the “disorder” in the motion of quantum objects taking part in this process. Among the known physical processes: gravitational, electrical, magnetic (between uncharged objects), spin supercurrent transferring angular momentum, only spin supercurrent depends on the difference in the velocities of motion of objects between which it emerges.

According to Eqs (1.6), (1.8), (1.12), (1.16)-(1.17), spin supercurrent emerging between two virtual photons created by quantum objects is determined by energies and speeds of motion of those objects. If the precession frequencies of spins of virtual photons are oriented along the same axis (axis  $\mathbf{z}$ ), spin supercurrent  $I_{ssz}$  emerging between them is determined by:

$$I_{ssz} = -t \cdot b_1 \frac{U_2 - U_1}{\hbar} - b_2 \left( \arcsin\left(\frac{u_2}{c}\right) - \arcsin\left(\frac{u_1}{c}\right) \right), \quad (10.1)$$

where  $U_1$  and  $U_2$  are the energies of quantum objects creating the considered virtual photons;  $u_1$  and  $u_2$  are speeds of motion of those quantum objects along axis  $\mathbf{z}$ .

The effective action of spin supercurrent (the fulfillment of inequalities [1.14]-[1.15]) on virtual photons between which it emerges takes place under Condition (1.20). As the action of spin supercurrent is not significantly dependent on the distance, Condition (1.20) can hold for virtual photons created by quantum objects located at a significant distance. Thus, a long-range area can exist in which the difference  between precession frequencies of spins of virtual photons created by any quantum objects of this area is determined to be:

$$\Delta\omega_v \approx 0. \quad (10.2)$$

The area can be called the area of “Long-Range Frequency Coherence”.

It follows from Eq. (10.1) that, according to Eqs (1.6), (1.8) and (1.14)-(1.17), the action of spin supercurrent minimizes the differences between energies  $\Delta U_q$  and speeds  $\Delta u_q$  of any interacting quantum objects in the area of long-range frequency coherence, that is, the following equalities for any interacting quantum objects in the area are possible:

$$\Delta U_q \approx 0; \tag{10.3}$$


$$\Delta u_q \approx 0. \tag{10.4}$$

Thus, spin supercurrent can support the molecular “order” in the system of interacting quantum objects, in accordance with Schrödinger’s model of living organism.

A similar model of functioning of a BS was proposed in 1977 by H. Fröhlich [123]. He advanced a theory of long-range coherence in BSs while simulating the system’s properties by the properties similar to room-temperature non-equilibrium Bose–Einstein condensate of quasiparticles and introducing the wave functions phase correlations over macroscopic distances. A system that attains this coherent state is known as a Fröhlich condensate. However, Fröhlich did not specify the physical process providing long-range coherence in BSs.

## **10.1. The Properties of Area with Long-Range Frequency Coherence in a Biological System**

### **I. The emergence of magnetic field.**

According to Eq. (1.9), a uniform orientation of spin precession frequencies  of virtual photons in the area of long-range frequency coherence can mean uniform orientation of velocities of quantum objects creating those virtual photons. The latter, with taking into account spin-orbit interaction of quantum objects in atom [109], means the uniform orientation of spins  $\mathbf{S}_q$  of these quantum objects and, consequently, the uniform orientation of their spin magnetic moments. Thus, a nonzero magnetic field emerges in the area of long-range frequency coherence.

It should be noted that the existence of magnetic field in a BS is proved by many experiments [124].

## II. The emergence of electromagnetic oscillations.

According to Eqs (1.16)-(1.17) and (10.2), the equality of precession angles can hold in the area with long-range frequency coherence in a BS:

$$\Delta\alpha_v \approx 0, \quad (10.5)$$

where  $\Delta\alpha_v$  is the difference between precession angles (phases) of virtual photons created by any quantum objects of this area.

The precession (with frequency  $\omega_v$ ) of virtual photon spin means, with taking into account Eq. (1.5), the precession of electric component  $\mathbf{E}_v$ , connected with the spin, and consequently the generation of alternating electric (electromagnetic) oscillations with frequency  $\omega_v$ . According to equality (10.5), the electromagnetic oscillations generated by all virtual photons in the area of the long-range energy-frequency coherence are synchronized by phase. Consequently, significant electromagnetic oscillations will be generated in this area.

It cannot be excluded that the experimentally detected electromagnetic field generated by BSs in optical, infrared and MHz bands of the spectrum [125] contains as well electromagnetic oscillations with frequency  $\omega_v$ , radiated by virtual photons.

