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Model of Polariton, Quantum Neuron, Its Network & Quantum Information

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We proposed the positive hypotheses of neuo-interferences, ephapse as engineering models. The nero-interferences and synaptic ones as ephapse are propagated by polaritons which are a kind of quasi particles, i.e. quantized polarization waves. Polaritons, which has spin 1, are massive vector particles and massive photon. polaritons are connecting between many ionic current, Na+, K+, Cl- etc when neurons, fibers (axons) are conducting their excitations. The Na+ currents, into insides of membranes of axons, cause the K+ currents to outside of axons through charged or non-charged quantized polarization wave, i.e. polaritons. Various interferences, ephapse, synaptic and the other interferences are intermediated by polaritons. Those quantum interferences are commonly adjusting our neural and brain's conditions by interacting with each neurone. One of my purposes is to study effect of quantum neuro-interferences, and propose new concepts of neural network accompanied with quantum interferences. And I would like to show the application for Quantum Neural Networks, Quamtum Bayes' theory that they have quantum interferences and can considered as quantum version of Bayes theory and neural Network.

1. Introduction

Hodgkin & Huxley proposed most famous neural action mopdels, which are based on mathematical cable theory, ionic currents (Na^+, K^+), local currents and conductions of action potentials. This model can be able to explain many phenomena of neuro-electrical physiology. Arvanitaki discovered the phenomena of ephapse, which is an interference between two neural axons. When he stimulated one axon and generated action potentials, the generated signals affected on another axon despite of defection of direct connections between two axons. So, his discovery and experiments are thought that he made up a kind of artificial synapse. However, the ephapse have been thought not to be in the cases of normal healthy neuro-fibers and its phenomena existed in pathological neuro-axons, i.e., for examples, neuralgia, causalgia, and so on. So, the axon's or synaptic interferences is regarded as an evidence of wrong symptom and we have been drawing negative images. In this paper, I would like to propose the positive hypotheses of neuo-interferences, ephapse and we would like to show engineered models. (I don't intend to mention biological models). I think, nero-interferences or synaptic ones as ephapse is propagated by polaritons, which are a kind of quasi particles, i.e., quantized polarization waves. Thus, polaritons, which have spin 1, are massive vector particles and massive photon. And polaritons are connecting many ionic current, Na^+, K^+, Cl^-, when neurons and fibers (axons) are conducting their excitations. The Na^+ currents into insides of membranes of axons cause the K^+ currents to outside of axons through propagation of the charged or non-charged quantized polarization wave (polaritons) along to axons. We think that various interferences, ephapse, gap junction between neurons, and synaptic interactions are intermediated by polaritons. We thought that those quantum interferences are useful to adjust our neural and brain's conditions by interacting with each neuron. One of my purposes is to study effects of quantum neuro-interferences, and to propose new concepts of neural network having quantum interferences, and to give an expression for new ideas of computers, which sometimes make mistakes as human being doing.

