ПЕРВИЧНЫЙ МЕХАНИЗМ ВОЗДЕЙСТВИЯ НИЗКОИНТЕНСИВНОГО ЭЛЕКТРОМАГНИТНОГО ИЗЛУЧЕНИЯ НА БИОЛОГИЧЕСКУЮ ЖИДКОСТЬ

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Представлен первичный механизм взаимодействия низкоинтенсивного электромагнитного излучения на биологическую жидкость.

THE PRIMARY MECHANISM OF LOW-FREQUENCY ELECTROMAGNETIC-RADIATION INFLUNCE ON BIOLOGICAL LIQUID

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The primary mechanism of low-frequency electromagnetic-radiation influence on biological liquid is presented.

Introduction.

The numerous experiences on detection of activity of a magnetic field on structural reorganizations of molecular liquids containing hydrogen bonds are actual today [1, 2]. The interest represents detection of non-thermal activity of electromagnetic fields of small intensity on liquid water, alcohols, gels, binary mixtures, and living organisms. At present, there is not inventory possible to arrested by this action at system, because small changes of physical and chemical parameters describing such systems and effect is very small. But there are substituted dates, which one supposed that interaction is exhibited in formation of inconvertible structures on times many times over hydrogen bridges superior a lifetime. Unfortunately, now there is only "living" indication of such phenomenon. The experience on planarians have shown, that some processes of vital activity, for example quantitative index vary, in water processed stationary and variable magnetic collinear fields comparable on intensity to a geomagnetic field [3].

Another way, probably, more reasonable is results molecular dynamics (MD) for such systems. Though here it is difficult to implement the mechanism of interaction is a restriction on number of particles, which one we can take into account. It was possible "to freeze" the molecular dynamic on 400 ns [4] by the help of numerical evaluations. And expedient of the registration of interaction at system, even if it multiplicative – allows to receive only numerical solution on a finite interval of time with losses of collective effects. We have delivered before ourselves a problem at a quality level, using asymptotical and operational methods, methods of a quantum field theory in statistical physics to take into account properties of action on model by a gauged field. Thus to reduce study not only to build-up of model of liquid water, but also fluids with H – bonds as a whole.

It is useful to enter parameters describing model ε_0, t_0, S_0, which are circumscribed further. Exchanging these parameters it is possible to conduct examination of similar systems. The influence EMF can be taken into account through a force constant EMF with substance. The matters containing chains of hydrogen bridges with 3 measuring structure in liquid state were termed as us – bulk knitted structures. They represent tangled. There are time processes: formations – destructure H – bonds, registration of dynamic bonds and bonds of base structure, action on such structures and strain of bonds.

It reveals a number of fine non-linear and quantum effects. Suppose the structure of such systems to be a bound band. The bands are tied by their edges between different parts, which builds up a three dimensional net, a bulk knitted structure. Such structure was earlier termed as large clusters, or briefly clusters. At study of action EMF on multiplicative mediums, including on living objects, we deal with nonlinear processes. The build-up of the primary mechanism of interaction for such systems is not possible, in a view of numerous parameters, non-equilibrium dynamics of system. And even the neglect by such feature as immunity for an living organism does not allow to reduce set of equations to precisely solved set of equations with arrested parameters and uniqueness of the solutions. But it is possible to suspect, that, as the living water is component of all such systems, it is a receptor of actions in a major frequency band and intensities EMF. Electric and magnetic fields, as well as electromagnetic radiation influence the position of phase transition points, shifting the temperature and smearing out the transitions themselves [5]. Therefore it is possible to compare such influence with origin in system of solitons, which will predetermine microstates of our macrosystem.

We managed to find dependence of action of a field, through change of concentration such onesolitons of the solutions. The operation is carried out in manysolitons approach for kinks. The registration of the breather solutions will allow to receive the new solutions.

It is known that the liquid structure changes when is influenced by constant and alternate magnetic fields, these changes being conserved during some tens of hours. These changes can be identified by kinetic properties, for instance by change of viscosity, reaction rate characteristics of dielectric relaxation spectra, IR-, UV- spectra and luminescence. We suppose that the structure of the liquid under consideration is defined by quantity of solitons on the band, between ties, soliton concentration, and by concentration of ties in the system.

Effective Hamiltonian.

We consider the liquid structure as a three-dimensional surface composed in the following way. At temperature lower than the critical one, the 3D-surface is supposed to transform into dipole hexagonal structure such that dipole momenta of liquid molecules are arrange according to the action minimum principle. We suppose that in liquid state the amount of H-bonds per one molecule becomes less than 4.

