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Simultaneously Influence of Magnetic and Electrical Field on the Human Body

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Introduction

The clinical results of separate therapy by low frequency magnetic field or by low frequency electrical field (including different kind of electrical signals) are well known in medicine. But one simultaneous influence of low frequency magnetic signals and low frequency electrical signals on the human body is a new method in physiotherapy. The parameters of applied low frequency electrical and magnetic signals can be optimized only on the base of one preliminary visualization of space configuration of the field of current density in the process of interference of two low frequency independent electrical currents and independent magnetic field in the alive tissue. This space configuration can be obtained as result of computer simulation of movement of some ions in the alive tissue. The lines of this movement of ions are very important in the process of medical therapy. The lines of ion's movement are the lines of the field of current density in alive tissue also. It's known that the ions of Na^+ and Cl^- have the top-level of concentration in the alive tissue. Therefore the next investigations are connected with these two ions.

Mathematical investigation

The ions of alive tissue are under influence of electrical intensity $\vec{E}(x,y,z,t)$ and magnetic induction $\vec{B}(x,y,z,t)$ .It's possible to accept that the ion is in the beginning of coordinate system XYZ (fig.1).
The mutual situation of vectors of electrical intensity $\vec{E}(x,y,z,t)$ and magnetic induction $\vec{B}(x,y,z,t)$ can be seen on the Fig. 1.
In this case:

$$\vec{E} = \vec{E}_x + \vec{E}_y + \vec{E}_z, \qquad (1)$$

$$\vec{B} = \vec{B}_z. \qquad (2)$$

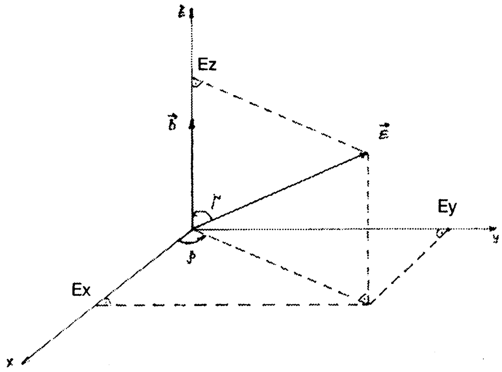

Fig. 1. Disposition of vectors $\vec{E}(x,y,z,t)$ and $\vec{B}(x,y,z,t)$

The angle β is between the projection of vector of electrical intensity $\vec{E}(x,y,z,t)$ on the plan XY and the axis X. The angle γ is between the vector of electrical intensity $\vec{E}(x,y,z,t)$ and axis Z.

The equation of movement of ion under influence of electrical intensity $\vec{E}(x,y,z,t)$ and magnetic induction $\vec{B}(x,y,z,t)$ is:

$$m\frac{d^2\vec{r}(t)}{dt^2} = q\vec{E}(x,y,z,t) + q[\frac{d\vec{r}(t)}{dt} x\vec{B}(x,y,z,t)], \qquad (3)$$

where m – the mass of ion; q – electrical charge of ion; $\vec{r}$ – the tangential vector of movement of ion;

According to the Fig. 1:

$$\begin{cases} E_x = \left|\vec{E}(x,y,z,t)\right| \sin\gamma\cos\beta, \\ E_x = \left|\vec{E}(x,y,z,t)\right| \sin\gamma\cos\beta, \\ E_z = \left|\vec{E}(x,y,z,t)\right| \cos\gamma. \end{cases} \qquad (4)$$

Its possible to obtain equation (5) taking in account equations (3) and (4):

$$\begin{cases} m\dfrac{d^2x(t)}{dt^2} = q[E(x,y,z,t)\sin\gamma\cos\beta + B(x,y,z,t)\dfrac{dy(t)}{dt}], \\ m\dfrac{d^2y(t)}{dt^2} = q[E(x,y,z,t)\sin\gamma\sin\beta + B(x,y,z,t)\dfrac{dx(t)}{dt}], \quad (5) \\ m\dfrac{d^2z(t)}{dt^2} = qE(x,y,z,t)\cos\gamma. \end{cases}$$

One of the often used apparatus for electrotherapy is AMLIPULS. This apparatus provides a middle frequency electrical signals with amplitude modulation. Usually the frequency of the carrier signals is 4000Hz. There are one pair of output electrodes. In this case the movements of ions are on different curved lines. The different output signals $\vec{E}_{out}(t)$ of this apparatus in the case of separate application can be seen on fig.2. The character of trajectory of ions under influence of this signals is the same as $\vec{E}_{out}(t)$.