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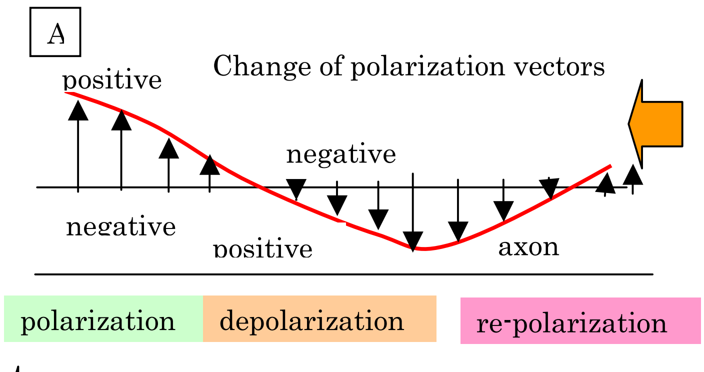
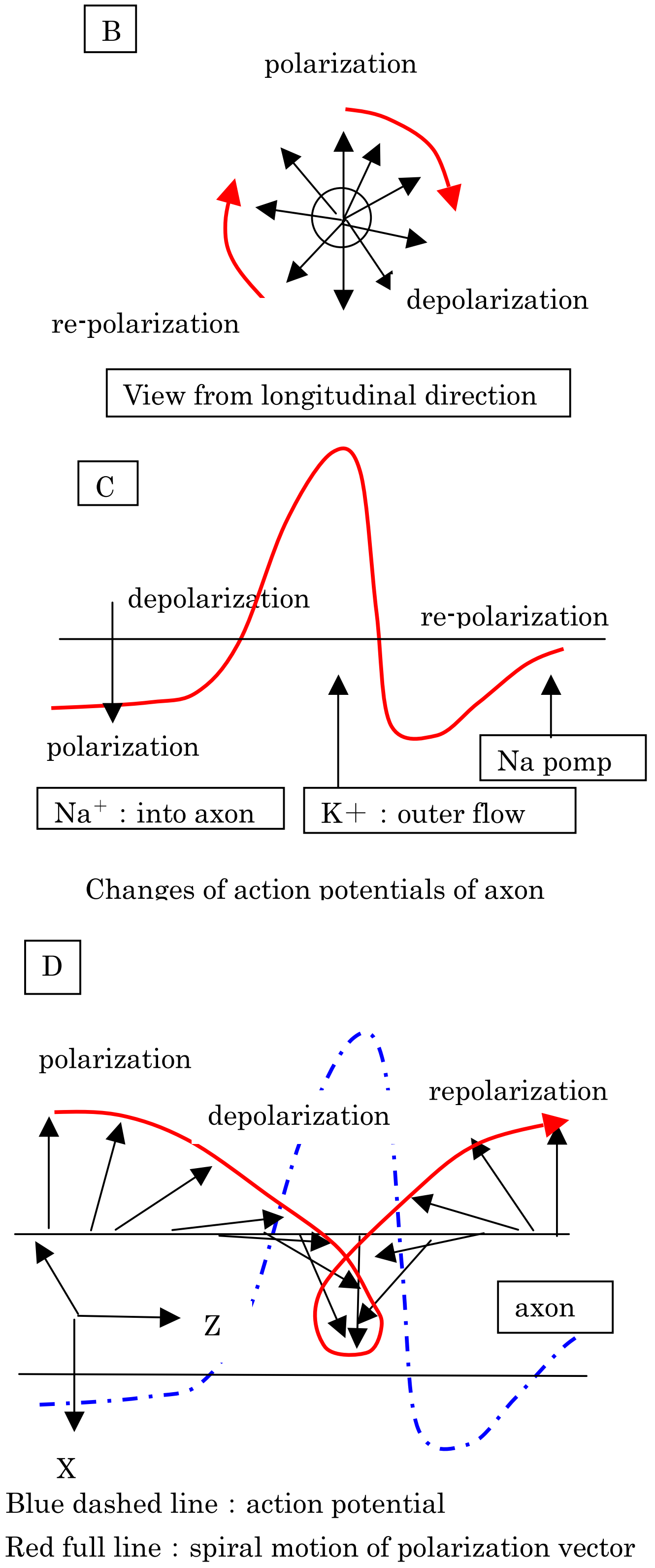
2. Model of Polariton as Quasi-Particle

Axons of neurons have a series of processes called as polarizations, depolarization and re-polarization through Na^+- and K^+ -currents penetrating axon's membranes. If we observe the changes of magnitude of polarization vectors, we notice to enable to describe the changes of action potentials on axons as the rotating polarization vectors, nevertheless its angular velocities are always changing. (Fig.1-A, -B).

(Fig.1-A,B,C & D)



[comments] If we observe from this direction of conduction of excitation (action potentials), the processes can be described as rotating vectors. Those processes, polarization, depolarization, re-polarization are quantized vectors, which are quasi particles, what is called, polariton.



