Mechanisms of action of weak constant and low frequency alternating magnetic fields on the development of tumors in mice with Erlich ascetic carcinoma.

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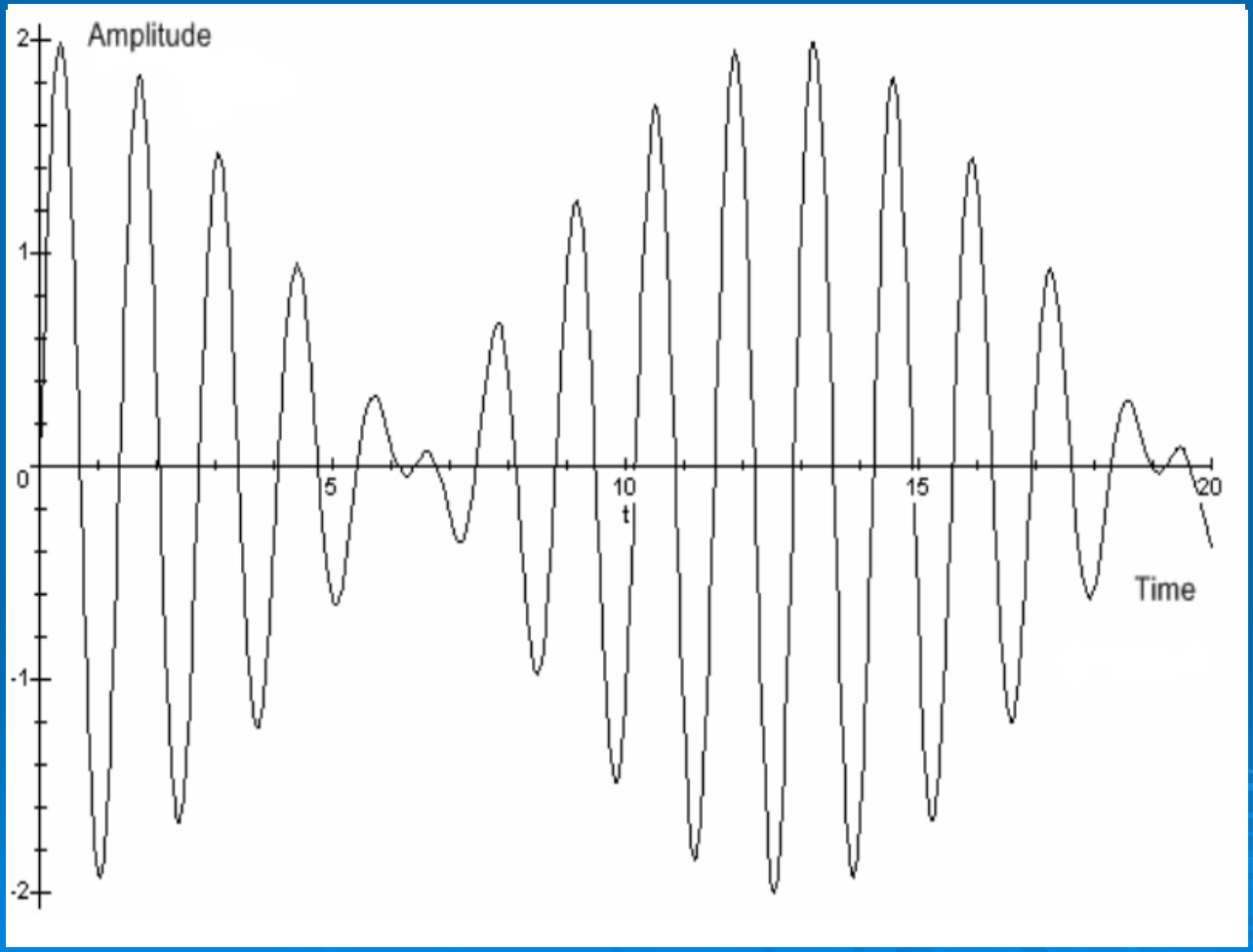
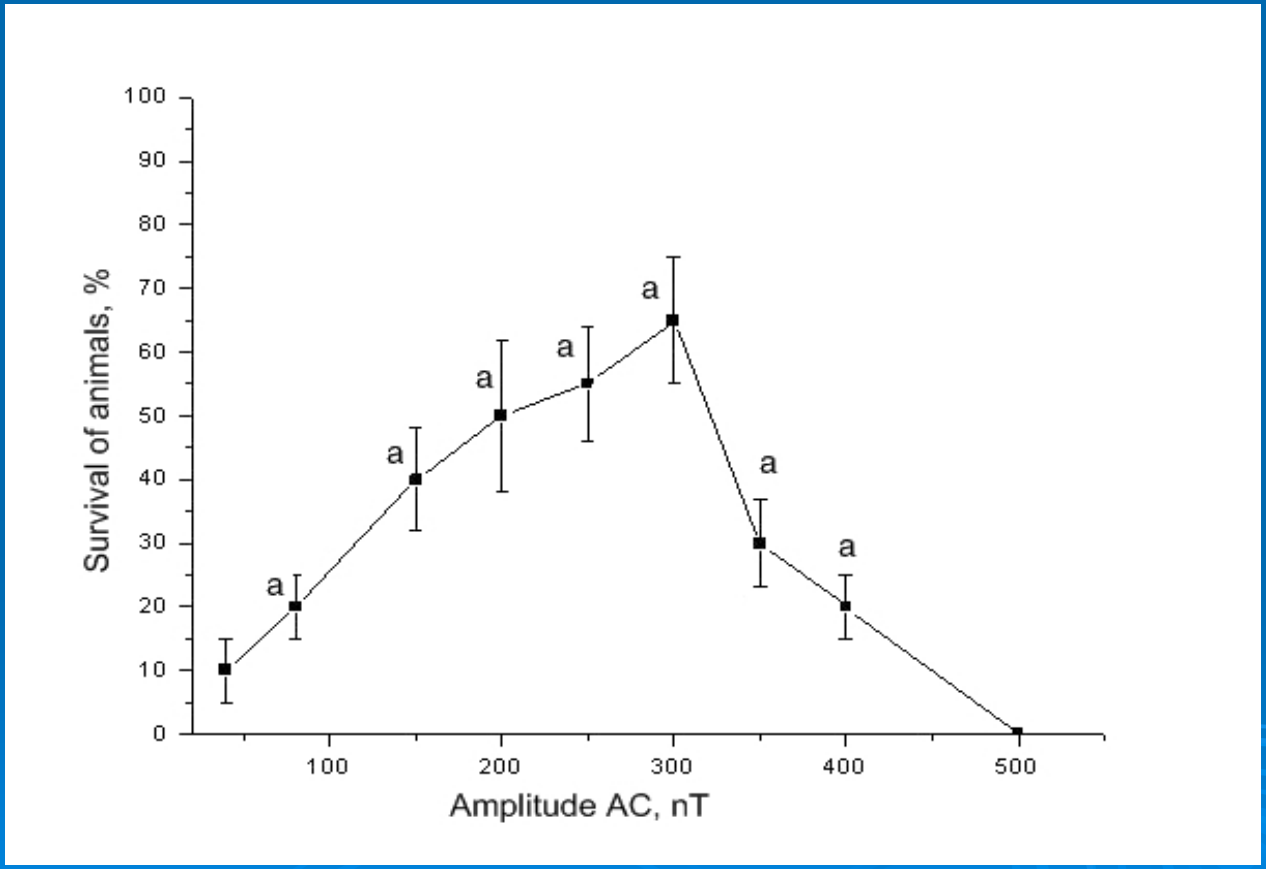
The experimentally found solution of the problem of forming the biologically active MF on the basis of two-frequency signals made it possible to use the known transformation:

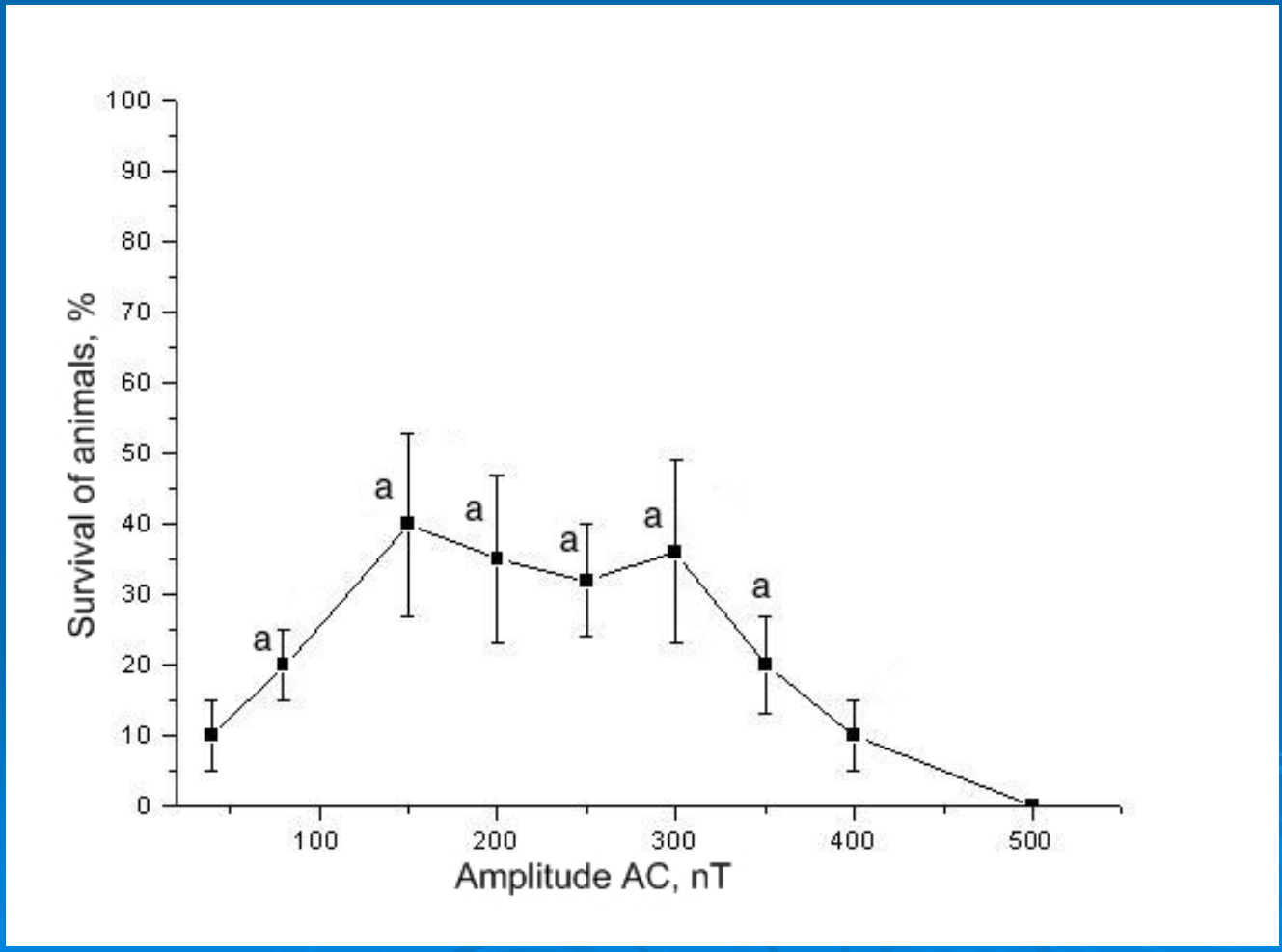


$$A_0\left(\sin\omega_1 t+\sin\omega_2 t\right)=2A_0\sin\left[\left(\omega_1+\omega_2\right)t/2\right]\cdot\cos\left[\left(\omega_1-\omega_2\right)t/2\right]$$

Dependence of the antitumor activity of weak combined collinear magnetic fields (DC field 42 μT) on the amplitude of the AC component at a modulating frequency of 0.5 Hz and carrier frequency of 16.5 Hz

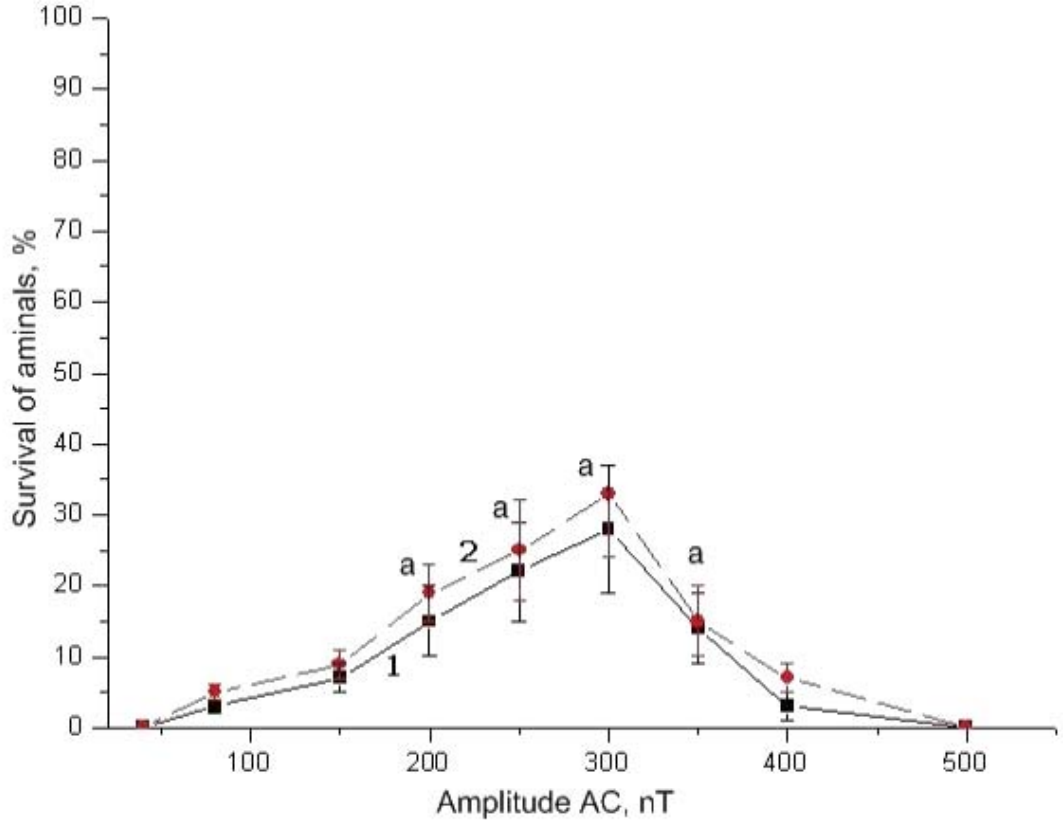


Dependence of the antitumor activity of weak combined collinear magnetic fields (DC field 42 μT) on the amplitude of the AC component at a frequency of 16.5 Hz (cyclotron frequency of potassium ions)