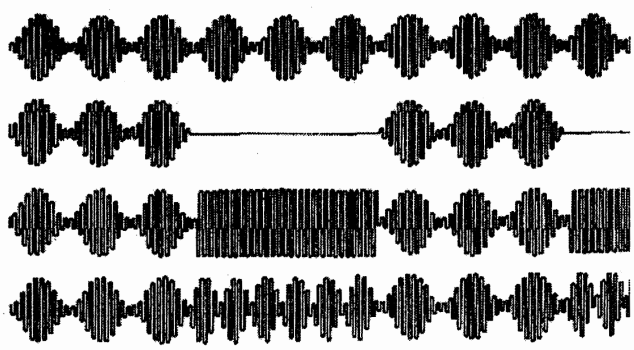

Fig. 2. Output signals of apparatus AMPLIPULS

According to the medical investigations and conclusions, the therapy would be more successful if the movements of ions would be in 3D space. This 3D movement can be obtained easy if the ions are under influence of magnetic field simultaneously with the influence of electrical field according to the equations (5).In the case of application of output electrical signals of AMPLIPULS with amplitude modulation, the conditions for solving of equations (5) are:

$$\vec{E}(t) = \vec{E}_m(1 + m\cos\omega_1 t)\cos\omega_2 t \wedge$$
$$\wedge \vec{E}_m(x,y,z) = const \wedge \vec{B}(x,y,z,t) = const \wedge$$
$$\wedge m = 1 \wedge \omega_1 = const \wedge \omega_2 = const \wedge$$
$$\wedge \beta = 45^\circ \wedge \gamma = 45^\circ, \quad (6)$$

where ω_1 – the frequency of amplitude modulation; ω_2 – the frequency of carrier signals; m – the coefficient of amplitude modulation; β and γ – angles according to Fig. 1.

The differential equations (5) can be written in modification (7), (8) and (9) taking in account the conditions (6):

$$m\frac{d^2x(t)}{dt^2} = q[E_m \sin\gamma\cos\beta(1 +$$
$$+ m\cos\omega_1 t)\cos\omega_2 t + \frac{dy(t)}{dt}B], \quad (7)$$

$$m\frac{d^2y(t)}{dt^2} = q[E_m \sin\gamma\sin\beta(1 +$$
$$+ m\cos\omega_1 t)\cos\omega_2 t + \frac{dx(t)}{dt}B], \quad (8)$$

$$m\frac{d^2z(t)}{dt^2} = qE_m \cos\gamma(1 +$$
$$+ m\cos\omega_1 t)\cos\omega_2 t. \quad (9)$$

Computer simulation of movements of ions in live tissues

The equations (7),(8) and (9) can be solved by computer, using MATLAB package. The visualization of solutions of equations (7),(8) and (9) can be seen on fig.3 for the following values of parameters:

$$\left|\vec{E}_m\right| = 100[V/m], \omega_1 = 2\pi 50[1/s],$$
$$\omega_2 = 2\pi 4000, m = 1, \left|\vec{B}\right| = 30[mT]. \quad (10)$$

