# RESEARCH ON THE INFLUENCE OF PERMANENT MAGNETIC FIELD DURING LIVE TISSUE LASER TREATMENT

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## Abstract

*This paper deals with the change of the optical transparency of human tissue during the simultaneous influence of laser radiation and magnetic field. The work has been supported by practical research conducted with the respective hardware. The research features the search for integral effects in terms of both wavelength and the duration of the experiment. Both the need for controlled environment and the morphological differences from the live tissue have also been taken into account. The paper is part of a general plan for the evaluation of the synergetic influences of different electromagnetic radiations over the human body. The goal is for the gradually derived results to be maximally approximated to the practically applicable ones.*

## 1. Introduction

For the last years there have been a series of researches on the influence of the permanent magnetic field over laser treatment, and some interesting results have been observed [1-5].

Two possible reasons for such effects have been observed. The first one is the Faraday effect or, more precisely, the influence over the environment between the laser source and the object treated. In this way one can influence treatment polarisation. However, no practical use of optical treatment polarisation control has been found yet. This is mainly due to the non-homogenous structure of flesh and the comparatively quick change of molecular level [2]. The second possible reason is the local influence of the magnetic field over the treated area. This is the most perspective way to earn benefit from the joint influence of optical and magnetic fields. In the paper, we have speculated on the second way [6-9].

## 2. Theory

### 2.1. Problems with the choice of research method

There are several ways to measure the optical parameters of the tissue [4]. Depending on the experimental approach, one can derive the average coefficient of attenuation and the two coefficients of absorption and diffusion. If the angle dependence between the diffused energy is measured through twisting the respective detector, then the anisotropy coefficient can also be derived. The simplest method for measuring the attenuation is presented in fig.1.

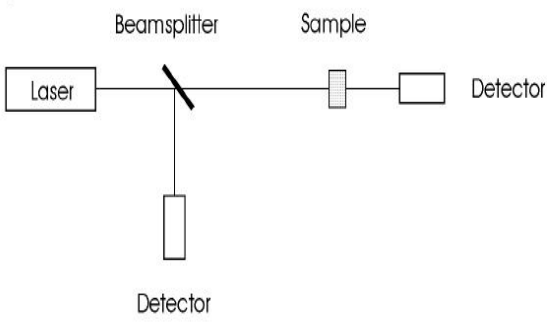


Fig.1. Measurement of the attenuation using a light divider

By using a light divider, half of the energy is directed to a comparative detector. Its other half is directed to the tissue sample. There is also a second detector located on the optical axis, which measures the energy that has passed. By subtracting the derived intensity from the one derived for the comparative detector, the attenuation coefficient can be derived. The problem with this set is that there is no way to differentiate between the absorbed and the diffused light. Another method through which the absorption can be defined contains one more additional component: integration sphere. This sphere has a high reflectional internal surface. An integrated detector measures only the light which has not been absorbed from the object inside the sphere. Another problem with the measuring process is the property of the biological tissue to change its parameters during the process of irradiation due to heating. That is why it is important that measuring is done simultaneously and with the same model of the set. Another problem is the non-homogeneity of biological tissue [4]. This hinders the comparison of experimental results from different test probes. Optical characteristics measured in vitro can differ significantly from the in vivo ones. There are a number of reasons: the tissues have different morphological structures; the tissue changes easily as a consequence of deformations and drying, freezing or dipping in liquids.

### 2.2. Choice of optical source

In the practical research we will use two different sources working in different wavelengths. The goal is to expand the spectrum researched and reduce errors. It is known that tissue has very selective characteristics for single wavelengths. For a first source we will use an infrared LED. Advantages of infrared LEDs are higher emitting power as well as higher effectiveness and optical penetration. The infrared light is absorbed mainly in water molecules: this defines great differences in the results in vivo and in vitro. The research of prof. H. Freedmann [1] also includes infrared LEDs. For the second source we will use a He-Ne gas laser [3]. The average wavelength is 632.8 nm. With such a wavelength, there is a relatively good absorption, mainly from pigments and proteins.

2.3.Choice of measuring equipment and experimental object

We choose the research media (biological tissue) to be in vivo. In this way the derived results will be maximally approximated to the practically applicable ones. We also take into account the restrictions defined which are prompted by the in vitro research: a controlled environment is needed, also morphological differences from the live tissue and the lack of available equipment. For the research we choose the surface of the fingers. The construction of the receiver has to be of such a type, so as to be stably fixed to the tissue.