The model takes into account the interaction of neighboring molecules as well as ones that far from each other bulk interaction. The three-dimensional structure is assumed to be with elasticity defined analogously to that in the theory of nematics [6 – 8]. Structure transformations are associated with transformations of H-bonds, and we call each structure breach or disturbance a topological defect, which has a dimension, that can be fractional. Our model may be thought of as quasi-polymeric liquid. Several liquid molecules form band sections, that in turn are tied by their edges with the help of H-bonds. As a break of an H-bond occurs, the transformation of 3D-structure is coming. The sections of molecules change their orientation according to the action minimum principle, and then a retie0ing is taking place. So, the model describes isotropic medium, which has local anisotropy. Instantaneous interaction of the edges of a chain composed by oriented segments is assumed to be much weaker than the interaction that builds the band itself. In the first approximation this interaction is neglected, and the behavior of the band twisted in a ball is considered. The system is placed into external electromagnetic field of low intensity. In such system, solitons and breathers appear, which essentially influence its properties.

The kink propagation on the segments of 3D-structure along the band will turn it at angle 2π, while breather propagation – at angle 4π. Kinks and breathers propagate with velocities v_0 and v_S correspondingly. Analytical form of breather and soliton type solutions of SG – equation is described in [9]. Consider the case when there are no breathers. Then, the knitted system in the ground state is described by the Hamiltonian

$$H_0 = H'_k + \sum_j \int_{-l_j/2}^{l_j/2} [\frac{1}{2} I \dot{\phi}^2_j(s,t) + \frac{1}{2} C \left(\frac{\partial \phi_j}{\partial s} \right)^2 + \frac{U}{2}(1 - \cos 2\phi_j) \qquad (1)$$

$$+ \frac{\mu}{l_j} \mu_1 \cos\phi_j - \delta I H(t) \dot{\phi}_j] ds + \sum_{j>j_1}^{N} U\left(\left| r_j - r_{j_1} \right| \right) + \sum_j U(r_j),$$

where H'_k – kinetic energy of the system minus the kinetic energy related to collective coordinates of solitons, $\phi_j(s,t)$ – rotation angle of a twisting band on the segment between the points j and $j+1$, which is of length l_j, at the points j and $j+1$ the band is tied with another one with a potential $U\left(\left| r_j - r_{j_1} \right| \right)$, I – the inertia momentum density corresponding to the twist per unit length of the band, C – band's constant elasticity, U – density of molecular field interaction energy, μ' – dipole momentum density module, δ – the parameter of interaction of polymer chain with external magnetic field $H(t)$.

Notice that the points j and $j+1$ are not tied with each other. The dot over φ_j denotes time derivative. The quantity $U(r_j)$ is an external potential acting on the point j with coordinate r_j, for instance, from a capillary. Suppose that, on the band's segment between the points j and $j+1$ there are n_j solitons (i.e. we have an n_j – soliton solution). Suppose also, that the concentration of solitons is not very high, so that we may consider each soliton to be sufficiently distant from each other.

Then

$$\phi_j(s,t) \approx \sum_{\alpha=1}^{n_j} \varphi_{j\alpha}(s,t), \qquad \textbf{(2)}$$

where $\varphi_{j\alpha}(s,t) = 2\arctan\exp\left(\gamma_\alpha\left(s - s_\alpha - v_\alpha t\right)\right)$ – single-soliton solution [10], threaded on the band's segment between the points j and $j+1$, $\gamma_\alpha = \left(1 - v_\alpha^2\right)^{-\frac{1}{2}}$. Making use of (2) for the Hamiltonian (1) we have

$$H_0 = H_k + \sum_j \int_{-l_j/2}^{l_j/2} [\frac{1}{2}C\sum_{\alpha\alpha_1}\left(\frac{\partial\varphi_{j\alpha}}{\partial s}\frac{\partial\varphi_{j\alpha_1}}{\partial s}\right) + \frac{U}{2}\left(1 - \cos 2\sum_\alpha \varphi_{j\alpha}\right)$$
$$+ \frac{\mu'}{L}\mu_1 \cos\sum_\alpha \varphi_{j\alpha} - \delta I H(t)\sum_\alpha \dot{\varphi}_{j\alpha}]ds + \sum_{j>j_1}^{N} U\left(\left|r_j - r_{j_1}\right|\right) + \sum_j U(r_j), \qquad \textbf{(3)}$$

where $H_k = H_k' + \frac{I}{2}\sum_{j=1}^{N}\sum_{\alpha\alpha_1}^{n_j}\int_{-l_j/2}^{l_j/2} ds\,\dot{\varphi}_{j\alpha}(s,t)\dot{\varphi}_{j\alpha_1}(s,t)$ – the total kinetic energy of the system. The integration over s in (3) can be carried out explicitly, which leads to the effective Hamiltonian describing the system in terms of free particles, solitons and interactions between them. The Hamiltonian does not depend on time, and, therefore may be calculated at any time. The simplest way to do that is to chose $t = 0$.

