The photon model and equations are derived through time-domain mutual energy current

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Abstract

In this article the authors will build the model of photon in time-domain. Since photon is a very short time wave, the authors need to build it in the time domain. In this photon model, there is an emitter and an absorber. The emitter sends the retarded wave. The absorber sends advanced wave. Between the emitter and the absorber the mutual energy current is built through the combination of the retarded wave and the advanced wave. The mutual energy current can transfer the photon energy from the emitter to the absorber and hence the photon is nothing else but the mutual energy current. This energy transfer is built in 3D space, this allow the wave to go through any 3D structure for example the double slits. The authors have proved that in the empty space, the wave can be seen approximately as 1D wave and can transfer energy from one pointer to to another point without any wave function collapses. That is why the light can be seen as light line. That is why a photon can go through double slits to have the interference. The duality of photon can be explained using this photon model. The total energy transfer can be divided as self-energy transfer and the mutual energy transfer. It is possible the self-energy current transfer half the total energy and it also possible that the part of self-energy part has no contribution to the energy transferring of the photon. In the latter, the self-energy items is canceled by the advanced wave of the emitter current and the retarded wave of the absorber current or canceled by the returned waves. This return wave is still satisfy Maxwell equations or at least some time-reversed Maxwell equations. Furthermore, the authors found the photon should satisfy the Maxwell equations in microcosm. Energy can be transferred only by the mutual energy current. In this solution, the two items in the mutual energy current can just interpret the line or circle polarization or spin of the photon. The traditional concept of wave function collapse in quantum mechanics is not needed in the authors' photon model. The authors believe the concept of the traditional wave collapse is coursed by the misunderstanding about the energy current. Traditionally, there is only the

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energy current based on Poynting vector which is always diverges from the source. For a diverged wave, hence, there is the requirement for the energy to collapse to its absorber. After knowing that the electromagnetic energy is actually transferred by the mutual energy current, which is a wave diverging in the beginning and converging in the end, then the wave function collapse is not needed. The concept energy is transferred by the mutual energy current can be extended from photon to any other particles for example electron. Electrons should have the similar mutual energy current to carry their energy from one place to another and do not need the wave function to collapse.

1 Introduction

The Maxwell equations have two solutions one is retarded wave, another is advanced wave. Traditional electromagnetic theory thinks there exists only retarded waves. The absorber theory of Wheeler and Feynman in 1945 offers a photon model which contains an emitter and an absorber. Both the emitter and the absorber sends half retarded and half advanced wave [1, 2, 8]. J. Welch brought the theory of the advanced wave or potential to electromagnetic theory and introduced time reciprocity theorem [17]. J. Cramer built the transactional interpretation for quantum mechanics by applied the absorber theory [4, 5] in around 1980. In 1978 Wheeler introduced the delayed choice experiment, which strongly implies the existence of the advanced wave [7, 18]. The delayed choice experiment is further developed to the delayed choice quantum eraser experiment[6], and quantum entanglement ghost image and the ghost image clearly offers the advanced wave picture[3]. The first author of this article has introduced the mutual energy theory in 1987 [9, 20, 19]. Later he noticed that in the mutual energy theorem, the receive antenna sends advanced wave [10] and began to apply it to the study of the photon and the other quantum particles[14, 15, 13]. The above studies are all in Fourier domain which is more suitable to the case of the continual waves. The authors know the photon is the very short time wave, hence decided to study it in the time-domain instead of in the Fourier domain. The goal of this article is to build a model for the photon with classical electromagnetic theory and find the equations for the photon. Some one perhaps will argue that photon is electromagnetic field it should satisfy Maxwell equations, or photo is a particle it should satisfy Schrodinger equations, why now find some other equations? First the authors are looking the vector equations which photon should satisfy. These equations cannot be Schrodinger equation. Second the infinite more photons become light or electromagnetic field radiation which should satisfy Maxwell equations, hence Maxwell equations are a macrocosm field. But in microcosm, only singular photon, it is not clear whether the Maxwell equations still works. Hence for the singular photon, perhaps it satisfies Maxwell equation or perhaps it does not. The authors try to find these equations for photon to satisfy, from which, if Maxwell equations should be possible to be derived as a limit in Macrocosm.

