Photon theory of bio-electromagnetic athermal effect

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The formula $< n >_d = \frac{d}{2}$, which describes bio-electromagnetic athermal effect, is deduced employing quantum theory. This law shows that the bio-electromagnetic athermal effect has no relation to the irradiation power, but to the structure of the living tissues. The phenomena about multi-photon absorption and bio-electromagnetic athermal effect may occur in cell membrane. Finally, the assumption how to test this theory is put forward.

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The biological effect is produced by the interaction between electromagnetic wave (such as microwave) and organism is named bio-electromagnetic effect. It can be classified as bio-electromagnetic thermal effect and bio-electromagnetic athermal effect according to the state in temperature. After absorbing electromagnetic wave energy, the organism's bodily temperature is going up and the various function of the biological organism is making a change. This phenomenon is called as bio-electromagnetic thermal effect. Irradiated by the microwave, the organisms keep no change (or no obvious rise) in temperature. However the biological effect emerges obviously and results in taking a changing in the various physiological, biochemical and functional of the organisms. This phenomenon is named bio-electromagnetic athermal effect, which has been proved by a great number of experiments.

The previous experiment shows that a high yield xylanase producing strain A.niger HD-3.6 was screened out from its parent stain A.niger HD-3 by microwave irradiation. Properties of the highly producing xylanase remain stable after many times of subcultures and storage for two months. This indicates that the bio-athermal effect of microwaves induces mutation. The irradiated rats changed their abilities of dimension recognition and cognitive studies.

Lights are electromagnetic waves. Photosynthesis of plants is done on the condition of keeping no change in temperatures. Therefore, photosynthesis also belongs to bio-electromagnetic athermal effect. Lasers are light source with perfect coherence and mono-chromaticity, thus the lasers' bio-effects are better than normal ones. The bio-effects of lasers are mostly bio-electromagnetic athermal effect. Whether photosynthesis or lasers' bio-effects are the results of the interaction between lights and living organisms and they can be explained well by photon theory. The bio-electromagnetic athermal effect will be analyzed by quantum theory in the follows.

To simplify the problem, an equivalent model, namely multi-particle system composed of multi-atomic groups, is employed to describe the bio-molecule vibrating in one dimension. There should be an interaction between photonic field and the organism when the electromagnetic wave injecting into the living tissues. According to the viewpoint of quantum mechanics, the thermostatic state satisfies:

$$\hat{n}\,|n> = n\,|n> \, , \tag{1}$$

where $|n>$ is the eigenstate of the photon's number, n is the eigenvalue, $\hat{n}$ is the operator of photon's number.

The Boltzemann distribution's probability of the numbers of the photons in living tissues is given by

$$W_n = \frac{\exp(-\frac{n\hbar\omega}{kT})}{\sum\limits_{m=0}^{\infty}\exp(-\frac{m\hbar\omega}{kT})} = \exp(-\frac{n\hbar\omega}{kT})\left[1-\exp(-\frac{\hbar\omega}{kT})\right], \tag{2}$$

where ω is the average vibration frequency of the bio-molecule, and the corresponding density matrix is given by

$$\rho = \sum_n W_n\,|m><n| = \left[1-\exp(-\frac{m\hbar\omega}{kT})\right]\sum_\ell \exp(-\frac{\ell\hbar\omega}{kT})\,|\ell><m|\,.$$

As proved[8], the average photonic number in the living tissues at unit time is given by

$$<n> = \sum_m m\left[1-\exp(-\frac{\hbar\omega}{kT})\right]\cdot\exp(-\frac{m\hbar\omega}{kT}) = \left[\exp(\frac{\hbar\omega}{kT})-1\right]^{-1}. \tag{3}$$

Define the dimension number of molecular vibration as d, the corresponding average photonic number in the living tissues at unit time can be given by

$$<n>_d = d\cdot\left[\exp(\frac{\hbar\omega}{kT})-1\right]^{-1}. \tag{4}$$

By solving Eq. (4), the formula of temperature can be obtained

$$T = \frac{\hbar\omega}{k\ln(1+\frac{d}{\langle n\rangle_d})}. \tag{5}$$

An important relationship between $<n>_d$ and $<n>_0$ is given as

$$\frac{<n>_d}{<n>_0} = 1-\exp(-\alpha\ell), \tag{6}$$

where $<n>_0$ is the average photonic number injecting into the bio-organism in unit time, α is the absorption coefficient of the living tissues, ℓ is the molecular size.

