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Introductory Words from the Editorial Board

The International Society for Bioelectromagnetism (ISBEM) was founded in 1996 in order to offer an exchange platform for researchers from all over the world regarding advances in bioelectromagnetism. Therefore, the society sponsors the biennially organised international congresses on bioelectromagnetism, starting from 1996. The first International Conference on Bioelectromagnetism (ICBEM) has been held in Tampere, Finland in 1996, After that, the ICBEM conference took place in Melbourne (1998), Bled (2000), Montreal (2002), Minneapolis (2005), Aizu (2007), Rome (2009), Banff (2011), Geneva (2013) and Tallinn (2015). Following the fundamental idea of the ISBEM, the ICBEM provides a platform for researchers all over the world to share their experience regarding their work in the broad field of bioelectromagnetism, which includes:

- The behavior of excitable tissue (the sources)
- The electric currents and potentials in the volume conductor
- The magnetic field at and beyond the body
- The response of excitable cells to electric and magnetic field stimulation
- The intrinsic electric and magnetic properties of the tissue.

This year, we are very happy to welcome all participants to the 11th International Conference on Bioelectromagnetism in Aachen, Germany. In 2018, the ICBEM will be jointly held together with the 13th Russian-German Conference on Biomedical Engineering (RGC) hosted by the Philips Chair for Medical Information Technology (MedIT) at RWTH Aachen University. As regarding for the editorial board, we would like to thank all participants contributing to ICBEM & RGC 2018 with their research and hope the conference to be a great experience for all participants.

The Editorial Board:

Prof. Kazuo Yana	Prof. Jaakko Malmivuo	Prof. Steffen Leonhardt

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Possibilities of joint application of acoustic radiation and direct magnetic field for biomedical research

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Introduction

The use of acoustic radiation and a magnetic field in medicine has a long history. The study of human organs using ultrasound is one example of the use of acoustic radiation. The alternating magnetic field is used for local heating of human tissues in the treatment of inflammatory processes. The use of a permanent magnetic field is currently largely limited to its use in magnetic resonance imaging (NMR) tomography. The present work is devoted to the study of the combined action of acoustic radiation and a constant magnetic field on a biological medium. The current work consists of two parts. The first part is an analysis of the possibility of using the provisions of magnetic hydrodynamics to obtain information about the parameters of the biological surroundings. The second part is an analysis of the possibility of remote determination of the concentration of magnetic nanoparticles to transfer drugs to a given region of a living organism.

Materials and Methods

Considering the behavior of moving surroundings in a direct magnetic field with an induction (B), the basic characteristics of the theory of magnetohydrodynamics are electrical conductivity, speed (v) of moving surroundings and the directions of vectors $\boldsymbol{V}$ and $\boldsymbol{B}$. Occurrence of electric field with intensity E in the surroundings is a consequence of the joint influence of a field $\boldsymbol{B}$ on the surroundings and its moving with a speed $\boldsymbol{V}$ [1]:

$$\boldsymbol{E} = \boldsymbol{V} \times \boldsymbol{B} \quad (1)$$

Equation (1) has the simplest scalar appearance at a mutually perpendicular position of vectors $\boldsymbol{V}$ and $\boldsymbol{B}$:

$$E = V \times B \quad (2)$$

From a parity (2) follows that intensity of electric field is proportional to speed and value of a magnetic induction. A feature of a considered method of research is moving of the part of biological surroundings (BS) by means of influence on its acoustic radiation (AR).

The attractiveness of AR to biomedical research lays in the fact that wave AR can extend into BS on considerable distance without appreciable attenuation. It can also be focused till the millimetric sizes and can move the conducting surroundings in a contactless way.

One of the report purposes is a settlement estimation of moving speed of the BS part and an expected value of an intensity of electric field.

It is known that AR wave in the material surroundings (gas, a liquid, a firm body) extends in the form of longitudinal waves of expansion and compression of the surroundings [2]. In this case, the length of AR waves is defined by the following equation:

$$\lambda = c/f \quad (3)$$

where c – a speed of a sound wave in the surroundings, f – AR frequency.

A speed of a sound makes about 1500 m/s as density BS is close to water density. Forward moving of the BS part with AR frequency will occur, if its size is fewer lengths of the AR wave. This condition is provided by means of a choice of the AR frequency. For example, the length of a wave can be equal to 30 mm for a part with a size of 1 cm. In this case, the frequency estimated using (3) is equal 50 kHz.

