MODELING THE MOVING OF CHARGES IN HOMOGENOUS MAGNETIC FIELD

Prof. Dr. Dimiter Dimitrov
dcd@tu-sofia.bg, +359 2 9652278

Hristo Hristov
hristov@tu-sofia.bg, +359 898 718196
Technical University of Sofia, Bulgaria

Abstract

For years, the magnetic field finds great application for medical purposes. Its beneficial influence on humans is an established, though not particularly analyzed, fact. Nowadays, when the computer modeling of processes is coming in strong, it is opening up new vistas for us to provide a set of answers, concerning the magnotherapy, as well as to bring the magnetic fields into optimum use for people. The present article puts forward the concept and the laws that provoke the positional fluctuation and the speed of the charged particles, under the impact of homogeneous electromagnetic field.

Introduction to the problem

The main source of pain in number of diseases or contusions is the formation of ionic accumulations. They represent amassments of ions with equivalent charge, concentrated in a small area. In the human tissue there are lots of liquids that dissociate their molecules into ions with opposite charge (counter-ions) due to the chemical phenomenon – *electrolyte dissociation*. In normal condition, these ions are divided in relatively equal shares in the human tissue and there exists no tension between the particles [1], [2]. However, some contusions and diseases operate so that the ions could constitute ionic depots, in between which exists tension. The tension in question incites a force of strain (in the tissue), therefore: an origination of inner strain, respectively – an initiation of pain [3]. The result of applying the extern magnetic field is dispersing these ionic accumulations, thereby suppressing the pain [4]. How to use technical means to decrease the inner magnetic fields is of interest to us as engineers. An extern magnetic field, which is stronger than the inner one and which could neutralize it (i.e. suppress the ionic depots) is used for that purpose [5]. That particular sort of therapy is called *magnotherapy*. The magnotherapy is a method of the physiotherapy which includes treatment with constant or alternating low frequency magnetic fields. The large range of curative efficacy that provides the magnetic field transmutes the magnotherapy into a future technology. The easy setting of the magnetic applicators, their painless influence, the absence of secondary effects and their affordable price are a prerequisite for this alternative remedial-prophylactic approach to gain wide currency in ambulatory or domestic conditions.

The magnotherapy utilizes a physical phenomenon called the *Lorentz force*. When we put a magnet close to the human body, some magnet forces go through the tissue and they improve the circulation of the blood. This action enables the organism to resuscitate its forces; to overcome the toxicities and the causes of the malaise. As a whole, the application of the magnotherapy could decrease the duration of the treatment and the therapy with approximately 50% less than the foreseen.

Exposition

A weak and constant magnetic field results thanks to tiny magnets. It interacts with the deeper muscle layers and there it stimulates the normal course of the organic processes. The cramps decrease without any medications or other side effects.

The surrounding ambience is enlaced with magnetic fields: some generated by the natural terrestrial magnetism, others – by solar storms or weather changes. There are also magnetic fields created intentionally by electric apparatus (engines, TV-sets, office equipment, computers, micro ovens, etc.). Even the human body gives rise to a magnetic field, generated by chemical reactions of the nerve cells containing ions. The electromagnetic field represents simultaneously an electric and a magnetic field. It is identified as electronic because of the presence of charged particles (i.e. the electrons) and it is acknowledged as magnetic due to circulation of these charged particles. In roughly recent studies, the scientists found that the extern magnetic field could be good for the health – this inference led to the "invention" of the magnotherapy.

The dosage here is crucial, such as the posology of the medicines. Achieving optimum application performance needs good prior research of the practice; of the most advantageous for the human's body values, when exactly the magnetic field gives its most beneficial effect. For the purposes of the charge performance research (under a magnetic field), we've elaborated a program that simulates the process. Its goal is to illustrate the variations of the speed and the position of the charged particle (ion, electron, and proton) under a dynamically alternating and homogenous magnetic field.

The physical model of the system is as follows: two fields act to the charged particle – an electric field (prominent for its electric intensity) and a magnetic field (distinguished by its magnetic induction or magnetic flux density). These two fields vary in time according to a sinusoidal law and they initiate certain forces, which operate on the charges. More specifically, this brings up the Lorentz force, which originates the speed variation and the situation variation of the charge.