(Fig.1-A,B,C,D) Theory of rotating polarization vectors

We think to regard neural conductions as the polarizations vectors and their motions (rotation of vectors and propagating vectors), and the series of processes (polarization - depolarization-repolarization, etc) are caused by mainly ionic currents (Na^{+}, K^{+}, etc.). those two ionic currents are combined with polarization waves (polaritons based on quantum mechanics).

(A) This figure-A shows the feature of "the changes of magnitude of polarization vectors". According to the conduction of action potentials along to axons, the polarization vectors rapidly change their shapes and magnitude (Fig-A).

(B) The process of conductions of action potentials is shown as rotation of polarization vectors if we thought the polarization vectors travel along to longitudinal direction of axons (Fig-B).

(C) This picture shows the change of action potentials, which are mainly constructed by those currents, sodium ion's currents, potassium ion's currents and sodium pomp (Fig-C).

Those axon's membranes are constructed by phospho lipid bilayer which has characteristics of strong dielectric materials. Those dielectric materials can efficiently conduct the polariztion's waves, or its quantized quasi-particles, polaritons. After all, quantized polarization vectors run along to longitudinal direction of axon with its rotating motions.

We can estimate physical quantities of polaritons by simple quantum methode. Considering jumping conduction of excitations and action potentials, a rage of the existence of polaritons is almost equals to the width of Ranvier ring, whose length is about 1 μ m.

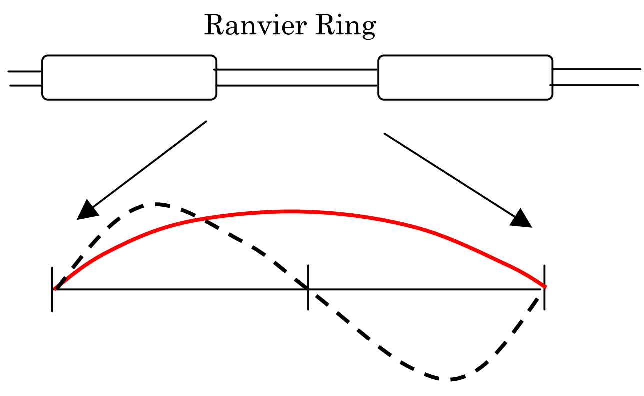


Fig .2 Polariton on Ranvier Ring

The red full line means the ground state of polariton on Ranvier ring. And the black dashed line corresponds to the first excited state of polariton. When the wave length of ground state of wave function corresponds to the width of Ranvier ring 1 μ m, the polaritons mass can easily estimated by following relation:

$$p = \frac{\hbar}{\lambda} = mv \qquad (1)$$

where we adopt the conducting velocity of myelinated axon v = 100m/s, and the wave length of wave function of ground state of polaritons, are about equal to the width of Ranvier ring 1 μ m . This calculation results in $6.7\mathbf{X}10^{-30}$kg. We know, the bare polaritons have about ten times as heavy as electron mass have at most. And the kinetic energy of free polaritons moving along to axon is estimated as

$$E_K = \frac{1}{2}mv^2 = 2.0 \text{ X } 10^{-7} \text{ (eV)} \qquad (2)$$

whose value indicates 10^{-6} times smaller than hydrogen bonds of water molecules, and that energy is ten times larger than kinetic energy of electron moving at 100m/s speeds. Polaritons work as intermediates of electromagnetic interaction being called as polarization waves, and so those bare quantized particle (or wave), which is a kind of massive photon, has the mass $6.7\mathbf{X}10^{-30}$kg and spin 1. If polaritons are exposed under circumstance whose temperature indicates about room temperature T=300K, the energy of thermal noise reaches the value

