SPECTRAL PROPERTIES OF ELECTROMAGNETIC FIELDS OF MILTA DEVICE AND BODY TISSUES

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INTRODUCTION

Magnetic infrared laser (MIL) therapy uses combined effects of several types of alternating electromagnetic fields with different radiation spectra and of a static magnetic field on the body. The electromagnetic field is defined as a space in which energy of electromagnetic oscillations spreads. The wavelength- (or frequency)-specific distribution of radiation intensity (power) is called a spectrum of electromagnetic oscillations. Electromagnetic oscillations have a dual nature in that they are simultaneously waves and particles (quanta). Their wave quality is more prominent at greater wavelengths and the quantum character at shorter wavelengths. Short wavelength-spectrum (roentgen and gamma) radiation is actually a quantum event, i.e. it is a particle flow. Both effects occur in the optical range, while quantum effects are absent in the millimeter wave range of extremely high frequency radiation.

Effects of magnetic infrared therapy are underlied by an intricate mechanism of interaction of low-energy electromagnetic radiation with the body. The mechanism is mediated by photophysical and photochemical reactions related to resonant absorption of radiation energy by body tissues, and to energy reception and transfer of effects of exposure in body fluids at several levels. The pattern and levels of these interactions are largely dependent on both radiation spectra and spectral characteristics of tissues.

At the lowest, atomic and molecular level, electromagnetic fields are absorbed by body tissues and fluids. Absorption of light energy results in electron-excited states of tissue and fluid atoms and molecules, subsequent migration of electronic excitation and the onset of primary photophysical effects and generation of primary photo products which activate metabolism.

For the photochemical and photophysical reactions to occur at the molecular level, molecules (atoms) should be excited by exposure to a portion (quantum) of energy at a frequency close to their resonance frequency of oscillations. The duration of an energy pulse must not be shorter than the energy accumulation time required by a given molecule - tens of nanoseconds. After excitation, a molecule releases accumulated energy to adjacent molecules and atoms, triggering photochemical and photophysical reactions. For molecules of human cells to be excited, they should be imparted at least a threshold energy which is determined by energy levels of electrons rotating in different orbits around positively charged nuclei of atoms and organic molecules. Energy accumulated by molecules and numbers of excited molecules increase by quanta with higher power flow densities, enhancing the intensity of reactions and therapeutic effects.

Exposure of tissues to electromagnetic waves produces five types of interactions: diffuse reflection from the skin; refraction; penetration; tissue absorption; and scattering. The pattern of these interactions is largely determined by spectral characteristics of the magnetic infrared laser therapeutic device (MILTA) and by spectral properties of body tissues.

Spectral Characteristics

Different modifications of the MILTA device can produce therapeutic electromagnetic fields in optical and millimeter wave ranges.

Figure 1 shows spectral features of optical-range magnetic fields and tissue properties at different wavelengths. Numerical designations are

1 - Laser monochromatic (narrow-band) infrared radiation of MILTA
2 - Broad-band spectrum of diode infrared (IR) light radiation of MILTA
3 - Broad-band spectrum of diode red light radiation of MILTA
4 - Broad-band spectrum of extremely high frequency (EHF) radiation of MILTA
5 - Daytime and nighttime spectral sensitivity of the human eye
6 - Skin reflection coefficient
7 - Relative penetration of radiation into tissues (tissue transparency)
8 - Photon energy (phe) in electronvolts
9 - Energy range of organic molecular links in electonvolts (hatched area). Photon energy is inversely proportional to the wavelengtgh; phe = 1.2 wavelength (in mcm).

Therefore, the shorter the wavelength the higher photon energy. The static magnetic field is not a radiation, and its spectrum is zero. The horizontal axis of Fig.1 is the wavelength (mcm) of the optical range which falls into three subranges: ultraviolet (UV), visible light and near infrared.

Left of ultraviolet are shorter-wave ranges: roentgen and gamma radiation. Right of near infrared are longer-wave ranges: far infrared and radio waves from extremely high frequency millimeter (the scale of the EHF range is not shown in the figure) to kilometer ones.