2 The photon model of Wheeler and Feynman

In the photon model of Wheeler and Feynman, there is the emitter and absorber which sends all a half retarded wave and a half advanced wave. The wave is 1-D wave which is a plane wave send along x direction. This wave like a wave transfers in a cylinder wave guide. For both emitter and the absorber, the retarded wave is sent to the positive direction along the x. The advanced wave is sent to the negative direction along x. Color red is drawn to express the retarded waves. Color blue is drown to express the advanced wave, please see the Figure 2. For the retarded wave the arrow is drawn into the same direction of the wave. For the advanced wave the arrow in the opposite direction of the wave (since the energy transfers in the opposite direction for the advanced wave). Hence the arrow is always drawn in the energy transferring direction. For the absorber, Wheeler and Feynman assume the retarded wave sent by absorber is just negative (or having a 180 degree of phase difference) compare to the retarded wave sent from the emitter. The advanced wave sent from the emitter is just negative (or 180 degree of phase difference) of the advanced wave sent by the absorber. It is seems Wheeler and Feynman assumed that all the retarded waves and the advanced waves can only be sent in one direction, ether left or wright but both.

See Figure 1. Hence, In the regions I and III, all the waves are canceled. In the region II the retarded wave from emitter and the advanced wave from absorber reinforced.

All this model looks ok and it is very success in cosmography, but it is difficult to be believe. First why the retarded wave is sent by the emitter to the positive direction and the advanced wave is sent to the negative direction? The wave should sends to all directions, in 1-dimension situation, it should send to the positive direction and send to the negative direction. Why the absorber sends retarded wave just with a minus sign so it can cancel the retarded wave of the emitter? It is same to the Emitter, why it can send an advanced wave with minus sign so it just can cancel the advanced wave of the absorber? 1-D model is too simple. The wave is actually send to all direction instead of a 1-D plane wave, hence we need to check whether this model can be applied to 3D situations. What happens if this model for 3D? Lack of a 3D model for photon, it is perhaps the real reasons that Wheeler and Feynman theory and all the following theories, for example the transactional interpretation of J. Cramer, cannot be accept as a mainstream of the photon model for interpretation of the quantum mechanics. The authors endorse the absorber theory of Wheeler and Feynman. In this article we will introduce a 3D time-domain electromagnetic theory which suits to the advanced wave and retarded wave to replace the 1-D photon model of Wheeler and Feynman. In this new theory the mutual energy current[9, 20, 19, 14, 15, 13] will play an important role.

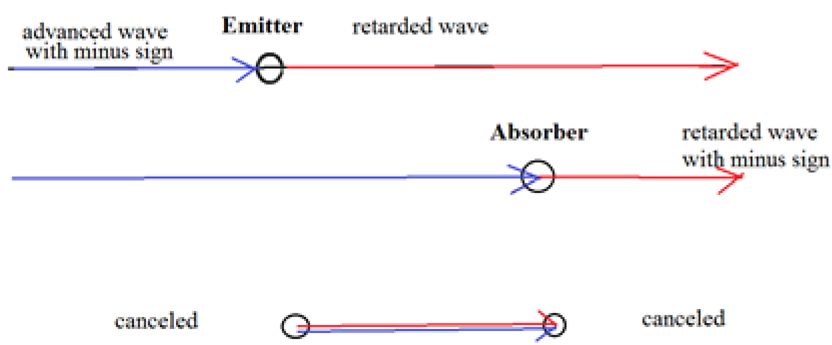

Figure 1: The Wheeler and Feynman model. The emitter sends retarded wave to right shown as red arrow. The emitter sends advanced wave to the left shown as blue. It is drawn the arrow in the opposite direction to the advanced wave. The absorber sends advanced wave to the left shown as blue and sends retarded wave to the right shown as red. However, the retarded wave of the absorber is just the negative value of the retarded wave (or it has 180 degree phase difference) of the emitter. The advanced wave sent by the emitter is also with negative value (or has 180 degree phase difference) of that of the absorber. Hence in the region I and III all the waves are canceled and in the region II, the waves are reinforced..

3 The photon model of the authors

The authors believe that in the traditional electromagnetic field theory there is a mistakes to the understanding of the Poynting theorem and Lorentz reciprocity theorem. The energy current calculated by Poynting vector perhaps does not carry any energy in microcosm world like photons. Second the Lorentz reciprocity theorem actually is not a physic theorem but only mathematical transform of the mutual energy theorem, which is a real physic theorem in microcosm.