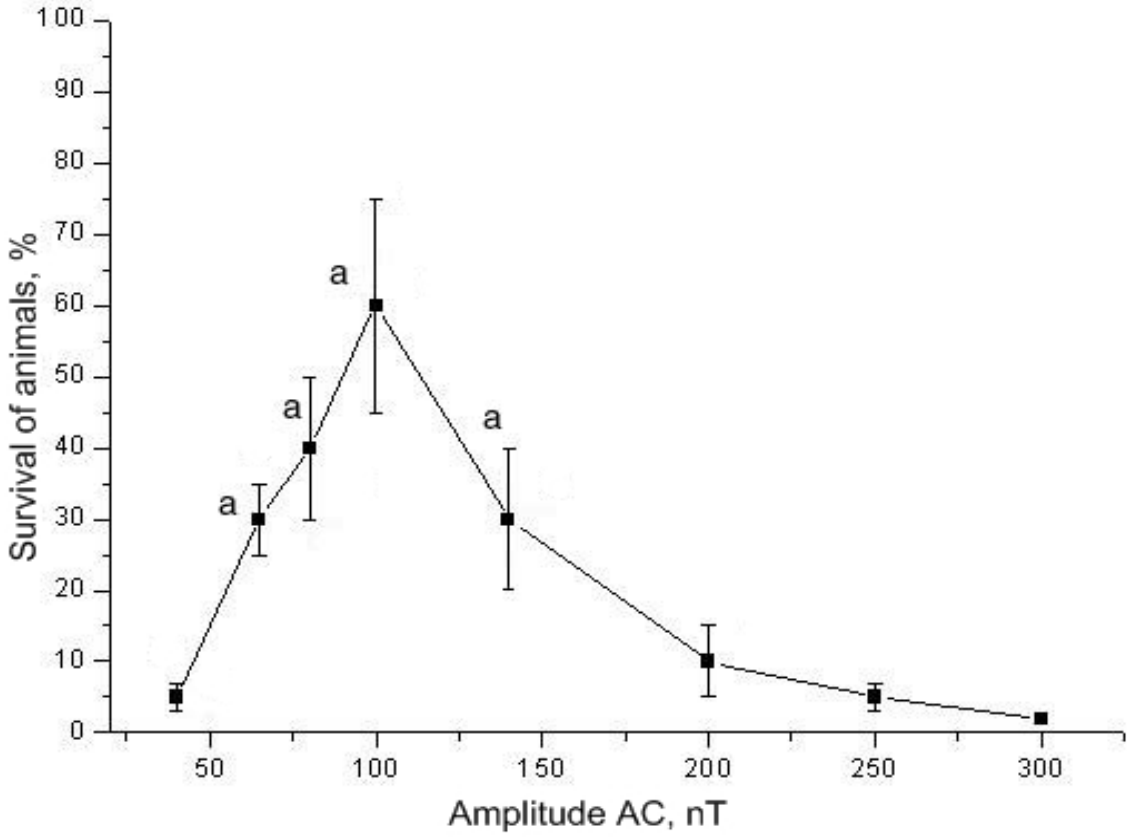


Dependence of the antitumor activity of weak combined collinear magnetic fields (DC field 42 μT) on the amplitude of the AC component at a frequency of 0.5 and 1 Hz (modulating frequencies)

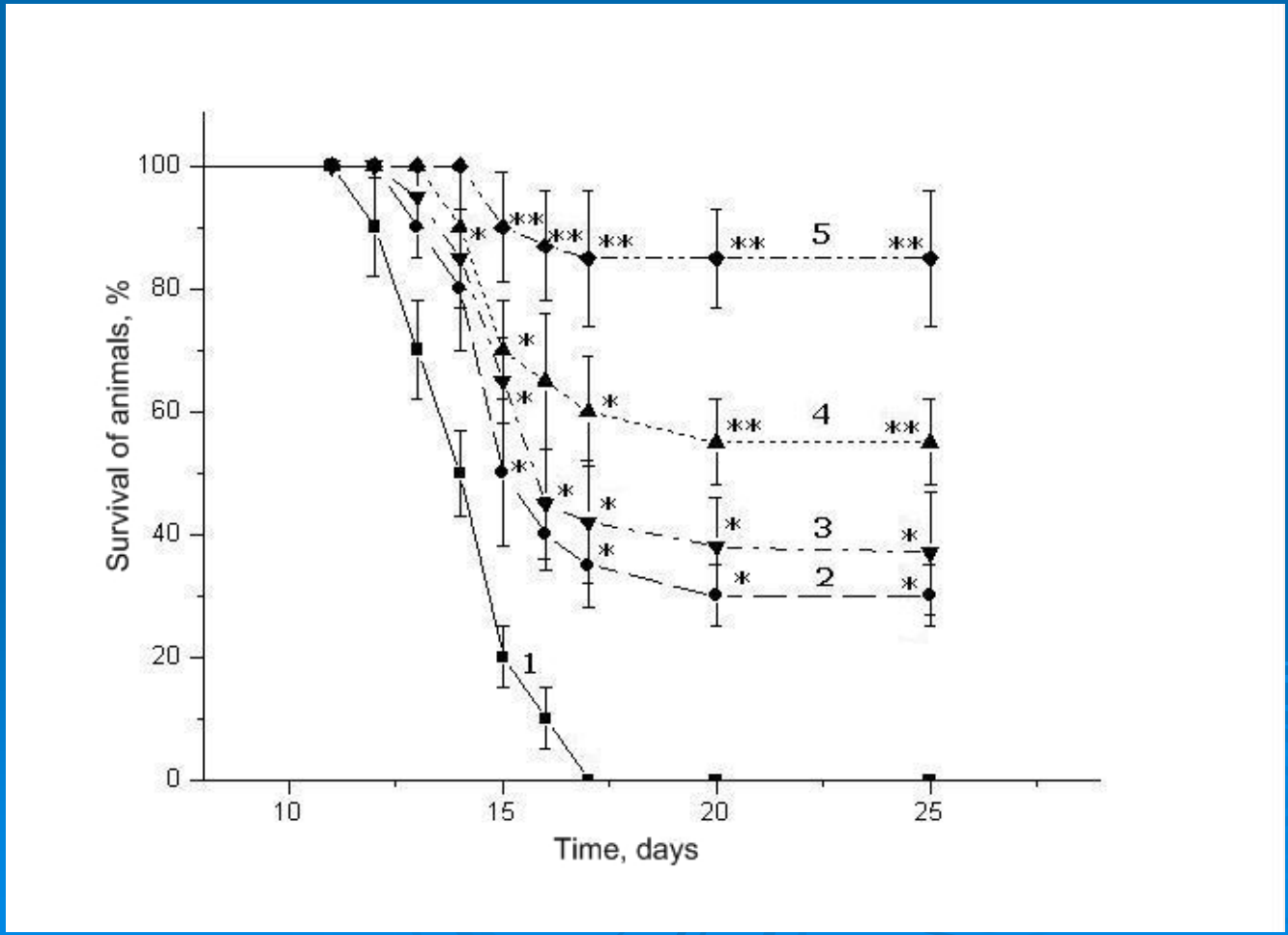
***1*, exposure at 0.5 Hz (squares); *2*, exposure at 1 Hz (circles).**