Human perception is limited to only a narrow range of electromagnetic radiation: to visual sensations in the visible spectrum with wavelengths of 0.38 to 0.76 mcm and thermal sensations in the infrared spectrum with wavelengths longer than 0.76 mcm, but shorter than 1 mm.

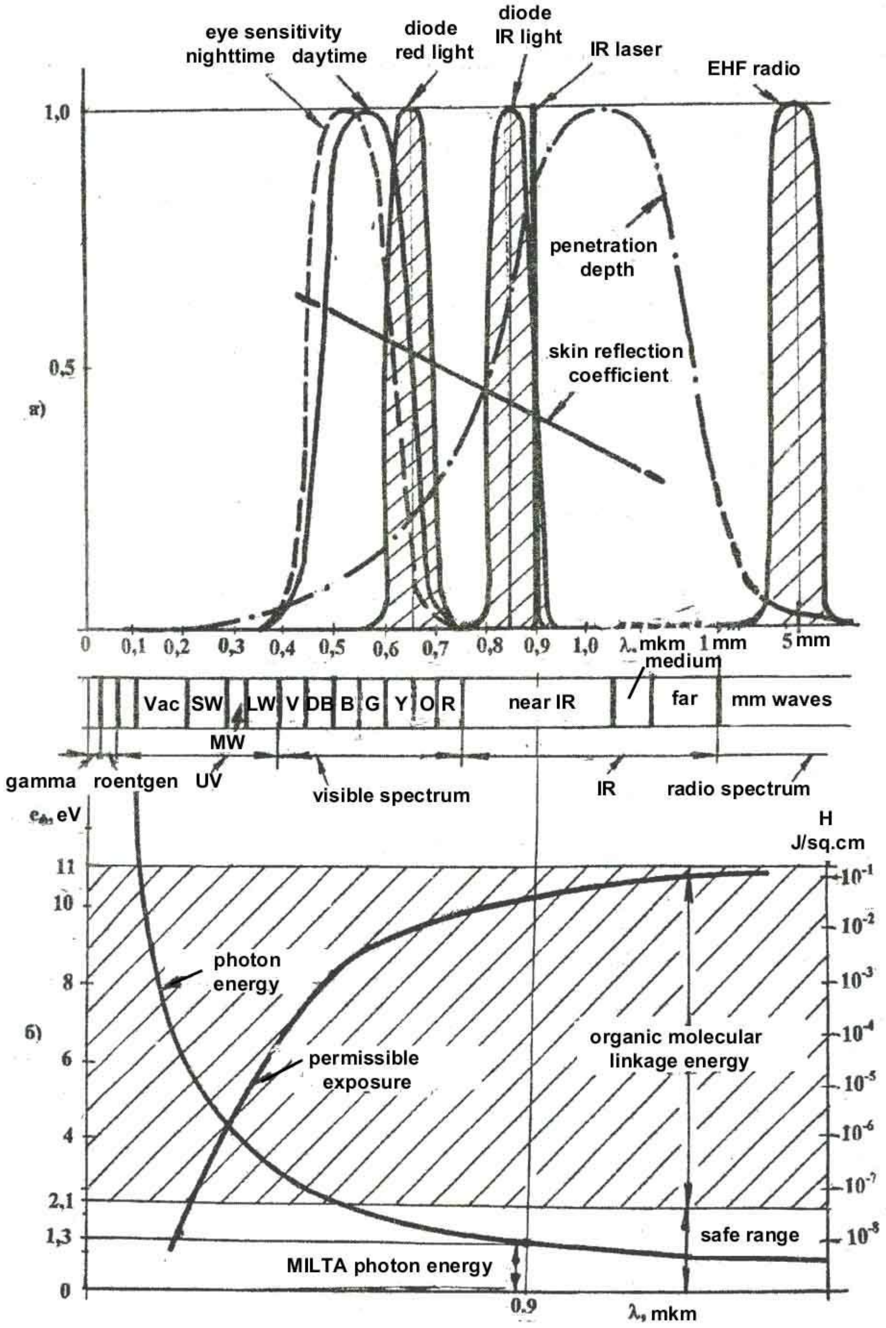

Fig.1. Spectral characteristics of optical-range electromagnetic fields and properties of body tissues

The human can protect himself from sensed radiation such as bright light by closing eyes, wearing tainted glasses, turning away or going away, and from overheating by cooling down or going away from a heat source. However, the human body does not sense ultraviolet optical, roentgen and gamma radiation and radio waves, and exposure to high levels of these can be very dangerous.

