INVESTIGATION ON SIMULTANEOUSLY INFLUENCE OF LOW FREQUENCY INTEREFERENCE ELECTRICAL SIGNALS AND LOW FREQUENCY MAGNETIC SIGNALS ON IONS IN THE LIVE TISSUE

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Abstract

An investigation of simultaneously influence of two low frequency electrical signals and one magnetic signals on the ions in the live tissue is described in the paper. The results of computer simulation of the movement of ions is shown. The investigations are in connections with medical application of electrotherapy (application ointerferent currents) together with magnetotherapy.

1. Introduction

The clinical results obtained by separate application of interferent currents and low frequency or permanent magnetic field are well known in medicine[…]. Nevertheless the results of investigation on the movement of ions in the live tissue provided by influence of external low frequency electrical or magnetic field are not known. There are not scientific results in medicine and in engineering, also on simultaneously application of low frequency electrical and magnetic field on the human body. These investigations are the goal of the present paper.

2. Mathematical description

The two low frequency electrical field are provided by two independent generators. The output tensions U_1 and U_2 are on the respective pair patient's conductors A-A and B-B (fig.1)

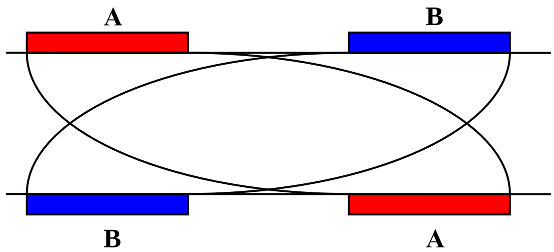

Fig. 1

The space disposition of the vectors of two electrical forces $\vec{F}_1$ and $\vec{F}_2$ and the vector of magnetic induction $\vec{B}$ can be seen on fig.2.

The ion with masse m and electrical charge q is situated in the centre of coordinate system X,Y,Z. There are influence of three forces $\vec{F}_1, \vec{F}_2, \vec{F}_3$ on the ions.

$$\overrightarrow{F_1}(t) = q\vec{E}_{1m} \cos \omega_1 t \qquad (1)$$

$$\overrightarrow{F_2}(t) = q\vec{E}_{2m} \cos \omega_2 t \qquad (2)$$

$$\overrightarrow{F_3(t)} = q(\vec{V} x \vec{B}_m \cos \omega_3 t) \qquad (3)$$

where:

U_1 and U_2 are the tensions on the two pairs of patient's conductors;

ω_1 and ω_2 are the frequencies of the two independent generators;

$\vec{E}_1, \vec{E}_2$ are the intensities of the two electrical fields;

$\vec{B}$ is the magnetic induction in the point of particle;

V is the velocity of particle.

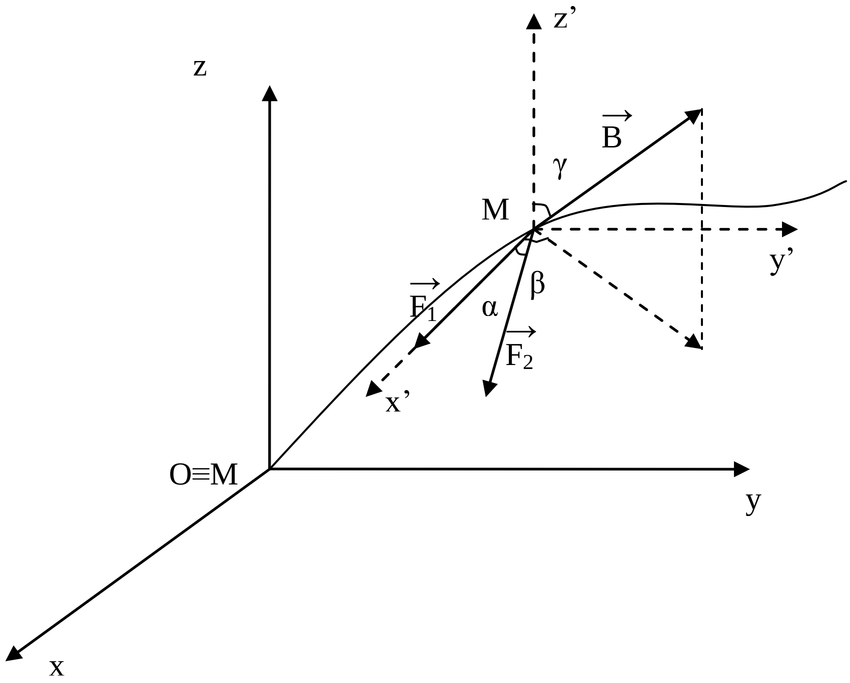

Fig. 2

$$\vec{F}_1(t) = \vec{i}F_{1x}(t) + \vec{j}F_{1y}(t) + \vec{k}F_{1z}(t) \qquad (4)$$

