Quantum equitation in empty space using mutual energy and self-energy Principle

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Abstract

For photon we have obtained the results that the wave of photon obeys the mutual energy principle and self-energy principle. In this article we will extended this to other quantum. The mutual energy principle and self energy principle corresponding to the Schrödinger equation is introduced. The results is that a electron for example travel in the empty space from point A to the point B there are 4 different waves. The retarded wave started from point A. The advanced wave started from point B. The return wave corresponding to the above both waves. There are 5 different flow corresponding to these wave. The self-energy flow corresponding to the retarded wave, the self-energy flow corresponding to the advanced wave. The return flow corresponding the above two flow. The mutual energy flow of the retarded wave and the advanced wave. It is found the the mutual energy flow is the energy flow or the charge flow or electric current of the the electron. The electron travel in the space is a complicated process and not only with one Schrödinger equation. This result should be possible to further widen to to Dirac equation.

Keyword:Poynting;Maxwell;photon;retarded wave;advanced wave;time-reversal;absorber;emitter;action-at-a-distance;Schrödinger

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I. INTRODUCTION

Maxwell equations have retarded solution and advanced solution. Wheeler and Feynman has introduced the absorber theory which involved the advanced wave [1][2]. The absorber theory is based on the action-at-a-distance [5, 16, 18]. In classical electromagnetic field theory the advanced wave is applied on mutual energy theorem, which is contribution of W.J. Welch [19], S.R. Zhao [6, 20, 21]. J. Cramer further worked on the absorber theory and introduced the transactional interpretation for quantum mechanics[3, 4].

This author combined the absorber theory and mutual energy theorem introduced the concept that the photon energy is transferred by the mutual energy flow[9–15, 17]. And the further derived that mutual energy principle[7] and self-energy principle[8]. The mutual energy principle says that the the electromagnetic field and the field of photon all should satisfy mutual energy principle. The solution of the mutual energy principle is retarded wave and an advanced wave. Both wave satisfies Maxwell equations. Both wave must synchronized.

The self-energy principle tells that the self-energy are returned. Hence the self-energy flow do not contributed to any energy transfer.

This article will apply the mutual energy principle and self-energy principle to other quantum for example electron. First we do not consider the spin in electron, hence assume the electron satisfy Schrödinger equation.

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II. SCHRÖDINGER EQUATION FOR RETARDED AND ADVANCED WAVE

We assume the quantum for example electron runs in the empty space from point A to B. This electron must satisfy in the the Schrödinger equation

A. Retarded equation for point A

We have know that the wave $\Psi_a(\mathbf{r},t)$ is retarded wave started from point A which satisfies,

$$i\hbar\frac{\partial}{\partial t}\Psi_a(\mathbf{r},t)=\hat{H}\Psi_a(\mathbf{r},t) \tag{1}$$

or

$$i\hbar\frac{\partial}{\partial t}\Psi_a(\mathbf{r},t)=\left[\frac{-\hbar^2}{2\mu}\nabla^2+V(\mathbf{r},t)\right]\Psi_a(\mathbf{r},t) \tag{2}$$

$\Psi_a(\mathbf{r},t)$ is retarded wave starting from point A. In empty space there is,

$$V(\mathbf{r},t)=0 \tag{3}$$

B. Advanced equation for the Point B

Advanced wave is obtained by a time reversal transform $\mathbf{R}$ which is defined by

$$\mathbf{R}\Psi(\mathbf{r},\mathrm{t})=\Psi(\mathbf{r},-\mathrm{t}) \tag{4}$$

Assume the Schrödinger equation is,

$$i\hbar\frac{\partial}{\partial t}\Psi(\mathbf{r},t)=\left[\frac{-\hbar^2}{2\mu}\nabla^2+V(\mathbf{r},t)\right]\Psi(\mathbf{r},t) \tag{5}$$

The corresponding retarded wave are,

$$i\hbar\frac{\partial}{\partial t}\Psi(\mathbf{r},-t)=\left[\frac{-\hbar^2}{2\mu}\nabla^2+V(\mathbf{r},-t)\right]\Psi(\mathbf{r},-t) \tag{6}$$

or

$$-i\hbar\frac{\partial}{\partial(-t)}\Psi(\mathbf{r},-t)=\left[\frac{-\hbar^2}{2\mu}\nabla^2+V(\mathbf{r},-t)\right]\Psi(\mathbf{r},-t) \tag{7}$$

Let $-t=\tau$

$$-i\hbar\frac{\partial}{\partial(\tau)}\Psi(\mathbf{r},\tau)=\left[\frac{-\hbar^2}{2\mu}\nabla^2+V(\mathbf{r},\tau)\right]\Psi(\mathbf{r},\tau) \tag{8}$$

