

Review Article

## LINKS BETWEEN EXTREMELY HIGH FREQUENCY ELECTROMAGNETIC WAVES AND THEIR BIOLOGICAL MANIFESTATIONS

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**Abstract** - In this mini-review, we describe some of the latest facts regarding the generation of condensed base phonons by biological entities, initially described by the renowned contemporary physicist, Nobel laureate, Herbert Fröhlich, who proposed a new biophysical interaction mechanism between extremely high frequency electromagnetic waves and the biological environment. As we will show, this extremely low intensity millimeter therapy crystallizes as an important new method, universal and effective in the management of diseases with different etiologies. Moreover, the existence of internal electromagnetic fields generated by biological entities, as well as external electromagnetic fields, are essential for understanding the electromagnetic-biological effect. In fact, it is estimated that at present millimeter-wave therapy is used for the management of more than 120 diseases in cardiology, neurology, oncology, gynecology, urology, gastroenterology, surgery, pharmacology and pediatrics. However, so far there is still no consensus regarding the interaction between extremely high frequency/extremely low intensity electromagnetic waves and the biological environment at its different levels of organization. Thus, the present paper was intended to contribute to the development for the theory of millimeter-wave interaction with living biological entities.

**Key words:** millimeter waves; biological entities; biological manifestations.

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For the last 10-20 years, millimeter wave electromagnetic biology has been considered one of the main new technologies in the management of various disorders and it is now used widely in medicine and pharmaceutical biotechnology (Whissell et al., 2007). The extremely high-frequency waves or millimeter waves are situated in the frequency range of 30 to 300 GHz corresponding to the wavelength range of 1-10 mm (Romanenko et al., 2014; Zhadobova et al., 2001). One of the first researchers to propose a possible mechanism for the generation of millimeter waves by living organisms was the Nobel laureate, Herbert

Fröhlich (1968, 1970). Generation of these extremely high-frequency electromagnetic waves is subject to metabolic energy. Moreover, these waves are coherent and are characterized by their well-determined frequency, phase, polarization and wave vector. According to Fröhlich, living biological systems generate polarized oscillations within the frequency domain characteristic for millimeter waves. The energy that underlies vital processes in living cells is transmitted to the local dipole-excited oscillations.

Due to the nonlinear phenomena caused by dipole oscillation interaction and its connection with

elastic waves, a system transition takes place to a metastable state with only one type of oscillation passing into the fundamental state, and giant collective dipole forms, representing a consistent state of the biologic object. This cooperative status is the basis for the creation in biological systems of the Bose phonons, condensed in the frequency ranges of approximately 1011 Hz, far from thermodynamic equilibrium zone. For this reason, the idea regarding the formation of Bose phonons, condensed in biological systems, is of great importance for understanding the processes caused by the interaction of electromagnetic millimeter waves with living organisms.

The aforementioned aspects also led to the elucidation of the functional control mechanisms for the main systems (such as the nervous and humoral) that provide the homeostasis of living organisms, and also explained various nonlinear and cooperative phenomena that took place at the level of interactions of millimeter electromagnetic waves with biological entities (Zhadobova et al., 2001; Torgomyan et al., 2007; Xia et al., 2012). Additionally, experimental research in this field only began in the early 1990s at the time when millimeter-wave generators started to be designed and produced. Experimental investigations have shown a number of particularities in the process of interaction between the millimeter electromagnetic field and its biological manifestations. It was also found that the biological effects of millimeter-wave coherent radiation can be detected at densities of the power flux density that are much lower than 10 mW/cm<sup>2</sup> (Deveatcov and Golant, 2001; Xia et al., 2012).

Informational actions are fundamental to the very existence of life. It was found that living entities not only generate electromagnetic millimeter waves, but these ensure the transmission of information from one cell to another, thus contributing to intercellular communication in plants, microorganisms and mammals. However, we must draw attention to the fact that in developing various mechanisms of processes in living biological entities involving millimeter waves, a separation of the electromagnetic fields is necessary: one is the external millimeter electromagnetic field generated by the concerned generators and the other is the internal field, which is called

the Fröhlich field and is generated by living biological entities. Of special interest in this area is the study of external millimeter radiation interaction with different hierarchical structures such as biomacromolecules, cells, tissues, and eventually the whole living organism. Because of this action, various biological, physiological, biochemical, biophysical and genetic effects occur in living organisms. The electromagnetic millimeter field causes biological effects at all levels of organization of living matter (Torgomyan et al., 2013).

An undeniable interest is also exhibited by the experimental research on millimeter-wave action on microorganisms and laboratory animals. It seems that the resonance character of the biological effect depends on the external electromagnetic field frequency, while the biological effects depend on the irradiation time until a temporary threshold is reached. In this way, the biological effect occurring at a certain value reaches the saturation value, after which the increase the radiation intensity ceases to increase it further (Romanenko et al., 2014).

The existence of internal electromagnetic and acoustic fields generated by biological entities, as well as external electromagnetic fields, are essential for understanding the electromagnetic-biological effect. It is estimated that currently millimeter-wave therapy is used for the management of more than 120 diseases in cardiology, neurology, oncology, gynecology, urology, gastroenterology, surgery, pharmacology and pediatrics (Usichenko et al., 2006; Zhadobova et al., 2011; Whissell et al., 2007; Torgomyan et al., 2013; Xia et al., 2012; Romanenko et al., 2014). In addition, the generators used in millimeter therapy are generators of coherent and stochastic radiation of small and very small intensities that do not lead to human body-tissue heating, making them different from other physiotherapeutic devices. Experimental investigations have shown a complete absence of harmful effects on the interaction of electromagnetic fields with biological entities, while positive effects are very different, ranging from increased body immunity and reduced allergic syndrome intensity to a therapeutic effect under combined millimeter, physio- and chemotherapies and other different medical treatments (Tronciu et al., 2002).

As previously mentioned, there is no unique and undisputed theory about electromagnetic-wave action. However, a few ideas to explain the mechanisms of action of this radiation on living biological entities have been proposed. According to the hypothesis of Deveatcov et al. (2001), all living entities are generating electromagnetic millimeter waves that streamline the internal processes of organisms. In this way, it is assumed that the external electromagnetic millimeter waves from living entities, under certain conditions, could be transformed into informational signals, in this way providing, directing and adjusting restorative processes that correct cell metabolism correction (Whissell et al., 2007).

A special role in the interaction between electromagnetic millimeter waves and biological entities is given to water and various aqueous solutions. Following numerous experimental investigations, it has been found that millimeter waves are heavily absorbed by water. This is because the rotation frequencies of water molecules are located in the frequency domain of millimeter and submillimeter waves of the electromagnetic spectrum. As a result of the electromagnetic millimeter-wave interaction with water molecules, a strong absorption of millimeter radiation occurs due to the phenomenon of resonance. Moreover, it was found that free water molecules absorb millimeter radiation more intensely than bound water molecules. Because of this, Khurghin et al. (2006) have assumed that water molecules represent the basis of interaction between millimeter waves and receptor proteins in cell membranes.

In conclusion, extremely low intensity millimeter therapy is crystallizing as a main new technological method, and could be universal and effective in the treatment of various disorders. Millimeter waves have crystallized into a new branch of modern biophysics and are extensively in medicine, biotechnology, agriculture and other areas. However, there are still controversies regarding the interactions between extremely high-frequency and extremely low-intensity electromagnetic waves and the biological environment at different levels of organization – submolecular, molecular, cellular, organ or organism as a whole. In this

way, it seems that further research and developments in this relatively new area of study are warranted.

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