$$\vec{F}_2(t) = \vec{i}F_{2x}(t) + \vec{j}F_{2y}(t) + \vec{k}F_{2z}(t) \qquad (5)$$

$$\vec{F}_3(t) = \vec{i}F_{3x}(t) + \vec{j}F_{3y}(t) + \vec{k}F_{3z}(t) \qquad (6)$$

where:

$\vec{i}, \vec{j}, \vec{k}$ are the single vectors on the axis X,Y and Z;

F_{1x}, F_{1y}, F_{1z} are the components of $\vec{F}_1$ on the axis X,Y,Z;

F_{2x}, F_{2y}, F_{2z} are the components of $\vec{F}_2$ on the axis X,Y,Z;

F_{3x}, F_{3y}, F_{3z} are the components of $\vec{F}_3$ on the axis X,Y,Z.

If the superposition can be used:

$$\vec{F}(t) = \vec{F}_1(t) + \vec{F}_2(t) + \vec{F}_3(t) \qquad (7)$$

The equations (8), (9) and (10) are the equations of movement of charged particle under simultaneously influence of two electrical fields and magnetic field.

$$m\frac{d^2x(t)}{dt^2} = F_x(t) = F_{1x}(t) + F_{2x}(t) + F_{3x}(t) \qquad (8)$$

$$m\frac{d^2y(t)}{dt^2} = F_y(t) = F_{1y}(t) + F_{2y}(t) + F_{3y}(t) \qquad (9)$$

$$m\frac{d^2z(t)}{dt^2} = F_z(t) = F_{1z}(t) + F_{2z}(t) + F_{3z}(t) \qquad (10)$$

where:

$x(t), y(t), z(t)$ are the components of movement of the charged particle.

$$\left| \begin{array}{l} F_{1x} = qE_1 \cos\omega_1 t \\ F_{1y} = 0 \\ F_{1z} = 0 \end{array} \right. \qquad (11)$$

$$\left| \begin{array}{l} F_{2x} = qE_2 \cos\alpha \cos\omega_2 t \\ F_{2y} = qE_2 \sin\alpha \cos\omega_2 t \\ F_{2z} = 0 \end{array} \right. \qquad (12)$$

$$\overrightarrow{F_3} = q(\vec{V}x\vec{B}) = q\begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ V_x & V_y & V_z \\ B_x & B_y & B_z \end{vmatrix} \qquad (13)$$

where:

$$\begin{cases} V_x = \dfrac{dx(t)}{dt} \\ V_y = \dfrac{dy(t)}{dt} \\ V_z = \dfrac{dz(t)}{dt} \end{cases} \quad (14)$$

$$\begin{cases} B_x = B\sin\beta\sin\gamma\cos\omega_3 t \\ B_y = B\cos\beta\sin\gamma\cos\omega_3 t \\ B_z = B\cos\gamma\cos\omega_3 t \end{cases} \quad (15)$$

Finaly:

$$m\frac{d^2x(t)}{dt^2} = q(\frac{U_{1m}}{l_1}\cos\omega_1 t + \\ + \frac{U_{2m}}{l_2}\cos\alpha\cos\omega_2 t) + \\ + q[\frac{dy(t)}{dt}\cos\gamma - \\ - \frac{dz(t)}{dt}\sin\gamma\sin\beta]B\cos\omega_3 t \quad (16)$$

$$m\frac{d^2y(t)}{dt^2} = q\frac{U_{2m}}{l_2}\sin\alpha\cos\omega_2 t + \\ + q[\frac{dz(t)}{dt}\sin\gamma\cos\beta - \\ - \frac{dx(t)}{dt}\cos\gamma]B\cos\omega_3 t \quad (17)$$

$$m\frac{d^2z(t)}{dt^2} = q[\frac{dx(t)}{dt}\sin\beta\sin\gamma - \\ - \frac{dy(t)}{dt}\cos\beta\sin\gamma]B\cos\omega_3 t \quad (18)$$