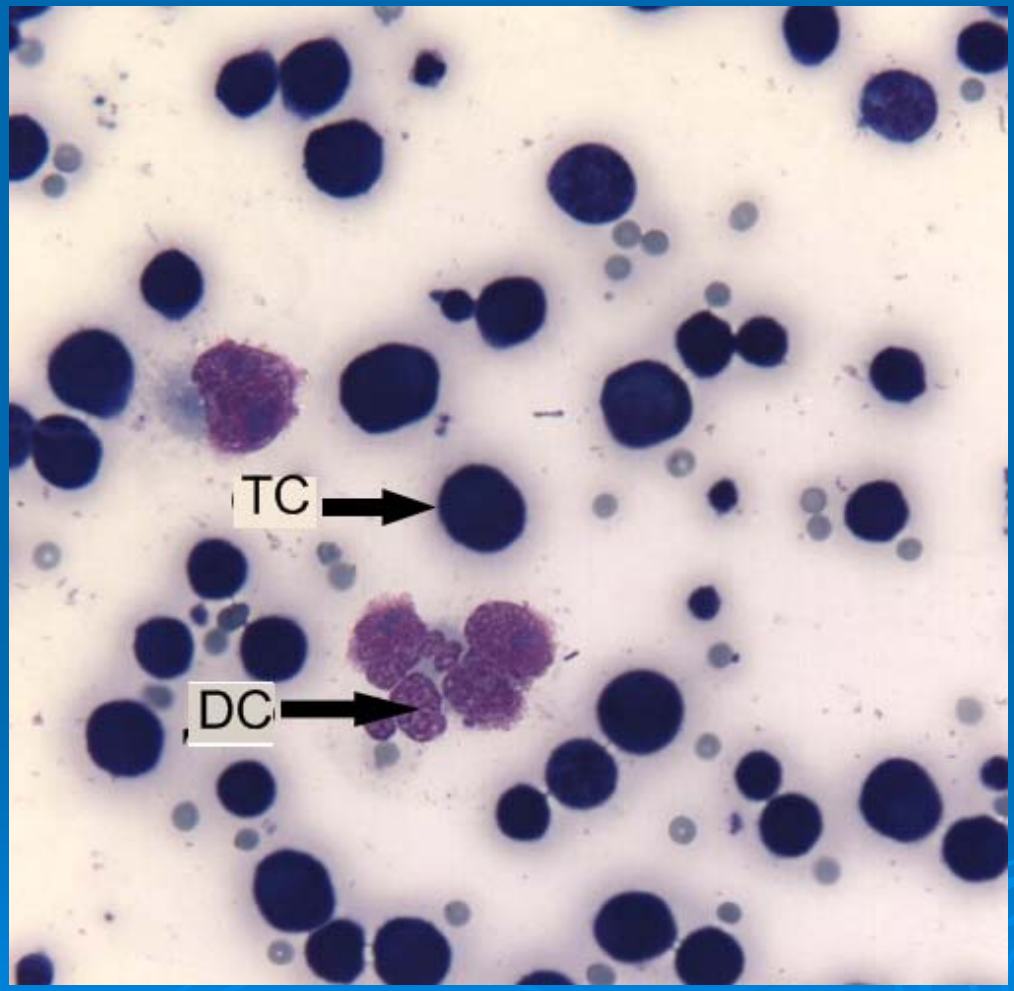
Dependence of the antitumor activity of weak combined collinear magnetic fields (DC field 42 μT) on the amplitude of the AC component at a frequency of 4.4 Hz (cyclotron frequency of the glutamic amino acid)



Life spans of tumor-bearing animals at different frequencies and amplitudes of the AC component (DC field 42 μT). On the abscissa is the period of observation of animals in groups after tumor inoculation. *1*, control; *2*, exposure at 1 Hz, 300 nT; *3*, exposure at 16.5 Hz, 150 nT; *4*, exposure at 4.4 Hz, 100 nT; *5*, exposure at the sum of frequencies (1 Hz, 300 nT; 4.4 Hz,100 nT; 16,5 Hz, 150 nT)

