MULTIPHOTON PROCESS AND ANOMALOUS POTENTIAL OF CELL MEMBRANE BY LASER RADIATION

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Abstract

In this paper, by the use of quantum biology and quantum optics, the laser induced potential variation of cell membrane has been studied. Theoretically , we have found a method of calculating the monophoton and multiphoton processes in the formation of the anomalous potential of cell membrane. In contrast with the experimental results , our numerical result is in the same order. Therefore , we have found the possibility of cancer caused by the laser induced anomalous cell potential.

1 Introduction

The ions of Na^+, K^+, Ca^{++}, Cl^- and electrons exist outside and inside a cell membrane. The distributions of these ions are different between the two sides[1]. Therefore the membrane potential is related to the unsymmetrical ion distribution. The electric field caused by the ion distribution will impose a force on the charged particles passing through the membrane. The balance of ion concentration gradient, potential gradient , Na–pump and Ca–pump is the key condition of forming a normal co-transport system. Under this balance, the free radicals, DNA, RNA and ATP can normally transport[2][3]. Our study is to find the laser induced variation of cell membrane potential. The result shows that the anomalous potential variation will do harm to the normal co-transport system and may promote the occurrence of an abnormal cell or a cancer cell.

2 Multiphoton Process and Anomalous Potential of Cell Membrane

By means of quantum optics and quantum biology, it is a new approach to study the occurrence of cancer induced by the anomalous membrane potential of laser radiated cells. Smith[4] and Bloch[5] have proposed a method for calculating the density of two-photon photoelectric current which is too local to explain the multiphoton photoelectric current of biological cell membrane.

In the present paper the steps adopted for solving this problem are 1) the forced oscillation is induced by the interaction of laser radiation field–electrons in the cell; 2) due to the fact that exists the surface potential of cell membrane, the electron in forced oscillation absorbs photon and transition occurs. On the cell membrane exists a potential—$\omega_A(z > 0)$, at the same time laser radiation propagates along axis z and the vector potential of electromagnetic field is

$$A_x = a\cos(kz - \omega t) \tag{1}$$

$$A_y = A_z = 0 \tag{2}$$

Schrödinger equation may be derived

$$i\frac{\partial\phi(\mathbf{r},t)}{\partial t} = [\frac{1}{2\mu}(\mathbf{p} + \frac{e}{c}\mathbf{A})^2 - \omega_a]\phi(\mathbf{r},t) \tag{3}$$

On account of that energy distribution of electrons in a cell at the ordinary temperature is not different far from that at the absolute zero, Fermi energy ω_f is about several electron-volts and the velocity of electrons would be much smaller than that of light, we have the solution of the equation

$$\phi(\mathbf{r},t) = exp[i\mathbf{p}\cdot\mathbf{r} - i(\epsilon_p + \frac{e^2a^2}{4\mu c^2})t]exp[\frac{iB}{2\sqrt{A}}\sin u - \frac{iD}{4\sqrt{A}}\sin 2u] \tag{4}$$

where

$$\epsilon_p = (p^2/2\mu) - \omega_a \quad u = kz - \omega t$$
$$A = (p_z k/\mu - \omega)^2/4(k^2/2\mu)^2$$
$$B = (ea/\mu c)p_z/(k^2/2\mu)$$
$$D = (e^2a^2/4\mu c^2)/(k^2/2\mu)$$

The wave function illustrates that the electron in laser radiation field has a translation motion and forced oscillation. Its transition Hamiltonian under the action of the second quantization electromagnetic field is as follows:

$$H = \frac{e}{\mu c}\sum_{\mathbf{k}}\sqrt{\frac{2\pi c}{k}}[a\cdot pe^{-i\omega_{\mathbf{k}}t+i\mathbf{k}\cdot\mathbf{r}} + a^+\cdot pe^{i\omega_{\mathbf{k}}t-i\mathbf{k}\cdot\mathbf{r}}] \tag{5}$$

where a^+, a—operators for the creation and annihilation respectively, $\omega_{\mathbf{k}}$—photon frequency characterized by wave vector. Finally we obtain the density of photoelectric current for monophoton process (n=1)

$$j_1 = N(\omega)\frac{e^3\mu^2\omega c}{4}\int_{0,\sqrt{\chi-\eta}}^{\sqrt{\phi}} R(\xi)(\phi - \xi^2)d\xi \tag{6}$$

and for multiphoton process ($n = 2, 3, 4, \cdots$)

$$j_n = (\frac{n-1}{4n})(\frac{1}{2^{n-1}(n-1)!})^4(2n-3)!N(\omega)e^3\mu^2c(\frac{ea}{\omega})^{2n-2}\int_{0,\sqrt{\chi-\eta}}^{\sqrt{\phi}} R(\xi)(\phi-\xi^2)^n d\xi \tag{7}$$

where

$$R_n(\xi) = \frac{\xi^2(\chi-\xi^2)^{3/2}}{[\delta\chi(\chi-\xi^2)^{1/2}][\eta(n\eta - \chi + \xi^2/\delta - n\eta/2 + \chi - \xi^2)/2]} \tag{8}$$

$$\lambda_0 = 1\mu c, \quad \xi = \lambda_0 p_z, \quad \chi = 2\lambda_0\omega_a/c$$

$$\delta = \ell/\lambda_0, \quad \phi = 2\lambda_0\omega_f/c, \quad \eta = 2\lambda_0\omega/c$$

As for the integral limit we take zero if $(\chi - n\eta) < 0$ otherwise should take $\sqrt{\chi - \eta}$, ℓ -- the effective thickness for cell membrane, $N(\omega) = [a^2\omega\Delta\tau\Delta\sigma]/8\pi c$ —the photon number passing through area $\Delta\sigma$ within time interval $\Delta\tau$.

3 Conclusions

Using our theory of monophoton and multiphonton process , we calculate the membrane potential of an Ehrilich cell[3]. The conditions are: the power of laser is 50mw; the energy of photon is 1.48ev and the focus area is $10^{-3}cm^2$. The theoretical result of the anomalous potential is 10mv. In comparison with the normal potential of an Ehrlich cell(40mv), which is measured by a microprobe, the difference of these two potentials is obvious. This change of membrane potential may cause about 8 percent change in the Na^+ distribution. This change will seriously disorder the normal cell transport system and result in the abnormality of a cell. Above process will cause diffusions and result in the changes of material transport in the cell. This passive transport has been studied [6] and the influence of the passive transport and co-transport will be studied further.

References

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