The Lorentz force is known from the physics:

$$\vec{\mathrm{F}} = \mathrm{q}\,(\vec{\mathrm{E}} + \vec{\mathrm{v}} \times \vec{\mathrm{B}}) = \mathrm{q}\,\vec{\mathrm{E}} + \mathrm{q}\,(\vec{\mathrm{v}} \times \vec{\mathrm{B}}) \qquad (1)$$

q – is used to denote the quantity of the electric charge (C)

E – is used to denote the vector of the electric intensity (V/m),

v – is used to denote the velocity of the charge (m/s)

B – is used to denote the magnetic flux density of the magnetic field (T)

$\times$ stands for cross product of the two vectors. We'll use this formula, whenever both (electric and magnetic) fields are active. And in case when the electric field value comes up to zero (or is insufficiently small, hence the abovementioned formula takes on a new mode):

$$\vec{F} = q(\vec{v} \times \vec{B}) \qquad (2)$$

We'll use this formula whenever the speed of the charges is generated on a random basis and not due to any given electric field.

After we find out the force, which acts to the charge, referring to Newton's second law, we could calculate the acceleration, which will gain the charged particle. The Newton's second law of motion encloses the following formulation:

$$\vec{F} = m\vec{a} \qquad (3)$$

where *m* represents the mass (kg) and *a* is the vector of the acceleration (m/s^2). From (3) we can express the acceleration:

$$\vec{a} = \frac{\vec{F}}{m} \quad (4)$$

After calculating the acceleration we can integrate it in time and this way we'll get the change of the velocity for certain time interval (the limits of the integral). It does matter what will be the integration step we'll use – the littler it is, the more points from the trajectory we'll calculate and thus the precision will grow. The formula we'll use is

$$\Delta\vec{v} = \int_{x1}^{x2} \vec{a}dt \quad (5)$$

The integration in this case is reduced to the integration of the three components of the acceleration vector, which are constant in every one moment of time. Knowing the new value of the velocity of the charge we can calculate how its position has changed. From the equation

$$\vec{S} = \vec{v}t \quad (6)$$

where *S* represents the track, covered by the charge, *v* represents the velocity and *t* – the time; we can calculate the distance, traveled by the particle. This way we can calculate the alteration of the position of the charge in the time.

To make all these calculations we can use some programming language. The investigation we've made uses the Java programming language (version 1.4). This is a modern object-oriented language, from the third- generation, who has lots of advantages – it is platform independent, has good support form the Internet browsers and is very widespread, portable and secure. One other big advantage of Java is the license under which it's distributed – totally free.

An example of the execution of the program can be seen at the following URL:
http://diplomna-javadoc.hit.bg/applet/applet.html