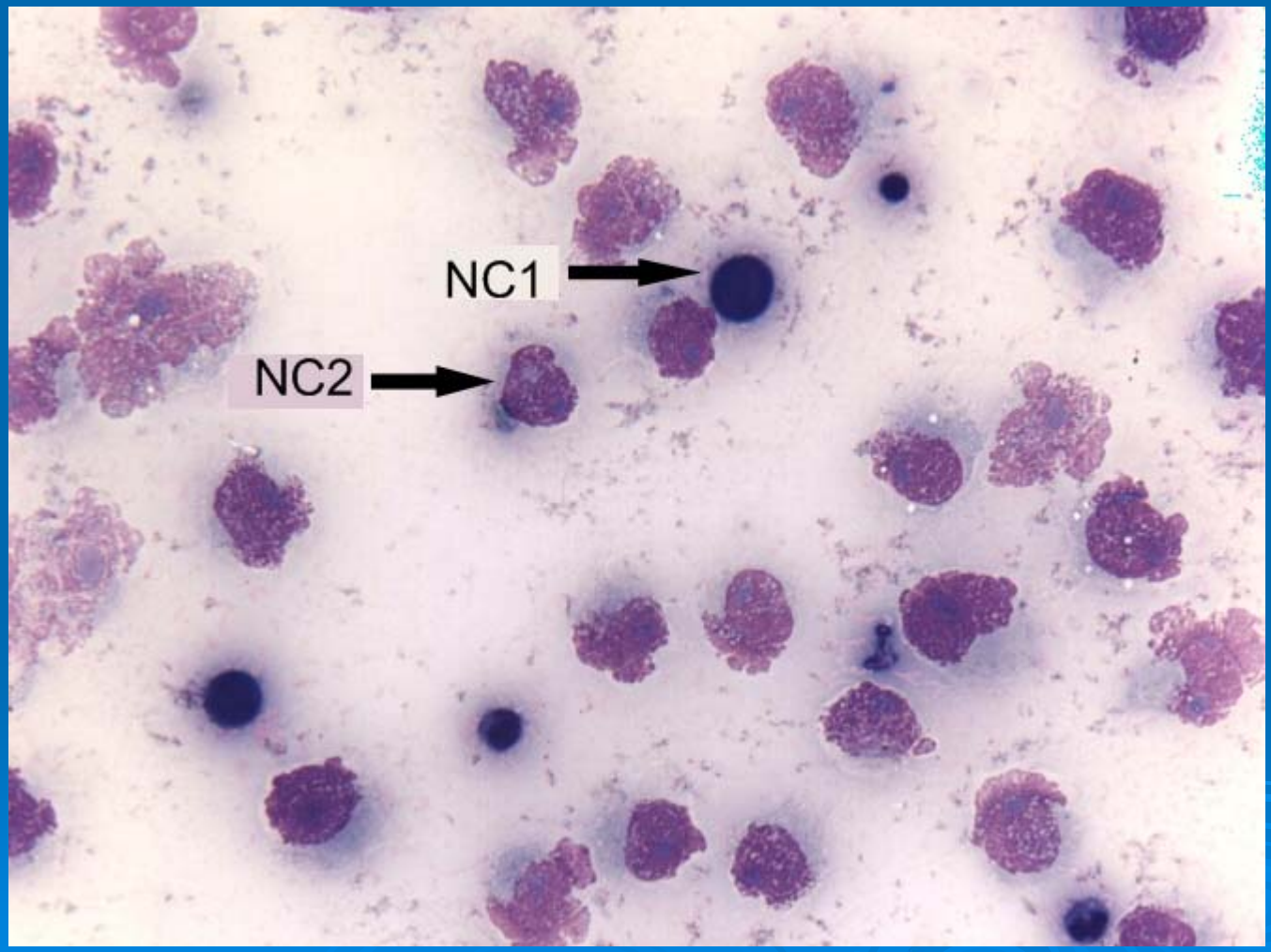


Cytological analysis **(control group).** 10 days after inoculated of tumor cells. x500.



TC – tumor cell (EAC) in norm;
DC- degenerative form of tumor cells.