This is the equation of the advanced wave. Assume in the Point B there are advanced wave which satisfy time reversal Schrödinger equation:

$$-i\hbar\frac{\partial}{\partial t}\Psi_b(\mathbf{r},t)=\hat{H}\Psi_b(\mathbf{r},t) \tag{9}$$

or

$$-i\hbar\frac{\partial}{\partial t}\Psi_b(\mathbf{r},t)=\left[\frac{-\hbar^2}{2\mu}\nabla^2+V(\mathbf{r},t)\right]\Psi_b(\mathbf{r},t) \tag{10}$$

We have write τ as t. $\Psi_b(\mathbf{r},t)$ corresponding a advanced wave starting from B. In empty space there is,

$$V(\mathbf{r},t)=0 \tag{11}$$

III. MUTUAL ENERGY FLOW

A. The mutual energy flow from A to B

$$(i\hbar\frac{\partial}{\partial t}\Psi_a)\Psi_b=\left[\frac{-\hbar^2}{2\mu}\nabla^2\right]\Psi_a\Psi_b \tag{12}$$

$$-i\hbar\Psi_a\frac{\partial}{\partial t}\Psi_b=\Psi_a\left[\frac{-\hbar^2}{2\mu}\nabla^2\right]\Psi_b \tag{13}$$

Subtract the above two formula we obtain

$$(i\hbar\frac{\partial}{\partial t}\Psi_a)\Psi_b+i\hbar\Psi_a\frac{\partial}{\partial t}\Psi_b$$

$$=\frac{-\hbar^2}{2\mu}(\nabla^2\Psi_a\Psi_b-\Psi_a\nabla^2\Psi_b) \tag{14}$$

or

$$\frac{\partial}{\partial t}(\Psi_a\Psi_b)=-\frac{\hbar}{2\mu i}\nabla\cdot(\nabla\Psi_a\Psi_b-\Psi_a\nabla\Psi_b) \tag{15}$$

or

$$\frac{\partial}{\partial t}(\rho_{ab})=-\nabla\cdot J_{ab} \tag{16}$$

where

$$J_{ab}=\frac{\hbar}{2\mu i}(\nabla\Psi_a\Psi_b-\Psi_a\nabla\Psi_b) \tag{17}$$

The above formula are mutual energy flow principle. J_{ab} are mutual energy flow. This flow is not a divergence flow. It is a converged flow.

$$\frac{d}{dt}\iiint\limits_V\rho_{ab}dV=-\oiint\limits_\Gamma\cdot J_{ab}\hat{n}d\Gamma \tag{18}$$

Assume Γ is big sphere, the radius of the big sphere is infinity. Since the retarded wave come to the big sphere in the future, the advanced wave come to the big sphere in the past.

The retarded wave and the advanced wave are not nonzero in the same time in the big sphere, hence the J_{ab} has no any flux go out the big sphere.

$$\oiint_{\Gamma} \cdot J_{ab}\hat{n}d\Gamma dt = 0 \tag{19}$$

This mutual energy flow do not go outside. Inside the volume V their is only the two sources A and B hence the flow can only started from A to B. The flow is very thin in the two end point A and B. The flow are very thick in the middle. The flow will has the same flux integral with time in any surface between the two point A and B. If the particle is a electron, this flow is the current. This flow is the electron itself.

IV. SELF ENERGY FLOW

A. Self-energy flow

We also know that for the retarded wave started from point A there is,

$$\frac{\partial}{\partial t}(\rho_a) = -\nabla \cdot J_a \tag{20}$$

For the advanced wave started from point B there is

$$\frac{\partial}{\partial t}(\rho_b) = -\nabla \cdot J_b \tag{21}$$

where

$$J_a = \frac{\hbar}{2\mu i}(\nabla\Psi_a\Psi_a^* - \Psi_a\nabla\Psi_a^*) \tag{22}$$

$$J_b = [\frac{\hbar}{2\mu i}(\nabla\Psi_b\Psi_b^* - \Psi_b\nabla\Psi_b^*)] \tag{23}$$

J_a is the so called probability current of retarded wave Ψ_a which is a current send energy from point A to infinite big sphere.

J_b is the so called probability current of retarded wave Ψ_b which is a current send energy from point B to infinite big sphere. Since this is advanced wave the energy current is at reversal direction. The energy flux is from infinite big sphere to the point B.