The investigations have been done in the case when the signal of the second generator is frequency modulated. The results of computer simulation of components of movements and velocity on the three axis X,Y,Z in the case of ions of Na^+ can be seen on fig.3. The parameters for this investigation are:

$$f_1 = 4000Hz,\ f_2 \subseteq 4000 - 4100Hz,\ B = 0{,}03mT,$$
$$U_1 = U_2 = 16V,\ \alpha = 30^\circ,\ \beta = 60^\circ,\ \gamma = 45^\circ$$

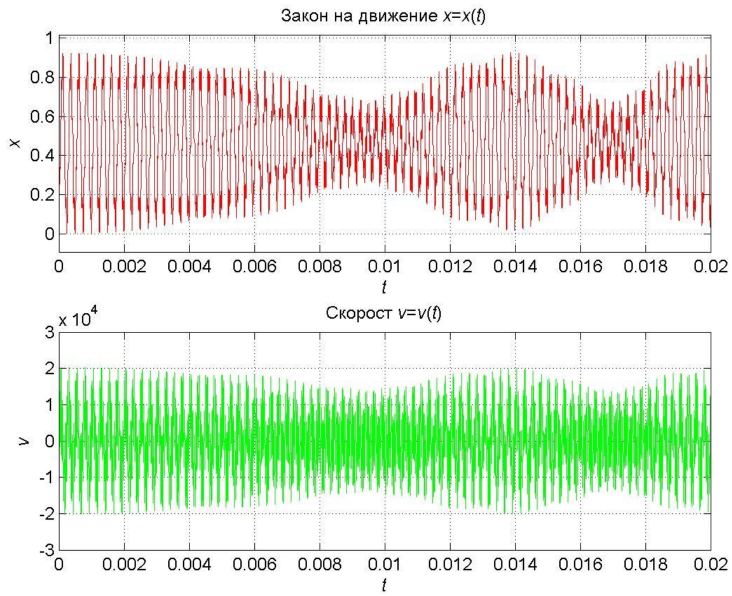

Fig. 3a. The movement and velocity of Na^+ on X