The relationship between the temperature and the irradiation power on the surface of the living tissues at thermal equilibrium can be got by combing $p = \hbar\omega_0 < n >_0$ and Eq. (6) with Eq. (5)

$$T = \hbar\omega \left\{ k \ln \left[1 + \frac{d\hbar\omega_0}{p(1-\exp(-\alpha\ell)} \right] \right\}^{-1}, \quad (7)$$

where ω_0 is the frequency of the electromagnetic wave, p is the irradiation power on the surface of the living tissues. This is the relationship between the temperature in the living tissue and radiation power under thermal equilibrium.

The $\hbar\omega_0$, of which value becomes small with frequency decreasing, is an infinitesimal quantity from the quantum theory. For example, a microwave with ω_0 being 2.45 GHz possess as an energy about 10^{-24} J. Generally, the irradiation power of microwave values is about 10^3–10^4 W, the molecular size ℓ values about 10^{-10} m, and α values about 10^{-1}–10^{-2}. With the dimension d fixed ($d = 3$) and the above values employed, the Taylor expansion of Eq. (7) keeping only the first order infinitesimal item can be given by

$$T = \frac{\hbar\omega}{k\ln(1+\beta)} = \frac{\hbar\omega}{k(\beta - \frac{1}{2}\beta^2 + \frac{1}{3}\beta^3 \cdots)}$$
$$\approx \frac{\hbar\omega}{k(\beta - \frac{1}{2}\beta^2)} = \frac{\hbar\omega}{\beta k(1-\frac{1}{2}\beta)},$$

where $\beta = d\hbar\omega_0 p^{-1}[1-\exp(-\alpha\ell)]^{-1}$ is an infinitesimal item. Further expansion employing $x = -\frac{1}{2}\beta$ is also given here, keeping still only the first order item here,

$$T = \frac{\hbar\omega}{\beta k}(1 - x + x^2) = \frac{\hbar\omega}{\beta k}(1 + \frac{1}{2}\beta + \frac{1}{4}\beta^2).$$

With the value of β added to the above equation,

$$T = \frac{\omega p}{k d\omega_0}[1-\exp(-\alpha\ell)]$$
$$\left\{ 1 + \frac{d\hbar\omega_0}{2p[1-\exp(-\alpha\ell)]} + [\frac{d\hbar\omega_0}{2p} \cdot \frac{1}{1-\exp(-\alpha\ell)}]^2 \right\}. \quad (8)$$

Let

$$\frac{\omega}{kd\omega_0}[1-\exp(-\alpha\ell)] = A(\alpha),$$
$$\frac{d\hbar^2\omega\omega_0}{4k[1-\exp(-\alpha\ell)]} = \beta(\alpha), \quad (9)$$

we can transform the Eq. (8) into

$$T = A(\alpha)p + \frac{B\alpha}{p} + \frac{\hbar\omega}{2k}. \quad (10)$$

If $A(\alpha)p = \frac{B(\alpha)}{p}$, hence

$$p_0 = \sqrt{\frac{B(\alpha)}{A(\alpha)}} = \frac{d\hbar\omega_0}{2[1-\exp(-\alpha\ell)]}. \quad (11)$$

Under the condition, T possesses its minimal value T_0

$$T_0 = \frac{\hbar\omega}{k} + \frac{\hbar\omega}{2k} = \frac{3\hbar\omega}{2k}. \quad (12)$$