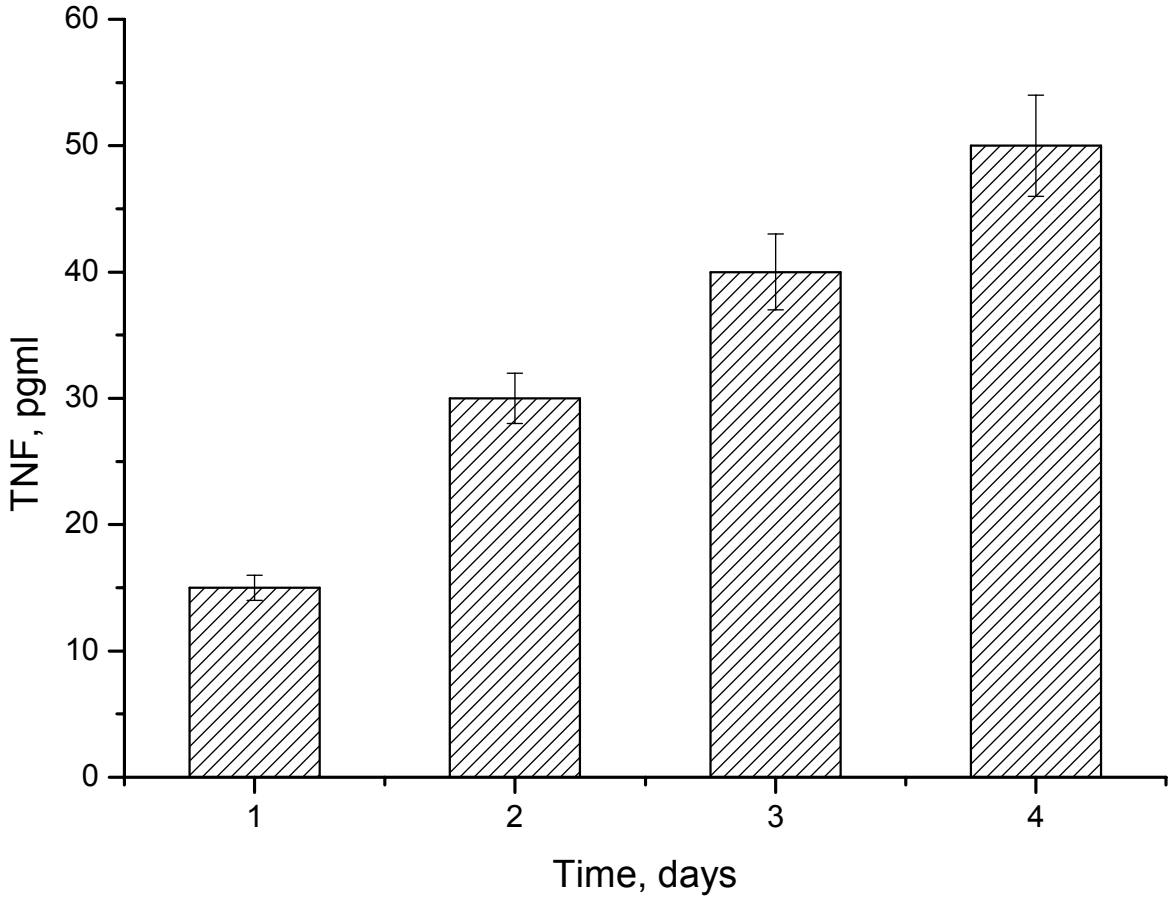
Cytological analysis **(experimental group – DC 42 μT; AC 1 Hz, 300 nT; 4.4 Hz, 100 nT; 16.5 Hz 150 nT).** 10 days after inoculated of tumor cells. x500.