Radiation Spectra and Ranges

Radiation spectra, i.e. wavelength-specific distribution of power can be broad-band continuous (e.g. optical-range solar radiation, light diode radiation) and narrow-band discrete (e.g. laser radiation). Table 1 presents wavelengths which are borderlines between electromagnetic radiation spectra and corresponding photon energies. Optical laser radiation is almost monochromatic and hence has one wavelength. Table 1 presents wavelengths of medical lasers and Table 3 electromagnetic wavelengths of the MILTA device.

Table 1. Electromagnetic radiation spectra

Type of radiation	Wavelength, mcm	Photon energy, eV
Gamma radiation	over 4×10^6	over 300
Roentgen radiation	4×10^6 - 0.1	300 - 12
Vacuum ultraviolet (air ozonization)	0.1 - 0.2	12 - 6
Short-wave ultraviolet (reddening effect on the skin)	0.2 - 0.28	6 - 4.3
Median-wave ultraviolet (bactericidal effect)	0.28-0.315	4.3 - 3.8
Long-wave ultraviolet (tan)	0.315 - 0.38	3.8 - 3.2
Visible spectrum	0.38 - 0.76	3.2 - 1.6
Near infrared	0.76 - 1.6	1.6 - 0.8
Median infrared	1.6 - 30	0.8 - 0.04
Far infrared	10 - 10^3	0.04 - 10^3
Millimeter radiowave (EHF)	10^3 - 10^4 (1 - 10 mm)	0

Table 2. Radiation spectra of medical lasers

Types of lasers according to working media	Wavelength, mcm	Photon energy, eV
Krypton chloride (KrCl)	0.25	4.8
Xenon fluoride (XeF)	0.31	3.8
Nitrogen (N2)	0.337	3.6
Argon (Ar)	0.38	3.2
Copper vapor (Cu)	0.51	2.4
Helium-neon (He-Ne)	0.633	1.9
Red arsenide gallium (AsGa)	0.63	1.9
Arsenide gallium (AsGa)	0.63	1.9
Infrared (MILTA)	see below	
Carbon dioxide (CO_2)	10.2	0.1

Table 3. Radiation spectra of MILTA device

Radiation type	Wavelength	Photon energy, eV
Infrared laser monochromatic	0.89 ± 0.06 mcm	1.3
Infrared light diode, broad-band	0.86-0.96 mcm	1.25-1.4
Red light diode, broad-band	0.60-0.75 mcm	1.6-2.0
Extremely high frequency, broad band radio (EHF)	4.5-5.6 mm	

Spectral Properties of Body Tissues

Any chemical substances have absorption spectra, i.e. wavelength-dependent degrees of absorption. The absorption spectra also may be continuous and discrete, depending on atomic weights of constituent chemical elements and their isotopes. Absorption spectra of organic molecules in tissues are discrete. Absorption is resonant if the radiation wavelength coincides with one of the molecule's own absorption wavelengths. Radiation with such a wavelength is absorbed more intensively, and therefore penetrates shallower depths of body tissues. Since biological molecules make a huge diversity, numbers of tissue absorption lines are great; therefore, there is an average correlation between absorption values and wavelength ranges.

Spectrum parameters and radiation ranges presented in Tables 1-3 prompt a look at the graphic relationship between radiation intensities of the MILTA device, spectral properties of tissues and wavelengths shown in Fig.1.

The analysis shows that only MILTA broad-band red light diode radiation with wavelengths in the range of 0.6 to 0.75 mcm (spectral curve 3) falls into the visible spectrum perceived by human eyes in the wavelength range of 0.38 to 0.76 mcm (curves 5).

Sensory organs do not perceive other types of MILTA radiation: laser infrared with a wavelength of 0.89 mcm (curve 1), infrared light diode radiation with wavelengths of 0.86 to 0.96 mcm (curve 2) and EHF radiation with wavelengths of 4 to 5.6 mm.