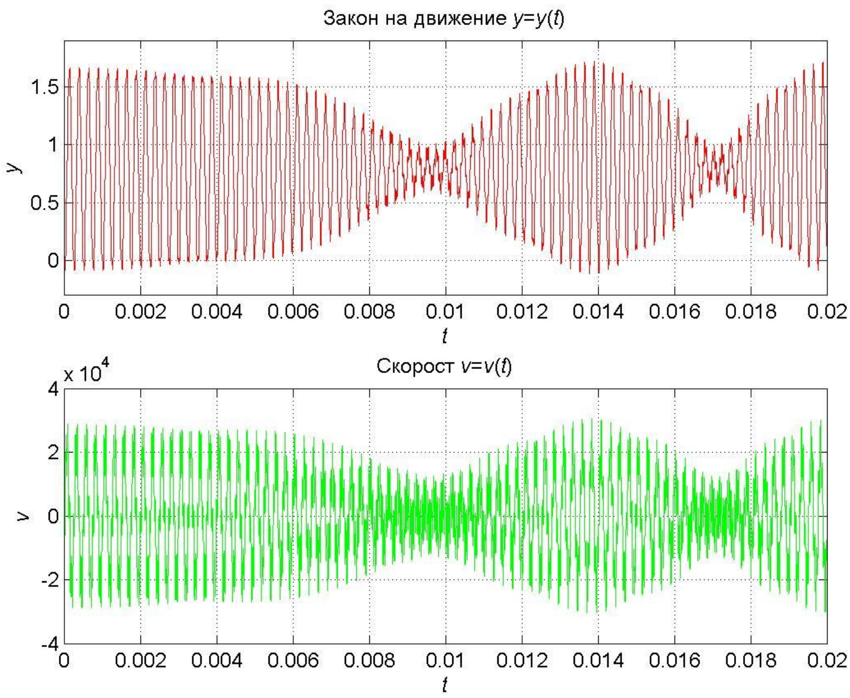

Fig. 3b. The movement and velocity of Na^{+} on Y

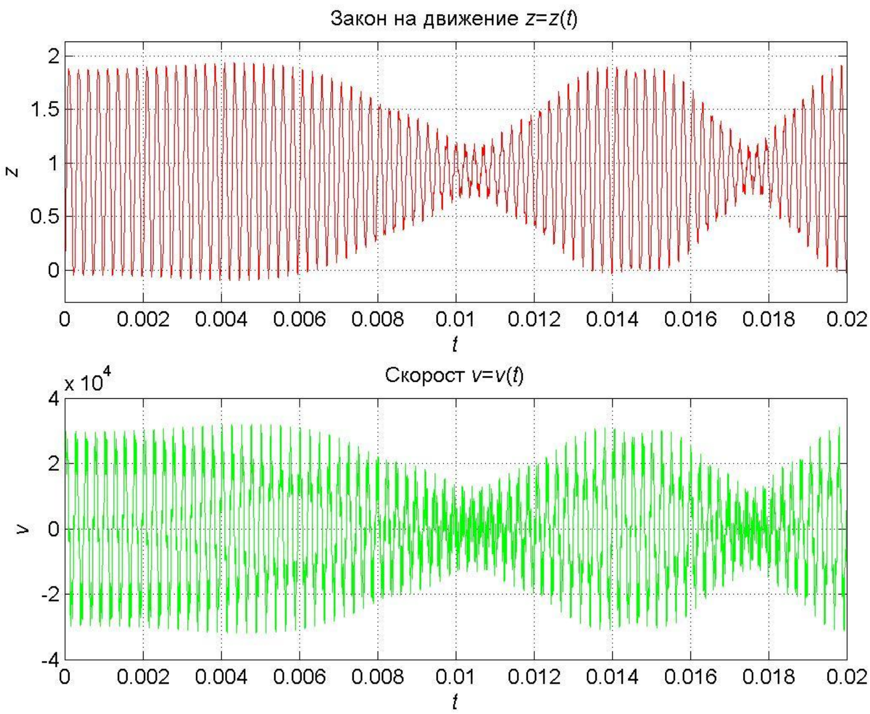

Fig. 3c. The movement and velocity of Na^{+} on Z

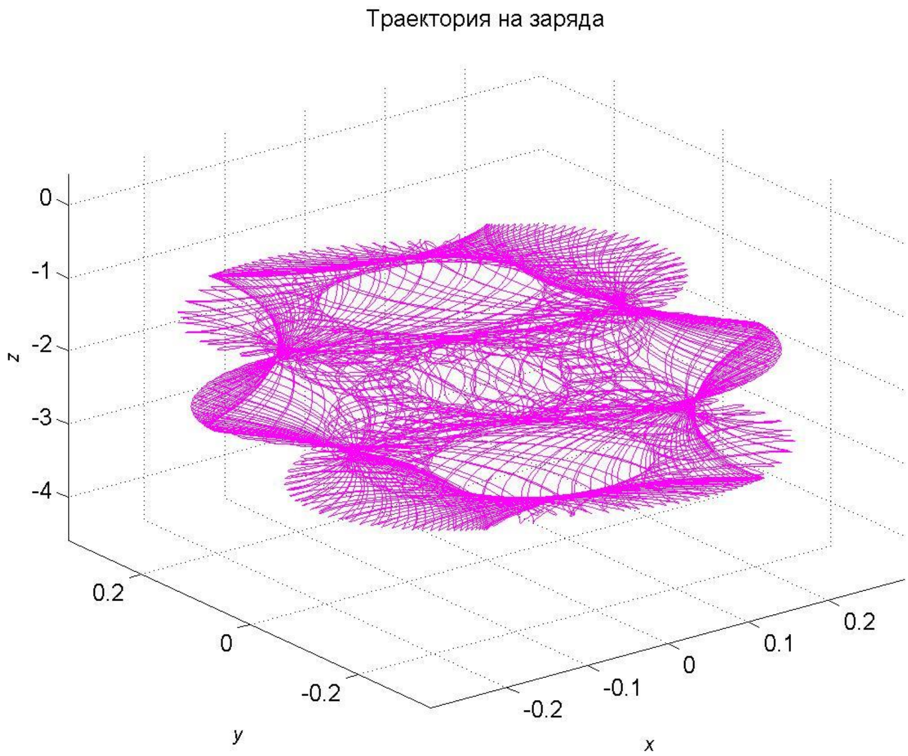

Fig. 3d. The movement of Na^{+}

3. Conclusion

The results of investigations, described in the paper are connected with new method for simultaneously application of permanent magnetic field and low frequency interferent currents.

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