## III. The possibility of spreading of metastases emerging from neoplasms.

That quantum objects constituting the area of long-range frequency coherence in BS have equal values of energies, speeds and characteristics of spins of virtual photons created by these objects, Eqs (10.2)-(10.5) (and also see below [10.6]), allows one to explain, from the physical point of view, the possibility of spreading in the BS of metastases emerging from neoplasms. A change in one organ of BS in the area of a long-range frequency coherence can by means of effectively acting spin supercurrent spread onto adjacent or distant organs located in the same area.

The therapeutic effect can exist in the area with long-range frequency coherence as well.

It is possible that the areas of acupuncture treatment introduced by ancient Chinese [35] in a BS are the areas of long-range frequency coherence as well. The change, with the use of acupuncture, in the characteristics of virtual

photons created by quantum objects of one part of area of long-range frequency coherence by means of spin supercurrent influences the characteristics of quantum objects constituting other parts of the area.

**IV.** The possibility of placing the same area with long-range frequency coherence in several BSs.

As the action of spin supercurrent does not depend significantly on the distance, the area with long-range frequency coherence can be placed not only in a single BS: it can be placed in a few BSs. For example, the organisms of twins can have identical (in values and orientations of precession frequencies) areas with long-range frequency coherence. That is, we can say that the organisms of twins can have a common area with long-range frequency coherence.

According to data of work [91], the investigation of diseases of a great number (~500) of identical twins showed that only near 40% of diseases of Twins have a genetic component. The researchers supposed that the special notation must be introduced: Twin Correlation

## 10.2. The Force Emerging Between Different Organs of a Biological System

According to Eqs (1.8) and (10.4), the equality of deflection angles of virtual photons spins can emerge in the area of long-range frequency coherence:

$$\Delta\beta_v \approx 0, \tag{10.6}$$

where  $\Delta\beta_v$  are the differences between deflection angles of virtual photons created by any quantum objects of this area.

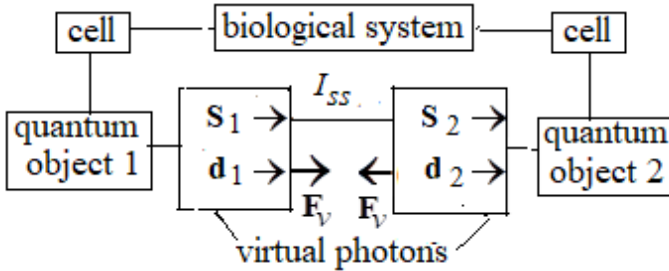
From equalities (10.5) and (10.6) it can follow the uniform orientation of spins of considered virtual photons,  $\mathbf{S}_1$  and  $\mathbf{S}_2$ , that is  $\mathbf{S}_1 \rightarrow \mathbf{S}_2$ . Then, according to Eq. (1.7), electric dipole moments of virtual photons,  $\mathbf{d}_1$  and  $\mathbf{d}_2$ , satisfy the condition  $\mathbf{d}_1 \rightarrow \mathbf{d}_2$ . In this case, attractive force  $F_v$  emerges between virtual photons created by quantum objects constituting the area of long-range frequency coherence.

In the CGS system,  $F_v$  is determined to be [62]:

$$F_v = 6(\mathbf{d}_1 \cdot \mathbf{d}_2) / r^4, \tag{10.7}$$

where  $r$  is the distance between virtual photons in question. The Eq. (10.7) holds under the condition that value  $r$  is greater than virtual photon size  $\delta_v$ ,  $r \gg \delta_v$ . According to Eq. (1.11),  $\delta_v$  equals wavelength  $\lambda_q$  of quantum object creating the virtual photon.

The  $\lambda_q$  is determined to be:  $\lambda_q = \hbar / \sqrt{2m_q U_q}$ , where  $m_q$  and  $U_q$  are respectively the mass and kinetic energy of quantum object. Thus, Eq. (10.7) holds under Condition  $r \gg \hbar / \sqrt{2m_q U_q}$ .



**Figure 10.1.** The forces acting between virtual photons constituting the area of long-range frequency coherence.  $S_1$  and  $S_2$  are spins,  $d_1$  and  $d_2$  are electric dipole moments,  $I_{ss}$  is a spin supercurrent,  $F_v$  is a force between virtual photons.

*Note.* If, as a result of an external disturbance a spin inversion of one of interacting virtual photons takes place, that is, the following emerges:  $S_1 \rightarrow \leftarrow S_2$  and due to Eq. (1.7):  $d_1 \rightarrow \leftarrow d_2$ , then force  $F_v$  will be transformed from an attractive force to a repulsive force [62].

