SIMULRTANEOUSLY INFLUENCE OF PERMANENT ELECTRICAL FIELD AND LOW FREQUENCY MAGNETIC FIELD ON THE HUMAN BODY

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Abstract

The separate influence on the human body of permanent electrical field and separate influence of low frequency magnetic field is well known in medicine and especially in physiotherapy. An investigation of simultaneously influence of permanent electrical field and low frequency magnetic field on the human body is described in the paper.

1. INTRODUCTION

The diffusion of ions of different medicaments through the skin (ionophoresis) can be provided by permanent electrical field. The effect of this therapy can be more significant if the movement of medicament's ions can be not only on the lines of vector of intensity of electrical field, but on 3D curves. This movement of ions can be provided in the case of simultaneously influence of permanent electrical field and low frequency magnetic field.

2. MATHEMATICAL ANALYSIS

The simultaneously influence of electrical and magnetic fields on ion (ion of tissues or medicament's ion) can be seen on fig.1 According to the fig.1, the movements of ion on axis X,Y and Z can be described by the equation (1):

$$m\frac{d^2\vec{r}(t)}{dt^2} = q\vec{E}(x,y,z,t) + q[\frac{d\vec{r}(t)}{dt} x\vec{B}(x,y,z,t)] \quad (1)$$

Where:

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

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

m is the mass of ion;

q is the electrical charge of ion.

$\vec{r}$ is the tangential vector of trajectory of movement of ion.

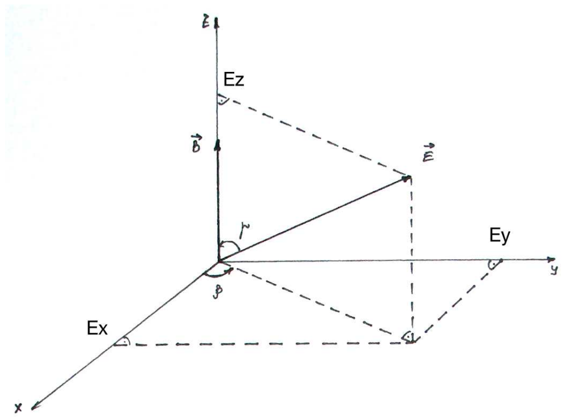

Fig. 1 Simultaneously influence of electrical and magnetic fields on ion

On the base of equation (1) can be obtained the system of equations (2) for every axis X,Y and Z.

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

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

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

3. COMPUTER SIMULATION OF MOVEMENT OF IONS IN LIVE TISSUES

The system of equations (2) can be solved using MATLAB. It's well known that the ions in alive tissues are first of all the ions of Na^{+} and ions of Cl^{-}. Therefore the investigations have been done for movement of these ions.

In the case of homogeny permanent electrical field and homogeny low frequency magnetic field can be used equations (3)

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

Where:

B_m is the amplitude of magnetic induction in every point of the homogeny low frequency magnetic field;

ω_3 is the frequency of magnetic field;

E is the intensity of electrical field.

In this case the system of equations (2) is as (4):

$$\begin{aligned}&m\frac{d^2x(t)}{dt^2}=q[E\sin\gamma\cos\beta+\\&+\frac{dy(t)}{dt}B_m\cos\omega_3 t]\\&m\frac{d^2y(t)}{dt^2}=q[E\sin\gamma\sin\beta+\\&+\frac{dx(t)}{dt}B_m\cos\omega_3 t]\\&m\frac{d^2z(t)}{dt^2}=qE\cos\gamma\end{aligned}\qquad(4)$$

The trajectories of movement of ions of Na^{+} in alive tissues taking in account (3) and (4) when:

$$E=100[V/m],\left|\vec{B}_m\right|=30[mT],\quad \omega_3=2\pi 50[1/s]\qquad(5)$$

can be seen on fig. 2.

The system of equations (4) can be solved for different values of parameters. This is the way for investigation of influence of the values of these parameters on the trajectory of movement of ions. The trajectory of movement of ions of Na^{+} for the case when:

$$E=200[V/m],\quad\left|\vec{B}_m\right|=3[mT],\quad\omega_3=2\pi 50[1/s]\qquad(6)$$

can be seen on fig. 3.

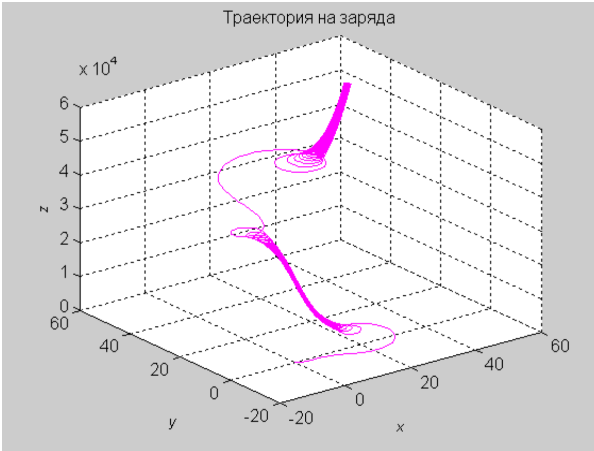

Fig. 2. Trajectory of movement of ions of Na^{+} according to the equations: (3), (4) and (5)