NC1 - beginning necrosis of tumor cell;
NC 2 - necrosis of tumor cell in process.

Organ	Data of the histological analysis	
	No treatment with weak MF (**control**)	Treatment with weak MF (**experiment**)
Brain	**Normal**	**Normal**
Spinal cord	**Normal**	**Normal**
Mesenteric lymph nodes	**Metastases in the region of the marginal sinus**	**Single encapsulated conglomerate of tumor cells in the region of the marginal sinus**
Spleen	**Normal**	**Normal**
Thymus	**Age-dependent norm**	**Age-dependent norm**
Adrenal glands	**Normal**	**Single foci of degeneration of secretory epithelium in the cortical layer**
Thyroid gland	**Normal**	**Normal**
Pancreas	**Conglomerates of tumor cells on the surface of the organ in the adipose tissue**	**Normal**
Liver	**Large-scale dystrophic vacuole-like alterations of hepatocytes**	**Accumulation of lymphocytic granulomas in the perivascular space and in the perenchyma; small and moderate foci of coagulation necrosis**
Seminal appendages	**Conglomerates of tumor cells on the surface of the organ in the adipose tissue**	**Normal**
Kidneys	**Conglomerates of tumor cells on the surface of the organ in the adipose tissue**	**Normal**
Mesentery	**Multiple metastases in the adipose tissue as conglomerates of tumor cells**	**Normal**
Locus of inoculation of tumor cells into the abdomen	**Invasion of tumor cells into the muscle of the abdominal wall**	**Normal**

Production of tumor necrosis factor by mice's macrophages after MF's treatment



Magnetic polarization of the medium nuclei

Magnetic moment of the proton system

$$M = \mu_p N \mathrm{th}\left(\frac{\mu_p B}{\varepsilon}\right)$$

The root-mean-square energy

$$\varepsilon = < E^2 > = \sqrt{\frac{1}{2}\left\{\left(-\frac{a}{4}\right)^2 + \left(\frac{a}{4}\right)^2\right\}} = \frac{a}{4}$$

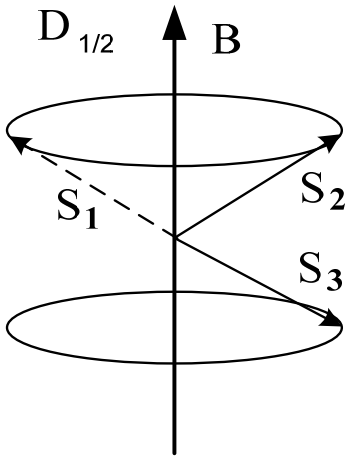
The average-mean of the projection of the nuclear spin

$$M = N\gamma < I_z > \quad \Rightarrow \quad < I_z > = \frac{M}{\gamma N} = \frac{1}{2}\,\mathrm{th}\,\frac{2\gamma B}{a} \approx \frac{\gamma B}{a}$$

The probability of the quartet-duplet's conversion

Hamiltonian of the three-spin system

$$\mathbf{H}(t) = g\beta_e(S_1 + S_2 + S_3)B(t) + 2J_1(S_1S_2) + 2J_2(S_2S_3) + S_1aI$$

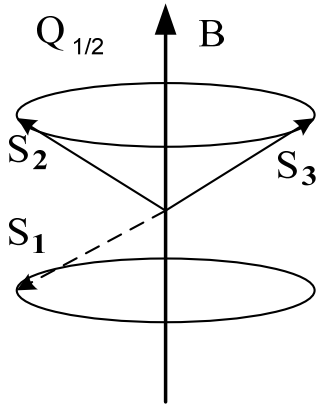


Wave function

$$\psi = C_D\left|D\right\rangle + C_Q\left|Q\right\rangle$$

Probability of the reaction

$$p = \int_0^\infty \left|C_D(t)\right|^2 \exp\left(-\frac{t}{\tau}\right)dt = \frac{8}{9}\sin^2 a \int_{-\infty}^{t} < I_z > (t)dt$$