Thus, electric dipole-dipole forces can exist between quantum objects constituting cells of BS, which allow one to explain, from the physical point of view, the following experimentally observed phenomena in the BS: division and aggregation of cells [91,126].

The concept of existence of electric dipole-dipole interaction between cells of BS is in accordance with models by H. Pohl [127] and B. Goodwin [125]. The model by H. Pohl suggests dipolar features and possibility of attraction of certain cells. The model by B. Goodwin suggests that the morphogenetic field can be of electric nature and electric forces can influence the development and regeneration of organisms.

### 10.3. The Destruction of Long-Range Frequency Coherence

The destruction of long-range frequency coherence in any area of BS means that spin supercurrent ceases to equalize the values of precession angles, deflection angles and precession frequencies of precessing spins of virtual photons created by quantum objects of this area, and consequently ceases to equalize the energies and velocities of these quantum objects. That is, Eqs (10.2)-(10.6) will not hold.

Such a change in the properties of spin supercurrent can take place, in particular, due to phase slippage (drop). The phase slippage (drop) emerges at a definite difference,  $\Delta\alpha_c$ , of precession angles of interacting virtual photons, see Eq. (1.19).

For increasing the difference between precession angles of spins of interacting virtual photons the spin-flip effect in one of the interacting virtual photons can be used [30]. The inversion of spin in the spin-flip effect results in changes in the spin deflection angle (by  $\pi$ ) and the spin precession angle.

A spin-flip in a virtual photon can be performed in the following way: the quantum object creating this virtual photon (the spin of the latter precesses with frequency  $\omega_v$ ) is placed in the area of electric field  $\mathbf{E}$  rotating with frequency  $\omega_E$ .

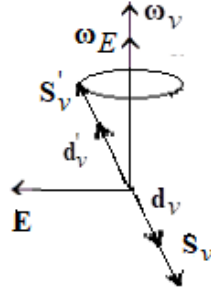
According to Eq. (1.7), spin  $\mathbf{S}_v$  is associated with the dipole moment  $\mathbf{d}_v$ . Consequently, under the action of moment  $\mathbf{M} = \mathbf{d}_v \times \mathbf{E}$  the precession of spin  $\mathbf{S}_v$  relative to  $\mathbf{E}$  emerges. The inversion of moment  $\mathbf{d}_v$  and, consequently, of spin  $\mathbf{S}_v$  takes place under the following Conditions [16]:  $\mathbf{E} \perp \omega_v$  and

$$\mathbf{S}_v \uparrow \downarrow \mathbf{S}_q. \quad (10.8)$$

The physical features of the spin-flip effect in the virtual photon are similar to the physical features of nuclear magnetic resonance (NMR) used in contemporary medicine for diagnosis of BSs [128]. However, between them the following differences exist: 1) in NMR the spin of the quantum object is inverted but not the spin of the virtual photon created by the quantum object; 2) in NMR the spin-flip effect is caused by an alternating magnetic field, not by an alternating electric field as in the spin-flip effect of the virtual photon;

and 3) NMR is accompanied by the generation of a magnetic pulse; as the virtual photon has the electric dipole moment (see Eq. [1.7]) its spin-flip effect is accompanied by the generation of an electric pulse.

Figure 10.2 illustrates the spin-flip effect of spin  $\mathbf{S}_v$  precessing with frequency  $\omega_v$ . The direction of the  $\mathbf{S}_v$  after the inversion is shown by vector  $\mathbf{S}'_v$ , the direction of the  $\mathbf{d}_v$  after the inversion is shown by vector  $\mathbf{d}'_v$ .



**Figure 10.2.** A diagram illustrating the inversion of the virtual photon's spin.  $\omega_v$  is the frequency of precession of spin  $\mathbf{S}_v$ ,  $\omega_E$  is the frequency of the rotation of  $\mathbf{E}$ ,  $\mathbf{d}_v$  is the electric dipole moment of the virtual photon,  $\mathbf{S}'_v$  is the inverse direction of  $\mathbf{S}_v$ ,  $\mathbf{d}'_v$  is the inverse direction of  $\mathbf{d}_v$ .

*Note.* The spin-flip effect in virtual photon can be used for determining its spin precession frequency. Really, knowing the frequency  $\omega_E$  at which the generation of the electric pulse caused by inversion of  $\mathbf{d}_v$  takes place, and using Eq. (10.8), it is possible to determine  $\omega_v$ .