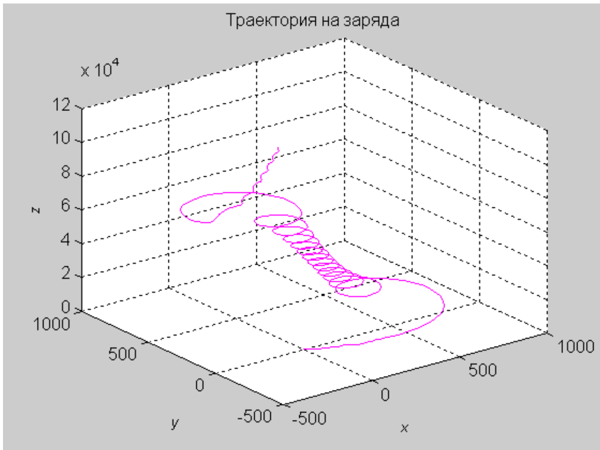

Fig. 3. Trajectory of movement of ions of Na^{+} according to the equations: (3), (4) and (6)

The trajectory of movement of ions of Na^{+} for the case when:

$$E=200[V/m],\quad\left|\vec{B}_m\right|=30[mT],\quad\omega_3=2\pi 100[1/s]\qquad(7)$$

can be seen on fig. 4.

The trajectory of movement of ions of Na^{+} for the case when:

$$E=200[V/m],\quad\left|\vec{B}_m\right|=30[mT],\quad\omega_3=2\pi 20[1/s]\qquad(8)$$

can be seen on fig. 5.

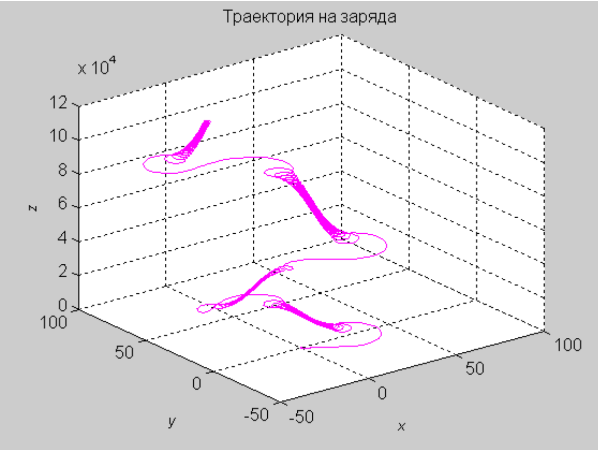

Fig. 4 Trajectory of movement of ions of Na^+ according to the equations: (3), (4) and (7)

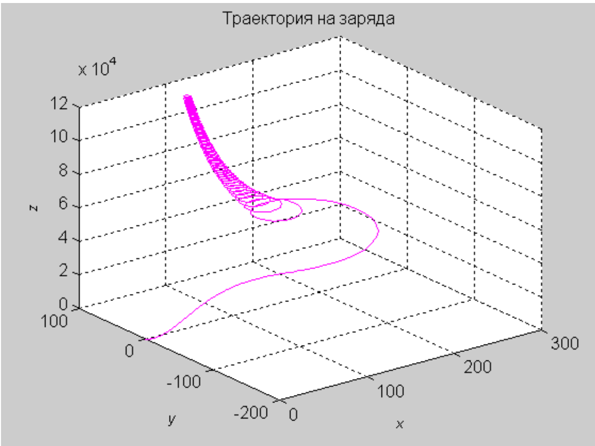

Fig. 5 Trajectory of movement of ions of Na^+ according to the equations: (3), (4) and (8)

The equations (3) are connected with application of low frequency magnetic field in the process of ionophoresis, which is often used in medicine. It's clear that 3D trajectory of movement of ions in alive tissues can be obtained as one result of additional application of low frequency magnetic field. It can be seen on Fig. 2, Fig. 3, Fig. 4 and Fig. 5 that the parameters of 3D trajectories of movement of ions can be changed not only by change of the value of intensity of permanent electrical field ,but by change of parameters of low frequency magnetic field, also.

4. CONCLUSION

The 3D trajectory of movement of ions allows to obtain more good effect of therapy by ionophoresis than in the ordinary case, when only permanent electrical field is used without application of low frequency magnetic field.

A simultaneously application of permanent electrical field and low frequency magnetic field in the process of ionophoresis of foot can be seen on fig. 6.

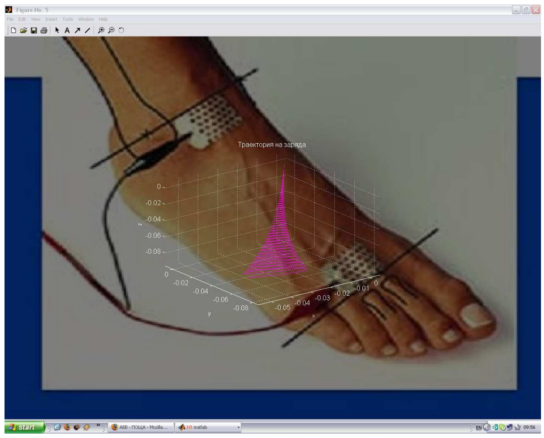

Fig. 6. A simultaneously application of permanent electrical field and low frequency magnetic field in the process of ionophoresis of foot.

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