Diagram 6 shows the relationship between the skin reflection coefficient and optical radiation wavelengths. It is known that the reflection coefficient is equal to the ratio of reflected to incident power. The lower is the coefficient the greater proportion of energy penetrates tissues to exert therapeutic effects.

The reflection coefficient is also related the condition of the skin: it is highest for a sebaceous white skin (55 percent) and lowest for a heavily pigmented, dry and wrinkled skin (10 percent). To reduce reflection before a magnetic infrared laser treatment, the skin can be cleaned of grease and sweat with alcohol or ether and then treated with brilliant green or iodine.

Curve 6 shows that the reflection coefficient decreases with longer wavelengths, tapering to a minimum in the infrared spectrum of the MILTA device.

Diagram 7 depicts the relationship between depths of radiation penetration of tissues and wavelengths. The penetration depth increases with lower radiation absorption in this range, i.e. the tissue is more transparent there. The diagram shows that a maximum penetration depth (tissue transparency) is close to the range of MILTA infrared radiation wavelengths, and this accounts for the most deep effects of MIL therapy. Direct and indirect measurements have shown that with an equal relative attenuation, the penetration depth in the ultraviolet spectrum is less than 1 mcm; it is less than 1 mm in the red optical and less than 1 mm in the EHF spectrum, but penetration is centimeters deep in the infrared spectrum of the MILTA device.

Photon Energy and Molecular Properties of Tissues

As it was stated above, short wave-spectrum electromagnetic radiation is a flow of elementary particles (photons) whose energy can change in quantum degrees with change of energy levels of electrons which rotate in different orbits around nuclei of atoms and molecules. Curve 8 in Fig.1 describes the photon energy-wavelength relationship. If photon energy is sufficient for moving an electron of a tissue molecule into a higher orbit (i.e. the radiation frequency coincides with the resonance frequency of the molecule), the electron jumps into one of higher, unstable orbits (absorption of photon energy occurs). The electron then returns into its old orbit, with photon emission. This radiation is defined as secondary. Secondary photons spread in all directions and elicit the electron jumping and excitation of adjacent tissue molecules with different resonance frequencies, an effect called scattering. In addition, body fluids (blood, lymph) transport the excited molecules in the body, which amplifies the scattering.

Owing to the scattering, monochromatic polarized and coherent radiation turns non-monochromatic, non-polarized and incoherent at tissue depths of only fractions of a centimeter, i.e. laser radiation becomes a diode light-like broad-band thermal radiation. Biologically, this radiation is far less active as compared with the laser. Its thermal energy concentrates mostly on cell membranes, stimulating cellular metabolism which determines most of the therapeutic effect.

If photon energy is higher than required for the electron to jump into the highest orbit, it beats the electron out of the molecule, resulting in the appearance of a positive ion and of a free negative electron which migrates in tissues until it is neutralized by another positive ion. This means that energy of such a photon proves higher than linkage energy of a particular organic molecule, and the molecule is ionized, with change of its properties. Such changes may result in genetic damage and risk of cancer. Molecular linkage energy in human tissues is in the range of 2.1 to 12.6 eV (see the hatched area 9 in Fig.1). Photon energy of infrared radiation is below 1.5 eV, i.e. below minimal energy of linkage (2.1 eV).

Therefore, radiation of the MILTA device is theoretically and practically safe and unable to cause genetic mutations and cancer.

If photon energy is in the range of organic molecular linkage energy (Tables 1,2), molecules with below-photon energies (i.e. with resonance frequencies lower than the radiation frequency) may be damaged. A photon energy higher than the maximum linkage energy of 12.6 eV (see ultraviolet, roentgen and gamma radiation values in Table 1) may damage any organic molecules. It follows that such radiation is very dangerous genetically. Damage severity is related to both photon energy (wavelength) and power (local power flow density) of incident radiation.

CONCLUSIONS

The analysis of spectral characteristics of radiation and body tissues suggests that the skin reflection coefficient is lowest in the infrared spectrum of optical radiation, and tissue absorption is minimal. These spectral properties of tissues allow noninvasive and more effective treatment of deeper located vessels and organs with the MILTA device as compared to tools using other wave ranges. Since photon energy of infrared radiation is smaller than minimal linkage energy of any organic molecules, this radiation is safe and unable to cause genetic mutations and cancer.