From now on we use this effective Hamiltonian for the description of the system, which consists of twisted bands between the points r_j and r_{j+1} and with the positions of twirls on them in the points s_α.

Free energy.

Finally, the free energy per unit volume for the globule is (for the ball last member of expression is equal to zero at $V \to \infty$)

$$\frac{F-F_0}{V} = -c_1 \frac{\pi^2\delta^2}{4kT} CI\left\langle v^2 \right\rangle H^2(t) + c_1 \frac{2\pi\sqrt{UC}}{\gamma} - c_1\left(-kT\ln c_0 + c_0\left(-\frac{\pi}{2}+\frac{8}{3\gamma^2}\right)C - \frac{c_0^2}{3!(kT)^2}\left(\pi - \frac{16}{3\gamma^2}\right)\left(2\gamma - \frac{8}{3\gamma}+\frac{256}{27\gamma^3}\right)\left(C^2\sqrt{UC} - \frac{32c_0^2}{3!\gamma^3}\left(\frac{C}{U}\right)\sqrt{UC}\right)\right) + \frac{kT}{4}\left(-3+\sqrt{1+8A(T)c_0^2}\right)^2 n_0(T). \quad (4)$$

Here $c_1(T) = \frac{1}{V}\sum_{j=1}^{N} n_j = c_0(T)\sum_{j=1}^{N}\frac{l_j}{V} = c_0(T)\sigma$, where σ the amount of bands intersecting the unit cross-section. For uniform liquid, this quantity is constant. Notice that n_0 – the concentration of ties depends essentially on the purity of the liquid, and decreases with clearing.

The analysis of the statistical integral for the knitted structures has shown that the soliton concentration increases with the magnetic field. In the absence of magnetic field, the system also has a certain amount of solitons, with the relative concentration. Bulk interaction reduces the free energy value proportionally to the amount of ties in the bulk. With the increase of soliton concentration, the value of this reduction decreases and becomes zero at $c_0^2 = A^{-1}$, then the free energy reduces again. With the increase of magnetic field, the free energy decreases. The heat capacity of the system decreases with the increase of temperature, but magnifies with magnetic field. Such behavior of the system in magnetic field is due to the fact that, with the enlargement of the field strength, the system acquires additional degrees of freedom corresponding to the solitons.

Describing liquid as continuous medium, we conclude that the minimal energy in the model of liquid corresponds to the absence of deformations in it. In liquid water, such state with minimal energy or the ground state is the configuration with uniform orientation in the whole bulk – hexagonal ice (Ih) for our model. Any deviation of director distribution from uniform (i.e. the same in the whole bulk) is connected with the presence of additional elastic energy in the model of liquid, that is may be implemented only by external influence, connected, for example, with the surfaces of a chosen segment, external electric and magnetic fields, etc. In the absence of these influences or after the termination of their action, the liquid tries to return to the state with uniform director orientation. In the soliton model of liquid, when affected by external magnetic field, turnings of certain band segments occur, which leads to the deviation of director orientation distribution from uniform. There appears some addition to the free energy. Liquid in magnetic field has a state in which it can remain for a long time $t_c >> t_H$, where t_H is hydrogen bond lifetime. The system will continue to be in the state with this energy until an external perturbation moves it to some other state, or until the temperature changes. The addition to the free energy in the soliton model of liquid is conditioned by soliton and breather concentrations. They become apparent already at low values of magnetic field strength.

Summary.

We consider, that in EMF the configuration of water band varies, and that is number of solitons on per unit length chains of hydrogen bonds varies. The field orientated water band in 3D-space, and at sufficient interaction in water there are local dedicated direction. EMF interacts with this current, changing a conformation state of a part of band, without essential change of it energy. Thus, there is a quasistationary transformation in system water + biological molecule, bound to orientation and coordination of it separate parts. The change of properties of system starts after some induction period indispensable for translation for a considerable proportion of parts in a new conformation state. It turned out that the knitted systems, those liquid water belongs to, have unique properties, which can be explained by the existence in them solitons and breathers. Many properties of water are explained in terms of continual soliton conception of water structure. Moreover, the structures of different knitted liquids under different magnetic fields can be described in terms of shift solitons and breathers. Soliton models provide good description of such systems. We have calculated the statistical integral which allows one to compute configurational contributions to the internal energy, heat capacity, entropy of knitted structures (including liquid water) within the wide temperature interval and in the presence of mag-

netic fields [11]. The calculated heat capacities for the liquid water without magnetic field are in good agreement with the experiment.

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