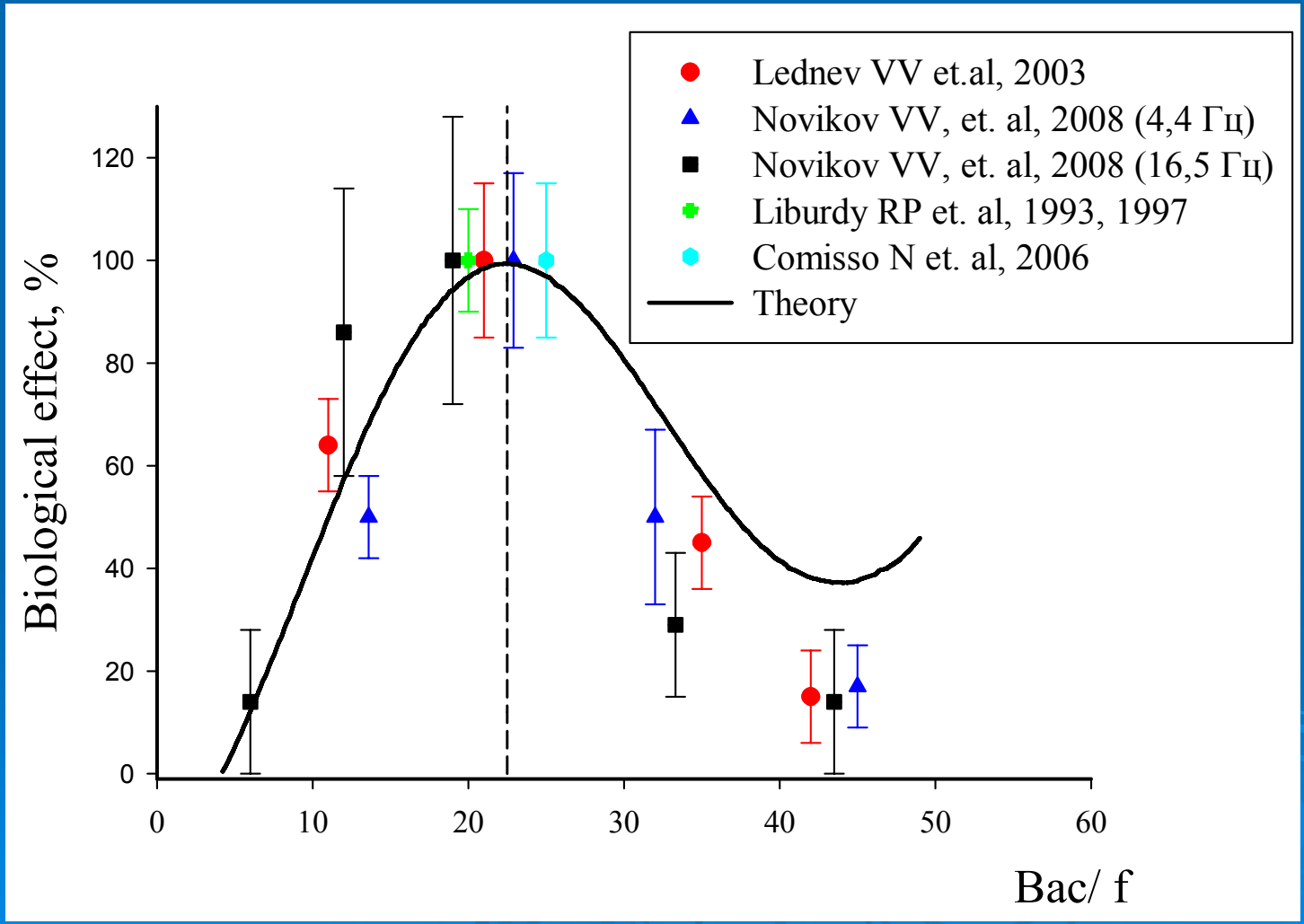


$$p(t) = \frac{4}{9}\left(1 - \sum_k J_k\left(\gamma\frac{B_{AC}}{\Omega}\right)\cos(k\Omega t)\right)$$

The adiabatic average

$$P = \lim_{T\to\infty}\frac{1}{T}\int_0^T p(t)dt = \frac{4}{9}\left(1 - J_0\left(\gamma\frac{B_{AC}}{\Omega}\right)\right)$$

The dependence magnitude of the biological effects on attitude of amplitude of external field to its frequency



Summary

- It has been shown that the ultralow-frequency extremely weak alternating component of combined magnetic fields (MFs) exhibits a marked antitumor activity. The parameters of this component have been found (frequency 1, 4.4, 16.5 Hz or the sum of these frequencies; intensity 300, 100, 150—300 nT, respectively) at which this MF in combination with a collinear static MF of 42 μT inhibits or suppresses the growth of Ehrlich ascites carcinoma (EAC) in mice.
- It was shown that the exposure of mice with EAC to combined MFs causes structural changes in some organs (liver, adrenal glands), which are due probably to the total degradation of the tumor tissue.
- In mice with transplanted EAC, the tumor tissue after the exposure to weak MFs was practically absent, as distinct from control animals in which the invasion of the tumor into the adipose tissue surrounding the kidneys, mesenteric lymph nodes, and spermatic appendages was observed.
- In animals without tumors, no pathological deviations from the norm in the structure of organs and tissues occurred after exposure to weak MF, indicating that this factor per se is not toxic for the organism.

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