Application of Appratus for Magnetotherapy together with Apparatus for Permanent Electrical Field in Medicine

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Abstract – **"The healing effect of separate application of permanent electrical field generated by apparatus, called galvanostad is well known. Usually penetrating of different drugs through the skin and dispersing of these drugs in the alive tissues are on the base of influence of permanent electrical field. The healing effect of separate application of low frequency magnetic field generated by apparatus for magneto-therapy is well known in medicine, also. But the simultaneously application of low frequency magnetic field generated by apparatus for magneto-therapy and permanent electrical field generated by galvanostat is a new method in physiotherapy. The mathematical description and computer simulation of movement of ions in alive tissue in the case of simultaneously application of apparatus for magneto-therapy and galvanostat is the main task of present paper. These mathematical description and computer simulation are important not only for medical education , but for engineering education, also.**

Keywords-**low frequency magneto-therapy ,permanent electrical field, galvanostat .**

I. Introduction

In the case of separate application of permanent electrical field, the vector of density $\vec{\delta}(x,y,z)$ of permanent electrical current in alive tissues depends only to the vector of intensity of electrical field $\vec{E}(x,y,z)$ and specific conductivity of alive tissues σ .

$$\vec{\delta}(x,y,z)=\sigma\vec{E}(x,y,z) \qquad (1)$$

Therefore the trajectories of movement of ions of drugs are identical with the lines of the vector of intensity of electrical field $\vec{E}(x,y,z)$. It's clear that the dispersing of the ions of drugs in the alive tissues is limited. Because of that the process of therapy should be repeated too many times and it's impossible to be obtained good effect of therapy for a short time. Usually this effect is connected with reducing of pain. The pain can be reduced in the case of separate application of permanent or low frequency magnetic field, also. The process of separate magneto-therapy is too long, also.

In the case of simultaneously application of apparatus for magneto-therapy and apparatus for permanent electrical field called galvanostad there are influence of two fields on the ions in alive tissues: electrical with intensity $\vec{E}(t)$ and magnetic with magnetic induction $\vec{B}(t)$ (Fig.1).

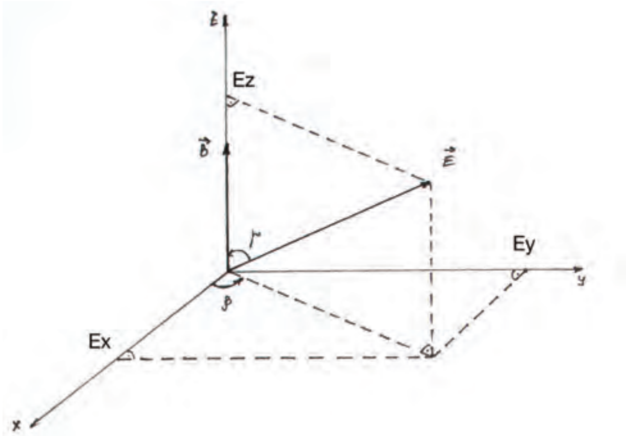

Fig.1 Influence of electrical and magnetic field on the ion, which in the centre of coordinate systems X,Y,Z

II. Mathematical Description and Computer Visualisatiuon of Movement of Ions

A. Mathematical description

According to the Fig.1, in the case of simultaneously application of apparatus for magneto-therapy and galvanostad, the movement of ions can be described using the differential equations:

$$m_i\frac{d^2x(t)}{dt^2}=q[E(x,y,z,t)\sin\gamma\cos\beta+$$
$$+B(x,y,z,t)\frac{dy(t)}{dt}]$$

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$$m_i \frac{d^2 y(t)}{dt^2} = q[E(x,y,z,t)\sin\gamma \sin\beta + \\ + B(x,y,z,t)\frac{dx(t)}{dt}] \qquad (2)$$

$$m_i \frac{d^2 z(t)}{dt^2} = qE(x,y,z,t)\cos\gamma$$

where:

$\vec{E}(x,y,z,t)$ is the intensity of electrical field;

$\vec{B}(x,y,z,t)$ is the magnetic induction;

m_i is the mass of ion;

q is the electrical charge of ions;

β is the angle between axis X and projection of the vector of intensity of electrical field $\vec{E}(x,y,z,t)$ on the plane XOY;

γ is the angle between axis Z and vector of intensity of electrical field $\vec{E}(x,y,z,t)$;

If:

$$\vec{E}(x,u,z,t) = const \wedge \vec{B}(t) = \vec{B}_m \cos\omega_3 t \wedge \\ \wedge \vec{B}(x,y,z) = const \wedge \\ \wedge \omega_3 = const \wedge \beta = 45^\circ \wedge \gamma = 45^\circ \qquad (3)$$

where:

$\vec{B}_m$ is the amplitude of magnetic induction of the low frequency magnetic field in every point.