$$k_B T = 4.2 \text{ X } 10^{-21} \text{ (J)} \tag{3}$$

however, bare polariton's kinetic energy is almost 10^{-5} times smaller than thermal noise. Those conditions cause serious troubles because of preventing polaritons from normal neural conductions or carrying information. Thus, polaritons are needed to become 10^5 times heavier than its bare mass. Water molecule's mass is $3.1\mathbf{X}10^{-26}$kg. Then equivalent mass m_T means that those polaritons can sufficiently resist the thermal noise under conditions of 300K:

$$m_T \approx \frac{k_B T}{v^2} = 4.2 \text{ X } 10^{-25} \text{ (Kg)} \tag{4}$$

So, we obtain ratio of molecular weight between the equivalent mass and water molecule (mT/mw).

$$\frac{m_T}{m_W} \approx 12 \tag{5}$$

if each bare polaritons can attract about ten water molecules at least, then the bare polaritons make quasi polaritons.

Thus, quasi particle, polaritons mean

(polariton) = (bare polariton)+(dressed mass: water molecules).

Note that we can only detect that quasi polariton which are covered with some water molecules.

If we say "polaritons", commonly the polaritons mean "quasi polaritons" which are kinds of excitons. The following figure shows a polarion is traveling along an axon of neuron (Fig.3)

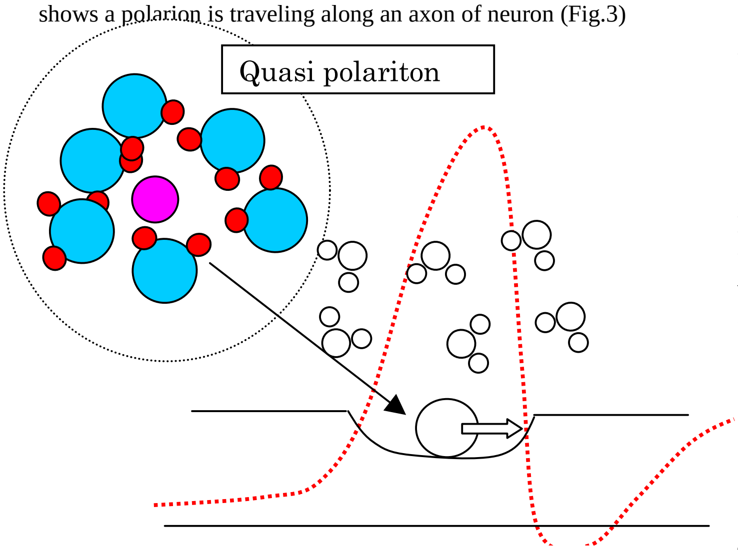


Fig.3 Image of quasi particle, polariton on axon

Polariton are equal to propagations of quantized polarization waves on axons, which are dielectric materials. Quantized polariozation waves correspond to particles, which are not ionic materials (anions or cations) and not fermions (protons or electrons), which are bosons and mediating electromagnetic interactions. Thus, we think polaritons to be massive photons, with spin 1, produced by the rotations of polarization vectors (action potentials of neurons). If the polaritons are traveling along to z-axis, those polaritons having right-handed polarized light are expressed as summation and superposition between state of x-polarized light and that of y-polarized light. This right-handed polarized photon is given as

$$\begin{aligned}\mathbf{E}(z,t) &= \\ & E_0\boldsymbol{\varepsilon}_\mathbf{x} \exp i(kz-\omega t) + E_0\boldsymbol{\varepsilon}_\mathbf{y} i(kz-\omega t+\pi/2) \\ &= E_0\boldsymbol{\varepsilon}_\mathbf{x} \exp i(kz-\omega t) + iE_0\boldsymbol{\varepsilon}_\mathbf{y} i(kz-\omega t)\end{aligned} \tag{6}$$

with ε vectors of polarized light. With\\using bra or ket vectors:

$$\begin{aligned}&|\mathbf{E}(z,t)\rangle \\ &= |\pi_x\rangle \exp i(kz-\omega t) + i|\pi_y\rangle \exp i(kz-\omega t) \\ &|\pi_x\rangle = E_0\boldsymbol{\varepsilon}_\mathbf{x}, \qquad |\pi_y\rangle = E_0\boldsymbol{\varepsilon}_\mathbf{y}\end{aligned} \tag{7}$$