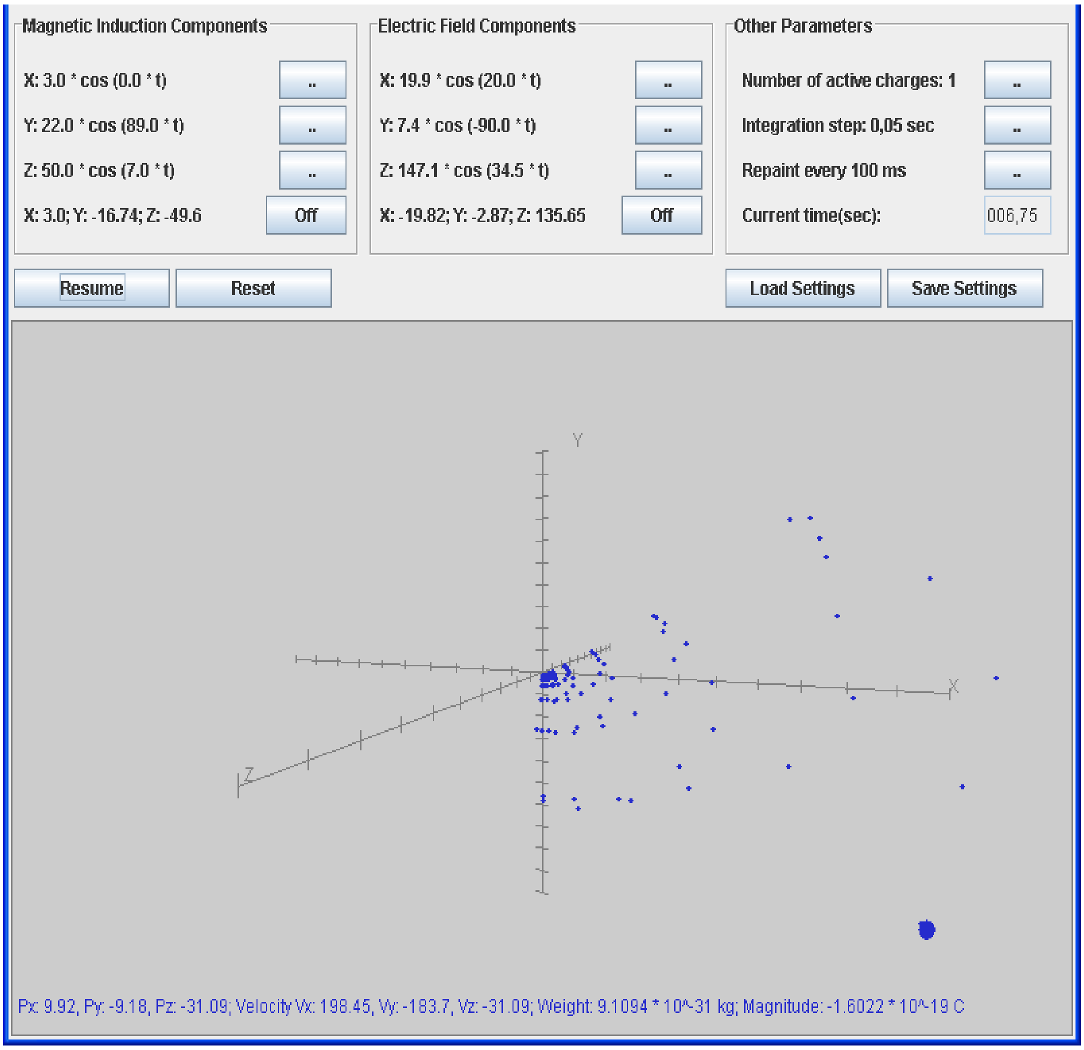
The aim of the program is to demonstrate how will vary the velocity and the position of one or more charged particles, under the influence of an electromagnetic field. For the research's purposes we've made some presumptions:

- we presume that the electric and the magnetic fields are homogenous in every one point of them and in every one moment of the time.
- we ignore the fact, that every moving in magnetic field particle produces an additional magnetic field around it. This supposition is correct because in the common case the external magnetic field is much more powerful then the one generated by the particle and that's why we can ignore it.

The results of the research we've made could be used to discover the most optimal values and form of the electromagnetic field, so we could use best its potential for better therapeutic effect when treating diseases and contusions. A well-know fact from the medicine is that for every type of treatment it's very important not to let the organism to get used to the therapy. That's why it's absolutely necessary to change the form and the value of the magnetic field which will operate on the object of the treatment. Physiotherapists and medicals can use such type of simulations to choose the most suitable values for the electromagnetic field so that the positive effect will continue as long as possible.

For the development of this simulating program we've created some java classes that describe the electric and the magnetic fields and the appropriate classes for visualization the change of the velocity and the position of the charge. For the magnitude and the weight of the particle we've used some known form the physics values.

The main screen of the application looks like this:



Conclusion

The magnotherapy is a method for curing a great number of diseases and contusions, which makes it very perspective for the future. To use the full potential of this type of therapy it's very important to study it and find the most proper parameters of the health equation. With the temps of progress of the techniques today (and especially those of the computers), we can make successful simulation of the processes that take place in the tissues under the influence of an external magnetic field. These simulations can lead to some conclusions which can optimize the use of magnetic fields. For this purpose we've developed a program for simulating the behavior of the charged particles placed in the influence of external homogenous electromagnetic field. The conclusions that physiotherapists and medicals can reach using such type of simulations can help for more optimal and quick treatment of the patients. In version one of our product we have mentioned the potential of using the computers like our ally in the war with the pain. At this stage of the development of the product, the program has more informational and research nature, then practical use. To be truly helpful for the real cases we will have to add some functionality like reading the resistance of the tissues, using the real form of the electromagnetic field, include the noises which are around us, etc.

References

[1] http://bg.wikipedia.org
[2] http://www.samozdrav-bg.com
[3] http://www.permahealth.com/bg/informacia.htm
[4] http://library.thinkquest.org/24206/therapies/magnetic-field_therapy.html
[5] Д. Димитров, Комуникационни системи в медицината, Изд. Технически Университет, София, 2005