ω_3 is the frequency of the magnetic field

the equations (2) can be written as equations (4):

$$m\frac{d^2 x(t)}{dt^2} = q[E\sin\gamma\cos\beta + \frac{dy(t)}{dt}B_m \cos\omega_3 t],$$

$$m\frac{d^2 y(t)}{dt^2} = q[E\sin\gamma\sin\beta + \frac{dx(t)}{dt}B_m \cos\omega_3 t] \qquad (4)$$

$$m\frac{d^2 z(t)}{dt^2} = qE\cos\gamma,$$

B. Computer visualization of movement of ions in alive tissues

The equations (4) can be solved by MATLAB. Their solutions can be investigated for different values of parameters. The solutions of equations (4) can be seen on Fig.2 in the case of movement of ions of Na^+ for the following values of parameters:

$E = 200[V/m], \left|\vec{B}_m\right| = 3[mT], \omega_3 = 2\pi 50[1/s]$.

The movement of ions is periodical because of the influence of periodical magnetic field. The trajectory of ions are not identical with the lines of the vector of intensity of electrical field $\vec{E}(x,y,z)$.This trajectory is 3D curve (Fig. 2d) because of simultaneously influence of low frequency magnetic field. Therefore in the process of ionophoresis (penetrating of different drugs through the skin), the dispersing of the ions of drugs in the alive tissues is in 3D space, also.

The trajectory of ions are as circumference with variable radius. The changes of radius are periodical because of periodical magnetic signals. The planes of circumferences (as parts of trajectory of ions) are parallel of the plane XOY (Fig.2d). Because of distribution of ions of drugs in 3D space, one good healing effect can be obtained in short time, reducing the number of procedures.