We attempt to practice normalization right-handed polarized light:

$$\begin{aligned}&|\mathbf{E}(z,t)\rangle \\ &= \frac{1}{\sqrt{2}}(|\pi_x\rangle + i|\pi_y\rangle)\exp i(kz-\omega t)\end{aligned} \tag{8}$$

And we partially differentiate the Eq.(7) by variable z, the expression is

$$\frac{\partial^2 |\mathbf{E}(z,t)\rangle}{\partial z^2} = -k^2 |\mathbf{E}(z,t)\rangle \tag{9}$$

Both sides are multiplied by $-\hbar^2/2m$ and add -V｜E(z,t)> to each side.

$$\frac{\partial |\mathbf{E}(z,t)\rangle}{\partial t} = \hbar\omega |\mathbf{E}(z,t)\rangle \tag{10}$$

Finally, we have

$$i\hbar \frac{\partial |\mathbf{E}(z,t)\rangle}{\partial t} = \left[\frac{-\hbar^2}{2m} + \hat{V}(z,t)\right] |\mathbf{E}(z,t)\rangle \tag{11}$$

, which is called as the time dependent Schrodinger equation. Notice that Eq.(12) is not scalar function, but it contains vector function with polarization vectors. Practicing derivations as well as same previous procedure, we obtain a relativistic expression of polaritons named as Klein-Goldon equation.

$$\begin{aligned}&\frac{1}{(\omega^2/k^2)} \frac{\partial |\mathbf{E}(z,t)\rangle}{\partial t} \\ &= \left[\frac{\partial^2}{\partial z^2} + +m^2 \frac{\omega^2}{k^2} + \frac{\hat{V}(z,t)}{(\omega^2/k^2)}\right] |\mathbf{E}(z,t)\rangle\end{aligned} \tag{12}$$

This equation (Eq.(12)) can be used for describing relativistic spin 0 particle under a scalar potential V. The common style of those equations dose not be expressed as an electric field **E**(x,t) or a magnetic field **B**(x,t), but vector potential A_μ: A_μ is connected by following relation as shown in Eq.(13). We can obtain simpler form for the motion's equation of polaritons, if a vector potential is introduced by re-writing Maxwell equations.:

$$\mathbf{B}(x,t) = rot\mathbf{A}(x,t)$$

$$\mathbf{E}(x,t) = -grad\phi - \frac{1}{c}\frac{\partial \mathbf{A}(x,t)}{\partial t} \qquad (13)$$

$$A^{\mu} = (\phi(x,t), \mathbf{A}(x,t))$$

In Eq.(13), we replace both electromagnetic fields (**E**(x,t), **B**(x,t)) and the scalar potential-interaction into vector potential A_{μ} and source term of field j_{μ}. Then we have an explicit and desirable field equation of polaritons, what is called, Proca field equation which is thought the equation for massive vector photon with spin 1:

$$(\partial_{\mu}\partial^{\mu} + m_T)A^{\nu} = j^{\nu} \qquad (14)$$

$$j^{\nu} = j^{\nu}_{K} + j^{\nu}_{Na}$$

Note that mass m_T is renormalized mass (qusi polariton's mass), and j ν means ionic v\currents : for examples, potassium ionic currents j_K, sodium ionic currents j_{Na} accompanied with neuro conduction.