B. The self-energy flow

We know that

$$\int_{t=\infty}^{\infty} \oiint_{\Gamma} \cdot J_a \hat{n} d\Gamma dt = Const \tag{24}$$

The wave started from point A is retarded wave and hence this part of energy is at a future time reach the the big sphere.

$$\int_{t=\infty}^{\infty} \oiint_{\Gamma} \cdot J_b \hat{n} d\Gamma dt = -Const \tag{25}$$

The "$-$" is because this is a advanced wave. is a positive constant. The wave started from point B is advanced wave, this is part of energy will at past time reach the big sphere. Unless our universe at the infinite big sphere is connected from future to the past, the energy send form point A can be received by the point B. Otherwise the retarded flow J_a from A will lose some energy in a future time at infinite big sphere. The advanced flow J_b started from B will receive some energy in the past time at the infinite big sphere . All these are not possible. This violate the energy conservation law.

V. RETURN WAVE

A. Return wave

Hence we assume there are return wave for J_a and J_b. The return wave for J_a is a wave from infinite big sphere at future to the point A. The return wave for J_b is a wave from infinite big sphere at past to the point B.

Hence for a quantum travel from A to B there 4 different waves, and 5 flows:

(1) retarded wave started from point A

(2) advanced wave started from point B.

(3) return wave for (1)

(4) return wave for (2)

The return wave for (1) satisfy

$$-i\hbar \frac{\partial}{\partial t} \Psi_{ar}(\mathbf{r}, t) = \hat{H} \Psi_{ar}(\mathbf{r}, t) \tag{26}$$

It has the same equation with advanced wave, but it is not a advanced wave. The advanced wave is send from current to the past. The returned wave is from future to the current.

The return wave for (2) satisfy

$$i\hbar\frac{\partial}{\partial t}\Psi_{br}(\mathbf{r},t)=\hat{H}\Psi_{br}(\mathbf{r},t) \tag{27}$$

It has the same equation with the retarded wave, but it is not a retarded wave. The retarded wave from current to the future.

$$J_{ar}=\frac{\hbar}{2\mu i}(\nabla\Psi_{ar}\Psi_{ar}^{*}-\Psi_{ar}\nabla\Psi_{ar}^{*}) \tag{28}$$

$$J_{br}=[\frac{\hbar}{2\mu i}(\nabla\Psi_{br}\Psi_{br}^{*}-\Psi_{br}\nabla\Psi_{br}^{*})] \tag{29}$$

We have

$$J_a+J_{ar}=0 \tag{30}$$

$$J_b+J_{br}=0 \tag{31}$$

We assume that the wave Ψ_{br} and Ψ_{ar} can not interfere. If it can interfere the mutual energy flow J_{ab} will be canceled also and that is not we hope.

VI. SUMMARY

For a quantum for example an electron, it travel from point A to point B in the empty space, there are 4 different waves instead one Schrödinger wave. The 4 wave are retarded wave started from A. The advanced wave started from B, the return wave for the retarded wave, the return wave for the advanced wave. Between point A and point B there is flow J_{ab} which is transfer the energy or amount of charge. This flow is from point to point and do not diverge. This flow is very thin in the two ends and hence in it looks like a particle. The flow is very thick in the middle between point A and B, and hence it looks a wave. In the middle if there are double slits. This flow will go through the two slits in the same time. This explained the duality of the quantum or particle.

The self-flow for J_a and J_b do not transfer and energy or amount of charge. We can think they are canceled by the return current J_{ar} and J_{br}.

A the above flow J_{ab}, J_a, J_b, J_{ar},J_{br} are physics flow and are not probability flows. The probability come from the source of the retarded wave at point A and the source of the advanced wave at point B, they are randomly send the retarded wave and advanced wave. Only when the two wave the retarded wave started from A and the advanced wave started at point B synchronized concurrently, the mutual energy flow J_{ab} is produced.

If the retarded wave flow J_a cannot meet a advanced wave which is synchronized to the retarded wave J_a. This retarded wave flow J_a just returned through the corresponding return wave J_{ar}. If it meet the advanced wave which is synchronized with the retarded wave, the mutual energy flow J_{ab} is produced. After the J_{ab} , there is the return flow J_a. Hence no matter the mutual energy flow is produced or not the self-energy flow J_a always returned through J_{ar}. For the advanced wave, the similar things also happens.

VII. CONCLUSION

We have introduced mutual energy principle and self-energy principle for photon and electromagnetic fields. In this article we applied the concept of the mutual energy flow and self-energy flow to other charges for example electron. We use Schrödinger equation to study this problems. But we believe this idea are also correct for the Dirac equation.

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