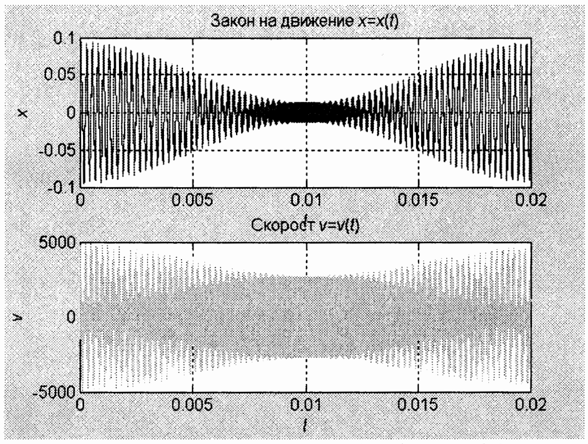

Fig. 3a. Trajectory of movement and velocity of ions on the axis X

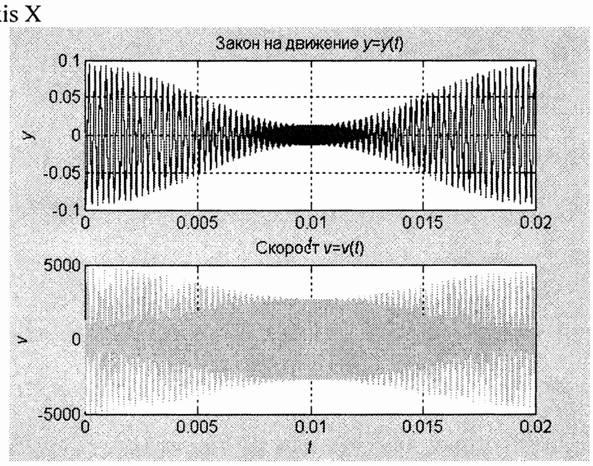

Fig. 3b. Trajectory of movement and velocity of ions on the axis Y

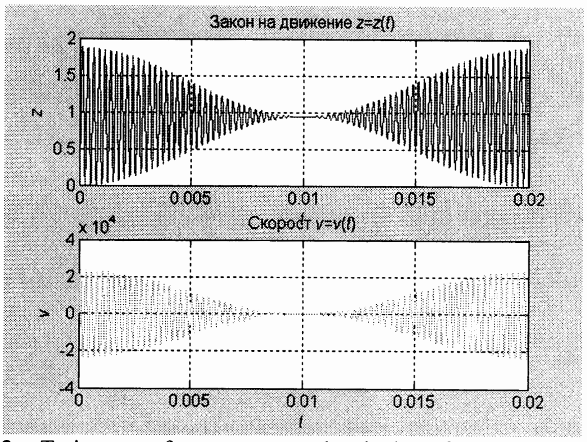

Fig. 3c. Trajectory of movement and velocity of ions on the axis Z

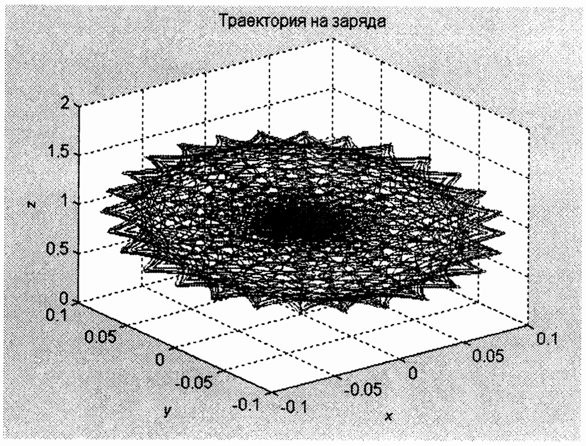

Fig. 3d. Trajectory of movement of ions in 3D space

The trajectory of movement and velocity of ions on the axis X can be seen on fig.3a, the trajectory of movement and velocity of ions on the axis Y can be seen on fig.3b and the trajectory of movement and velocity of ions on the axis Z can be seen on fig.3c. The trajectory of movement of ions in 3D space can be seen on fig.3d. It's easy to see the difference between the trajectories of movements of ions on fig.2 and on fig.3d. The 3D trajectory of movement of ions can be obtained very easy. It's necessary to be provided only influence of permanent magnetic field together with the output signals of AMPLIPULS.

On the Fig. 4 the visualization of solutions of equations (7), (8) and (9) can be seen for the following parameters:

$$\begin{cases} \left|\vec{E}_m\right| = 200[V/m], \omega_1 = 2\pi 50[1/s], \\ \omega_2 = 2\pi 4000, m = 0.7, \left|\vec{B}\right| = 30[mT]. \end{cases} \quad (11)$$

There is a difference between the trajectories of movement of ions on Fig. 3 and Fig. 4 because of difference between values of amplitudes of intensity of electrical field $\left|\vec{E}_m\right|$ and between the values of coefficient of amplitude modulation m. This is one simple method for change and optimization of trajectory of movement of ions in 3D space by change of values of parameters in equations (7), (8) and (9). In other side the trajectory of movements of ions depends to the mass and electrical charge of ion. The movements of ions of Na^+ is described in the paper as these ions and ions of Cl^- have the main level in the blood. The mass of ions of Na^+ is $m = 3.817\text{e-}26$[kg] and the electrical charge is $q =$ $1{,}6\times10^{-19}$ [C].