T_0 is not relation to the external factor because of ω is the natural frequency of the vibration of the biomolecule. T_0 can be considered as the temperature of the living tissue before irradiated. Let $T = \Delta T + T_0$, and ΔT is the increment of temperature of the living tissue after irradiated

$$\Delta T = T - T_0 = A(\alpha)P + \frac{B\alpha}{P} + \frac{\hbar\omega}{2k} - T_0$$
$$= A(\alpha)p + B(\alpha)\cdot p^{-1} - \hbar\omega \cdot k^{-1}. \quad (13)$$

The athermal effect is no change in temperature of the living tissue when radiated by the electromagnetic wave, thus ΔT is equal to zero, Eq. (13) becomes

$$A(\alpha)P + B(\alpha)\cdot p^{-1} = \hbar\omega \cdot k^{-1}. \quad (14)$$

This is the necessary condition on which electromagnetic wave produces athermal effect. Substituting Eq. (9) in Eq. (13), we obtain

$$\frac{p}{d\omega_0}[1-\exp(-\alpha\ell)] + \frac{d\hbar^2\omega_0}{4[1-\exp(-\alpha\ell)]p} = \hbar,$$
$$\frac{4p^2}{d\omega_0}[1-\exp(-\alpha\ell)]^2 + d\hbar^2\omega_0 = 4\hbar p[1-\exp(-\alpha\ell)],$$
$$\frac{4p^2}{d\omega_0}[1-\exp(-\alpha\ell)]^2 - 4\hbar[1-\exp(-\alpha\ell)]p + d\hbar^2\omega_0 = 0. \quad (15)$$

Solving the Eq. (15), thus

$$p = \frac{d\hbar\omega_0}{2[1-\exp(-\alpha\ell)]} = \hbar\omega_0 < n >_0, \quad (16)$$

$$< n >_0 = \frac{d}{2[1-\exp(-\alpha\ell)]}. \quad (17)$$

Using Eq. (5) in Eq. (17), we obtain

$$< n >_d = \frac{d}{2}. \quad (18)$$

There is no change in temperature of the living tissues (this phenomena is called as athermal effect) when corresponding photon's number of injecting into the living tissues at unit time is equal to a half of dimension number in the living tissues. $< n >_d$ is a positive integer according to quantum theory, so just only d=2 ($< n >_d$=1), the bio-effects of electromagnetic are athermal effects. The condition of producing athermal effects is that the dimension of molecule vibration is equal to 2, and number of photo absorbed by the living tissues at unit time is equal to 1. It shows that the electromagnetic athermal effects are not relation to the irradiation power of electromagnetic wave, but only to the structure of the living tissues. In one-photon absorption, the incident photon is in the plane of the molecule vibration of the living tissues, and it can produce the athermal effects of electromagnetic.

The above theory was tested by the experiment that the "ultraweak" electromagnetic wave can produce the bio-effects remarkablely[8,9].

We transform the Eq. (18) to $2\langle n\rangle_d = d$. It indicates that there is possibility of multi-photon absorption: there is two-photon absorption in one dimension, four-photon absorption in two dimensions, six-photon absorption in three dimensions.

Bio-photon has highly coherent, photon field in the living system is in coherent state and squeezed states have been produced by the previous experiments[11,12]. The coherence is important condition of multi-photon absorption. If there is multi-photon absorption within the living system, the athermal effects of bio-electromagnetic is isotropy, otherwise, it is anisotropy.

Whether above conclusion is true or not has yet to be proved in the future. In order to prove the conclusion by the experiment, there are three works should be done at least: 1) effectively fix the plane of molecule vibration in living tissues; 2) determine the photon absorbed by the living tissues; 3) determine the bio-photon emission the living system after absorbing photon.

Because pyrimidine is plane molecule and purine is nearly plane molecule too[10,11], the plane of base in nucleotide formed by base and sugar is perpendicular to the plane of sugar's ring. Maybe we will can prove above conclusion by one-photon test system and coincidence counting system[12].

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