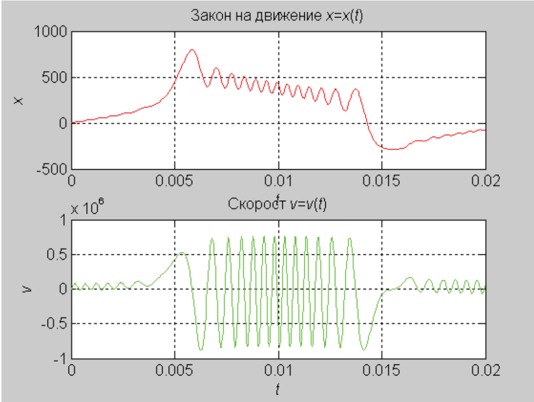

Fig.2a Movement and velocity of Na^+ ions on the axis X

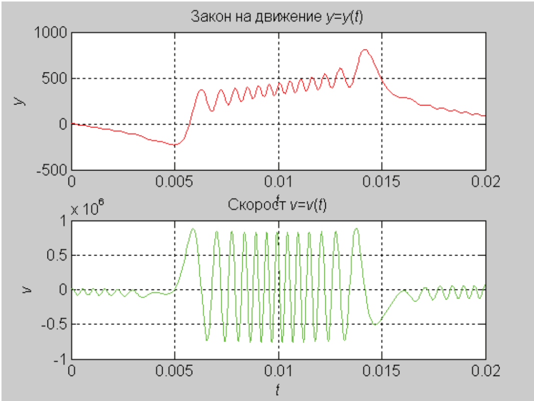

Fig.2b Movement and velocity of Na^+ ions on the axis Y

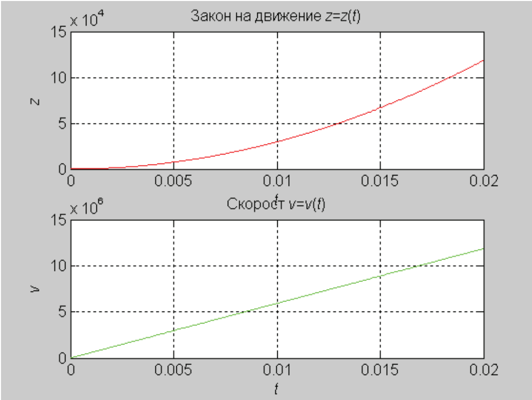

Fig.4c Movement and velocity of Na^+ ions on the axis Z

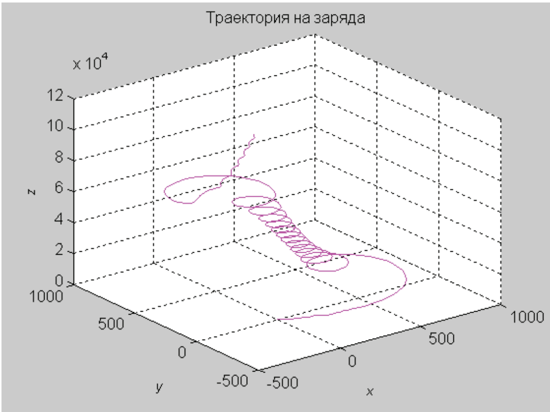

Fig.2d 3D -trajectory of movement of Na^+ ions

The solutions of equations (4) can be seen on Fig.3 in the case of movement of ions of Na^+ for the following values of parameters:

$$E = 100[V/m], \left|\vec{B}_m\right| = 30[mT], \omega_3 = 2\pi 50[1/s]$$

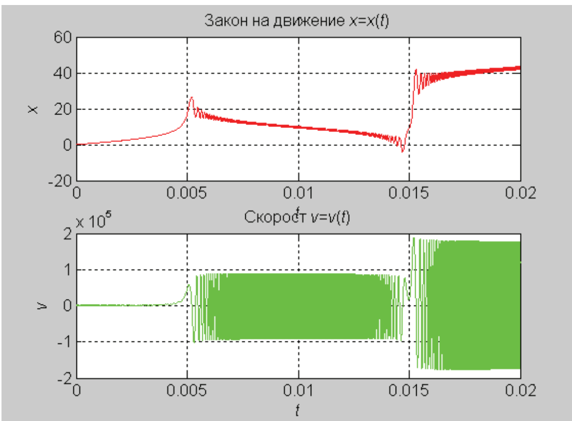

Fig. 3a Movement and velocity of Na^+ ions on the axis X

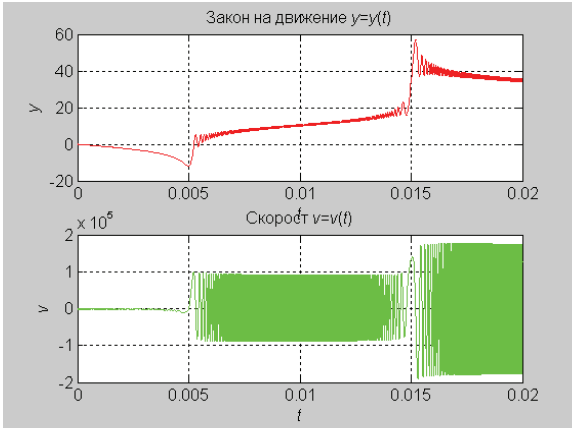

Fig.3b Movement and velocity of Na^+ ions on the axis Y

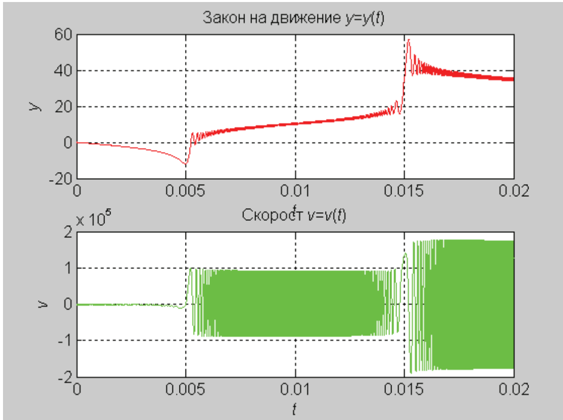

Fig.3c Movement and velocity of Na^+ ions on the axis Z

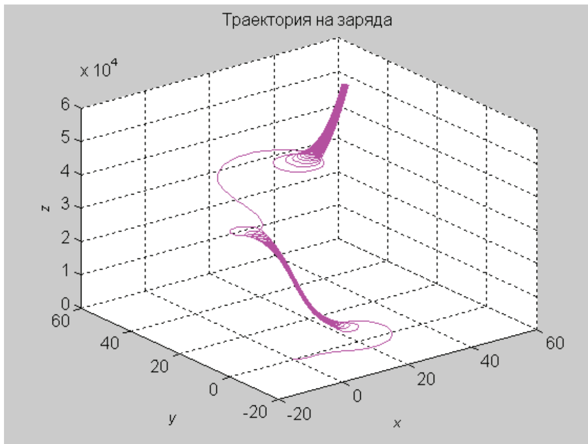

Fig.3d 3D -trajectory of movement of Na^+ ions

The periodical character of 3D curve trajectory of ions can be seen more clear on the Fig.3d than on Fig.2d. The influence of the value of amplitude of magnetic induction $\vec{B}_m$ on the character of 3D trajectory is more significant than influence of intensity of electrical field $\vec{E}(x, y, z)$. Therefore it's easy to modify the character of 3D trajectory of movement of ions by change of value of amplitude of magnetic induction $\vec{B}_m$.