4. Definition of Quantum Neural Network

If we pay attention to quantum neural networks, these networks can be written by the same manner to classical neural networks:

$$\left|A^B_K(t)\right\rangle = \sum_j^N C_{Kj}(t)\left|A_j(t)\right\rangle \qquad (15)$$

$$= \sum_j^N C_{Kj}(t)\exp\left(\frac{-i\varepsilon_j t}{\hbar}\right)\left|A_j\right\rangle$$

The quantum outputs are given by the following relation:

$$\Phi_K = \left\langle x\right|A^B_K(t)\left.\right\rangle = \sum_j^N C_{Kj}(t)\left\langle x\right|A_j(t)\left.\right\rangle$$

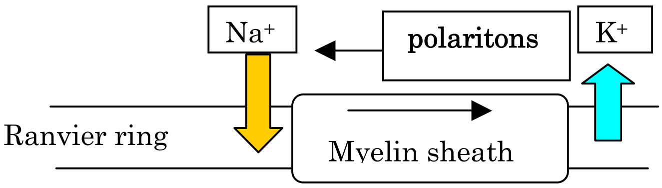
$$= \sum_j^N C_{Kj}(t)\exp\left(\frac{-i(\mathbf{px} + \varepsilon_j t)}{\hbar}\right) \qquad (16)$$

in the coordinate space. So, the classical out put Y_k can be replaced by the quantum expression Ψ_K:

$$\Psi_K = f(\Phi_K) = \frac{1}{1+\exp(-a\Phi_K)} \qquad (17)$$

5. Conclusion

We would like to proposed hypothesis of quasi particle, polariton's theory as models of quantum neural interferences and as basis of quantum conductions of action potentials. We attempt to describe polaritons as rotating polarization vectors and translation motion along to the neuro axons. Polaritons are spin1 and massive photon, whose bare mass of polaritons have only $6.7\text{x}10^{-30}$Kg, and polaritons have been hydrated and enclosed by about 10 water molecules at most. If bare polaritons become dressed polaritons, which are called as quasi particles, quasi-polaritons. So qusai polaritons whose mass are increasing up to about 10^{-25}Kg can be only observed by our experiments, and ordinary we can not find out bare polaritons. The wave length of polaritons of ground state are estimated from 0.6 μ m to 10 μ m (near 1 μ m). So polaritons carry three types of the charges (positive, negative, non-charge) as weak bosons of weak interactions (W^+, W^-, Z) do. Exactly, polaritons should be governed by Proca field (massive vecter meson with caherged), however, I showed polaritons approximately to obey Schrondinger field or complex Klein Goldon field and more exactly Proca field. Plorarions are not real particles but are virtual particles-qusai particle carrying their charges, momentum and energies. The real phenomena are various ionic currents (Na+, K+ Cl- currents etc), which are sources of neuro conductions. Movements of various ions generate the ionic currents and vibration-waves of polarization, and those quantized polarizations correspond to qusai particles, what is called, polarionts. Polaritons ordinary run along to the membranes of axons or leak to the other parts of inter cellular spaces, whose phenomena are local currents, neuro-conductions, and ephapse, and so on. Our brain's spaces are filled with various polaritons in order to adjust and to maintain our neural functions, however, we think our brain often cause many mistakes by quantum interferences between polaritons and axons.



Various ionic currents (Nq^+, K^+, etc.) are sources generating waves of polarizations, and qusai particles- polaritons, quantized polarization waves, carrying charges, momentum and energies. We propose the new model of neruro conduction, which say that the real ionic currents (Nq^+, K^+ etc.) or electrons do not flow through Myelin sheath, but virtual-quasi particles (polaritons) carry the charge, momentum, and various information. The polaritons are the quantized polarization waves with mass and spin 1, and they are expressed as massive photons. The polaritons, which propagate the change of the real ionic currents (Nq^+, K^+, etc.) mean the quasi particles mediating between Na^+ ionic currents and K^+ ionic currents when we observe the neural conductions. We think capacitive currents of neural conductions mentioned in the physiological books can be replaced by polaritons in terms of quantum theory.

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