The maximum speed of oscillatory moving v_{max} can be defined from the following relationship [3]:

$$I = PVmax/2 = P^2/2c\rho \quad (4)$$

where I – AR intensity, P – sound pressure upon surroundings particles, ρ – surroundings density.

Based on equation (4), v_{max} can be extracted as follows:

$$Vmax = P/c\rho \quad (5)$$

The value ($c\rho$) is an acoustic resistance of the surroundings. Sound pressure is within the limit of 10^3 – 10^5 Pa for a range of averages on value AR intensity [3]. From the equation (5) it is possible to calculate v_{max}= 0,6 (10^{-3}-10^{-1}) m/s for these values of pressure in BS. At these conditions, the value of surroundings moving is from shares of micrometers to several micrometers, which is possible to establish using equations (3) and (5).

The range of the maximum values of intensity of alternating electric field at $B = 1T$ can be received from the equation (2):

$$E \approx (10^{-3} - 10^{-1})V/m \quad (6)$$

In particular, the alternating voltage $V = E\ x\ L$ with amplitude from 10 μV to 1 mV with frequency AR arises at such electric field on BS part with an extent L = 10 mm.

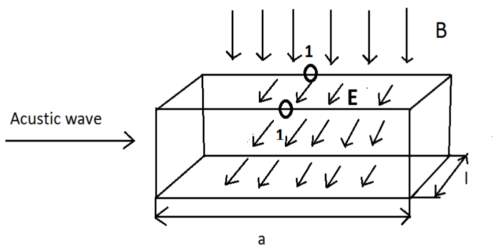

Figure 1. Scheme of the biological surroundings sample under the influence of a magnetic field (B) and acoustic radiation: 1-1 is sample extent along the E – direction.

It is possible to receive the generalized expression for an alternating voltage V arising on BS part as a result of magnetohydrodynamical process:

$$V = [2I/(c\rho)]^{0.5} B \times L \qquad (7)$$

In particular, focusing AR on body part (including internal organs) and measurement of corresponding values of voltage according to the formula (7) presumes to measure an arrangement of pathological anomalies with high accuracy in the long term. This arrangement is connected with the spatial distribution of BS acoustic resistance value. In turn, spatial distribution of density can be calculated considering acoustic characteristics of the biological environment.

Discussion

The problem of transport of a medical product in organism or organ is current challenge for modern biophysics and medicine. One of the perspective methods of research in the field of drug transport and their localization is in the linkage of a medical product with magnetic nanoparticles and their movement to a demanded place of an organism [4, 5]. The efficiency of treatment depends on the speed of accumulation of a medicine and its concentration (in the form of magnetic heterogeneity) in the set part of an organism. Until now, the control of accumulation of a medicine in a demanded part of an organism is carried out by means of contrast X-ray observation of organism areas where the accumulation of the particles with a medicine is expected. Application of an X-ray irradiation is always associated with safety concerns. After medicine accumulation, there is a necessity to supervise the process of deducing of magnetic particles of an organism that can cause the further application of an X-ray.

Nowadays, experiments with use of difficult and expensive NMR instruments have been started; however, there is a common problem in accessibility to this instrument.

We have started to investigate the possibility of joint application of acoustic radiation and a direct magnetic field for a location of magnetic particles in the biological surroundings. This method is new and completely safe. Moreover, application of magnetoacoustic effect for the specified purpose has barely been investigated.

Use of action of a direct magnetic field (DMF) and acoustic radiation (AR) on the magnetic particles, which are on BS part is a basis of this method. Both these methods are interesting because, unlike an alternating electromagnetic field, they can penetrate to a much bigger depth of a living tissue.

DMF serves for orientations (polarization) of the magnetic moments of particles, mainly along its direction. The magnetic field as well as total magnetic moment of BS part increase, if the particles collect at one place within a living tissue or an organism. AR serves for excitation of periodic vibration of BS together with the polarized magnetic particles with acoustic frequency. It should cause corresponding harmonious moving to space of a vector of the total magnetic moment of the oriented particles. The secondary alternating magnetic field (SAMF) should arise in the space of surrounding investigated part of BS. In turn, this field can be measured by a magnetometer being close to the part of BS. The values measured by the magnetometer are expected to be proportional to a value of the concentration of magnetic particles and the linked drugs in the set part of BS.

Conclusions

Application of magnetohydrodynamical process for the estimation of expected values of electric voltage on a part of the biological environment highlights the practical possibility of this approach to detect and monitor the properties of live tissues and organisms. Our work shows that such safe and contactless method to allocate magnetic particles in the biological environment by means of the joint influence of a direct magnetic field and acoustic radiation is very promising and can be used in further biomedical investigation.

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