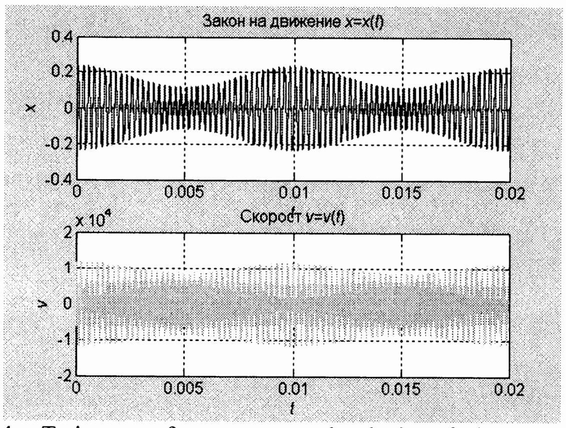

Fig. 4a. Trajectory of movement and velocity of ions on the axis X

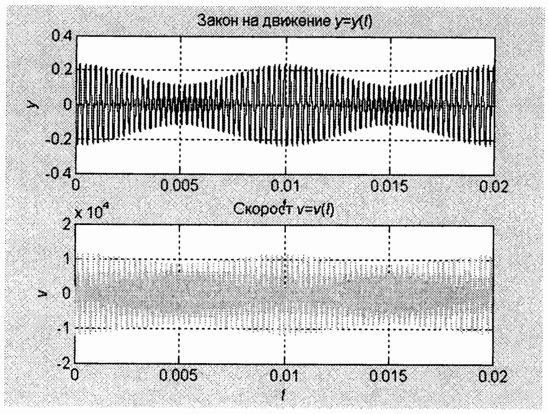

Fig. 4b. Trajectory of movement and velocity of ions on the axis Y

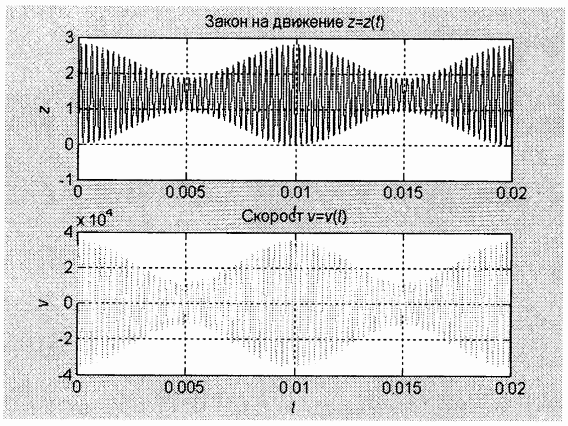

Fig. 4c. Trajectory of movement and velocity of ions on the axis X

The trajectory of movement and velocity of ions on the axis X can be seen on Fig. 4a, the trajectory of movement and velocity of ions on the axis Y can be seen on Fig. 4b and the trajectory of movement and velocity of ions on the axis Z can be seen on Fig. 4c. The trajectory of movement of ions in 3D space can be seen on Fig. 4d.

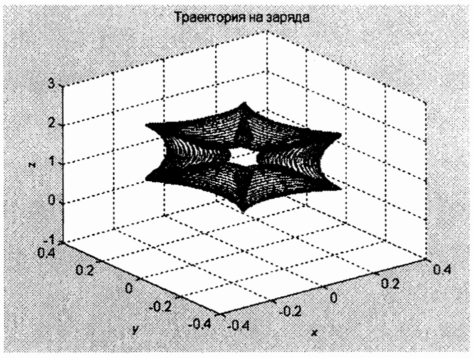

Fig. 4d. Trajectory of movement of ions in 3D space

The visualization of solutions of equations (7), (8) and (9) can be seen in the Fig. 5 for the following parameters:

$$\begin{cases} \left|\vec{E}_m\right| = 200[V/m], \omega_1 = 2\pi 50[1/s], \\ \omega_2 = 2\pi 4000, m = 1, \left|\vec{B}\right| = 3[mT]. \end{cases} \quad (12)$$