The character of this 3D trajectory can be modified easy by change of the value of frequency of magnetic signals, also. The solutions of equations (4) can be seen on Fig.4 in the case of movement of ions of Na^+ for the following values of parameters:

$$E = 200[V/m], \left|\vec{B}_m\right| = 30[mT], \omega_3 = 2\pi 100[1/s].$$

The number of specific "spirals" of 3D trajectory of movement of Na^+ ions increases as result of increasing of frequency of magnetic field. It can be seen after one comparison between Fig.3d and Fig.4.

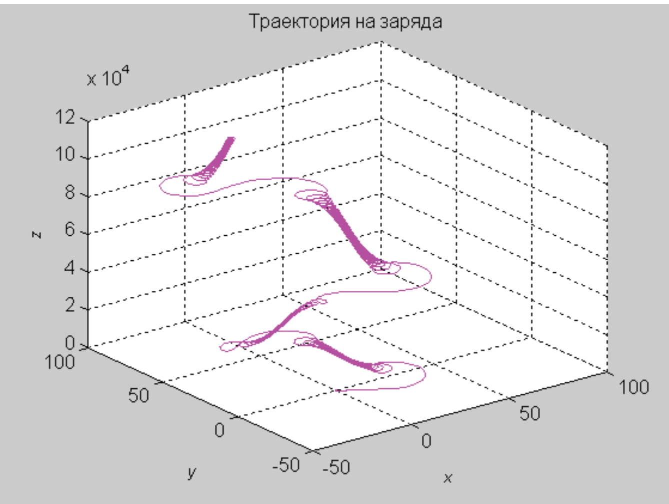

Fig.4 3D -trajectory of movement of Na^+ ions

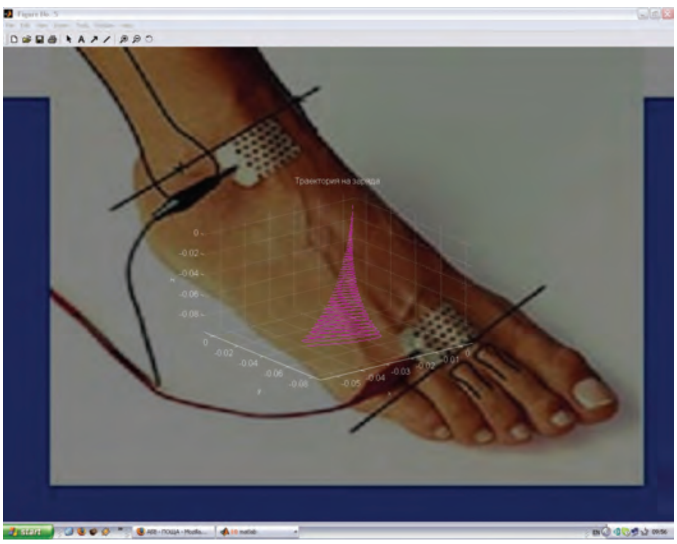

Fig.5 Visualization of 3D trajectory of movement of drug's ions in process of ionophoresis in the case of simultaneously application of low frequency magnetic field.

III. Conclusion

1.A mathematical descriptions and computer simulation of movements of ions in alive tissues in the case of simultaneously application of apparatus for magneto-therapy and galvanostad is described in the paper.

2.An investigation of influence of different parameters of external electrical and magnetic signals on the movement of ions in alive tissues has been done in the paper.

3.A mathematical evidence has been obtained that the trajectory of movement of ions is 3D in the case of simultaneously application of apparatus for magneto-therapy and galvanostad.

4.The trajectories and velocities of movement of ions in alive tissues are periodical if the external e magnetic signals are periodical.

5.The obtained results , described in the paper can be used not only as scientific and one base for development of medical therapy , using new more effective methods, but for presentation in the process of education, also.

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