## 3. Experimental Setup

### 3.1. Basic parameters

Intensity of the optical radiation -10mW/ cm2, Bandwidth – 600-1000nm; Magnetic Induction -35mT. Used in the setup infrared LED is L200CIR941,made by Ledtronics Inc. For the second emitter we use He-Ne laser. Maximum output power of the used laser P=3mW ($\lambda = 632{,}8nm$); Maximum output radiance of the infrared LED J=50mW/sr; Radiant angle of the LED $d = \pm 0{,}35rad$; Radiant angle of the He-Ne laser $\leq 0{,}48mrad$) Within this wavelength ($\lambda = 632{,}8nm$), there is relatively good absorption from pigments and proteins.

For the optical flux receiver of infrared light we are going to use a photodiode with integrated transimpedance amplifier TSL260 produced by Texas Advanced Optoelectronic Solutions.

For the optical sensor of the He-Ne laser we are going to use power meter Wilcom FM8510 Power Meter 850/1310/1550 InGaAs. Dynamic range - +5dBm to -70 dBm, respectively with central wavelengths at 850,1310,1550 nm. Resolution – 0.01dB.

For the source of constant magnetic field we have chosen a series of 8 tabular Neodymium magnets - Nd2Fe14B, with measures 15x30x3mm. Of all known ferromagnetic alloys, this one has the highest remnant static magnetic field Br=2000-3000Gauss, coercive force Hc=235-270kA/m and maximal magnetic energy (BxH)max=27-35kJ/m3. We chose the Neodymium magnets because of their high magnetic characteristics, relatively small price and compact size. Separate magnets make possible the regulation of the magnetic field by using them in different combinations.

### 3.2. Calculations

We calculate the intensity I of the laser beam by its given maximum output power:

$$I_0 = \frac{P}{\pi\omega_{1/e}^2} = \frac{3.10^{-3}}{3{,}14\omega_{1/e}^2} \quad , \qquad (1)$$

and

$$\omega_{1/e}^2 = \frac{\omega_{1/e^2}}{\sqrt{2}} = (0{,}707.0{,}83)^2 . \qquad (2)$$

This results in:

$$I_0 = \frac{3.10^{-3}}{3{,}14.0{,}344} = 2{,}77\, mW/sr , \qquad (3)$$

Where P is the radiant power in units of W, ω1/e is the beam radius specified at the 1/e points defined by the Gaussian-shaped beam profile. This beam radius is defined as the radius of an aperture that will just accept 63% of the incident power, i.e. 1/e of the incident power is blocked. We calculate roughly the absorption of the media and the absorption length of the laser radiation. The skin is one of the tissues with highest absorption properties. For this we assume the minimal depth of propagation in the turbid media to be 1mm and the maximal 5mm. The absorption coefficient of the medium (skin) is $\alpha = 268cm^{-1}$. We have the following results for the intensity:

$$I(x) = I_0 \exp(-\alpha z) = 2{,}77 \exp(-0{,}268.0{,}1) = 2{,}696\, mW/sr , \qquad (4)$$

$$I(x) = I_0 \exp(-\alpha z) = 2{,}77 \exp(-0{,}268.0{,}5) = 2{,}42\, mW/sr . \qquad (5)$$

The absorption length is calculated by the following expression

$$L = \frac{1}{\alpha} = 3{,}731cm . \qquad (6)$$

### 3.3. Experiments

We have measured the optical properties of the He-Ne laser, while adding and removing the constant magnetic field. We have performed a series of measurements with different amplitude of the applied magnetic field. No variations of the measured intensity of the radiation transmitted through the tissue are observed. The only source of alternation of the gathered results in the presence of fluctuations from the displacement of the tissue in relation to the emitter, heat variations due to overexposure of the powermeter's thermal sensor and the received reflection from the surface of the magnet.

By analogy, we have performed in the same way the measurement of transmitted intensity of the infrared LED. No variations of the measured intensity of the radiation transmitted through the tissue are observed.

There is no apparent change in the dielectric properties of the tissue, the side effect of this would be increased or decreased losses. Both magnetic and laser fields can change the morphological structure of the substances.

## 4. CONCLUSION

### 4.1. General conclusions

The methods used for measuring tissue parameters can be used for future research with the goal of practical application when solving a particular engineering problem.

The restriction in the number of the different methods of measuring optical parameters leads to a significant decreasing of the problem-solving time for problems of a similar nature.

The comparative wide-band irradiation as well as the weak sensitivity of the measuring equipment are the main reasons for the derived results. The short duration of the research has also restricted the derived results.

### 4.2. Future development

In the future, there can be application of a spectral analyser for the research. In this way the integration of the field intensity in wide-band detectors will be avoided. Other tissue samples can be chosen. The Electron paramagnetic resonance analyzer can be applied in order to achieve a highly sensitive measuring of the electron transfer and the synthesizing of free radicals in the researched environment, monitoring the spectrum of paramagnetic resonance emitted from the specific object.

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