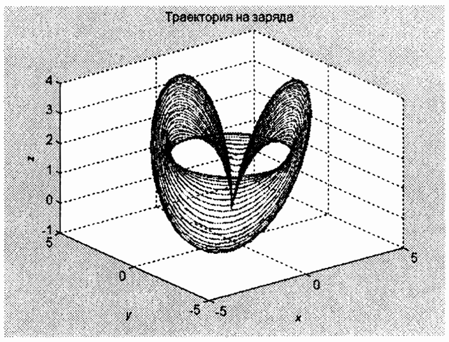

Fig. 5. Trajectory of movement of ions in 3D space

The trajectory of movement of ions in 3D space can be seen on Fig. 5. There is a significant difference between 3D trajectory of ions on Fig. 3d and Fig. 4d and in other side – on Fig. 5d because of significant decreasing of value of magnetic induction $\vec{B}$ of the permanent magnetic field. It's clear that the 3D trajectory of movement of ions can be modified very easy by change of value of magnetic induction.

Conclusion

On the base of mathematical investigation and computer simulation has been demonstrate one simple possibility for obtaining of 3D trajectory of movement of ions of alive tissues in the case of Amplipuls therapy, by simultaneously application of permanent magnetic field.

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D. Tz. Dimitrov. Simultaneously Influence of Magnetic and Electrical Field on the Human Body // Electronics and Electrical Engineering. – Kaunas: Technologija, 2008. – No. 7(87). – P. 77–80.

An investigation on influence of magnetic field on the trajectory of movement of ions in alive tissues in the case of electrotherapy by application of apparatus AMLIPULS is described in the paper. An mathematical description of movement of ions in alive tissues is done on the base of space disposition of vectors of electrical intensity and magnetic induction. Then some results of computer simulation of movement of ions of Na^+ is described in the paper as these ions and ions of Cl^- have the main level in the blood in the case of simultaneously influence of low frequency electrical signals with amplitude modulation and permanent magnetic field. Ill. 5, bibl. 8 (in English; summaries in English, Russian and Lithuanian).

Д. Ц. Димитров. Одновременное воздействие магнитного и электрического поля на человеческое тело // Электроника и электротехника. – Каунас: Технология, 2008. – № 7(87). – С. 77–80.

Описывается воздействие магнитного поля на траектории ионов в живых тканях, когда одновременно проводится электротерапия аппаратом АМПЛИПУЛЬСОМ. Математическое описание движения ионов в живых тканях дано на основе пространственного расположения векторов электрической наряженности и магнитной индукции. Даны результаты компьютерного моделирования движения ионов Na^+, потому что уровень этих и Cl^- ионов в крови один из самых больших, когда вместе с постоянним магнитним полем действует и низкочастотный амплитудномдулированный электрический сигнал. Ил. 5, библ. 8 (на английском языке, рефераты на английском, русском и литовском яз.).

D. Tz. Dimitrov. Vienalaikis žmogaus kūno veikimas magnetiniu ir elektriniu laukais // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2008. – Nr. 7(87). – P. 77–80.

Aprašoma magnetinio lauko įtaka jonų judėjimui gyvuose audiniuose atliekant elektroterapiją aparatu AMLIPULS. Pasinaudojus erdviniu elektrinės įtampos ir magnetinės indukcijos vektorių išsidėstymu, sudarytas matematinis jonų judėjimo gyvuose audiniuose aprašymas. Pateikti Na^+ jonų judėjimo modeliavimo rezultatai, nes jų ir Cl^- jonų kiekis kraujyje yra didžiausias, kai tuo pačiu veikia ir nuolatinis magnetinis laukas, ir moduliuotos amplitudės žemo dažnio elektrinis signalas. Il. 5, bibl. 8 (anglų kalba; santraukos anglų, rusų ir lietuvių k.).