The authors believe that the energy transfer for a singular photon from the emitter to the absorber can only be described with the mutual energy theorem. In microcosm, it is possible that the self-energy doesn't has any contribution to the energy transfer of a singular photon. Poynting theorem offers the theory about the self-energy hence the Poynting theorem is not important in microcosm. In this article it will be shown that in the macrocosm, the Poynting theorem can be derived from the mutual energy theorem which describes the energy transfer of a singular photon. In Fourier domain the mutual energy theorem and the Lorentz theorem can be derived from each others by applying a magnetic mirror transform. Hence there is the question that both the mutual energy theorem and the Lorentz theorem which is the original physic theorem, which is just a mathematical transform of a physic theorem? The author believe in empty space, the the mutual energy theorem is the original physic theorem. The Lorentz theorem is only a mathematical transform of the mutual energy theorem. In antenna calculation, it is never needed the concept of wave function collapse. The Lorentz theorem has been used to calculate the antenna problem which actually is because the Lorentz theorem contains the results of the mutual energy theorem. Since the photon can be seen as a system with an emitter and an absorber and can be further seen as a system with transmit antenna and a receive antenna. It is possible to apply the mutual energy theorem to the singular photon system.

The first author of this article has introduced the mutual energy theorem in 1987[9], found that the mutual energy current is just a inner product of two electric fields and pointed out that the mutual energy theorem is not just a transform of reciprocity theorem. The mutual energy theorem is established in lossless media, but the reciprocity theorem is established in symmetric media. The first author of this article has applied the mutual energy theorem to spherical waves and plane waves [9, 20, 19]. The authors have proved that the mutual energy theorem can be derived from Poynting theorem and hence it is an energy theorem[10] and hence the concepts: self-energy, mutual energy, mutual energy current are all suitable. In that article it is also proved that the reciprocity can be derived from the mutual energy theorem. The authors also proved that in the lossy media, the mutual energy theorem is suitable but the the Lorentz theorem isn't[11]. Afterwords the authors begin to apply the mutual energy theorem to the photon model and quantum physics[12, 16, 15, 14]. However all the discussions are restricted to the field in Fourier domain and the discussions only restricted to the mutual energy current but not the self-energy current. In photon model the self-energy current is also very important. Is the self-energy current transfer energy? If it doesn't transfer energy, is it collapsed or canceled by some other? Or it just sends to the infinity? In this article the authors will continue to prove that photon is nothing else but just the mutual energy current. The authors will show that the mutual energy current is never collapse and it is can be seen as 1D plane wave in a wave guide which has sharped tips at the two ends and which is very thick in the middle. The authors will prove this photon model theory based on the classical electromagnetic theorem with Maxwell equations. The authors will show that the Poynting theorem (and hence the self-energy current) in macrocosm is only a combination of many small mutual energy currents in microcosm.

3.1 The photon model

The authors would like to find the photon model from the solution of Maxwell equations. The photon should satisfies the following conditions.

(I) The electromagnetic field of the photon model should satisfies Maxwell equations.

(II) The electromagnetic fields of the photon model should not be diverged. If the field is diverged like the water waves, it need a concept of wave function collapse. We do not support the concept of wave function collapse, hence we seeks the electromagnetic solution which support converged wave that is the wave is allowed to be spread out in the beginning but it has to be converged in the end, so the absorber in one point can receive it without any wave function collapse. This wave somehow like the solitary particle.

(III) The light sources or emitter should be possible to be put inside a metal container with a hole. The photon should be possible to send out from this hole.

(IV) The photon should be possible to go through not only a hole but double slits.

(V) The macrocosm field of point emitter should be the total contribution of the field of many photons, which should satisfies the Poynting theorem and hence produce a diverged field. In (II) we have said that the field of microcosm can not be diverged, but the macrocosm field of a emitter must be diverged like the water waves.

(VI) The field of photon model has to support the polarization that means it must has two items and for the two items, the electric fields are perpendicular, and for two items it should be possible to allow a phase difference -90 to 90 degrees.

(VII) The current of the emitter and the absorber must very simple, which have only one directions. Here it is not allowed the too complicated sources, for example like a antenna arrays. The current of the emitter and the absorber should be just have only one direction.

(VIII) The force act on the photon must be consistent with energy conservation, momentum conservation. This condition is a little completed, it will not include in this article, but will be discussed in the future.

For photon model, the electric magnetic fields solution that satisfies the above conditions is looked by the authors. Next section the Poynting theorem is revised.

4 Poynting theorem

For a photon, all the energy has been received by one absorber. It is not known whether or not a photon can fully satisfy the Maxwell equations. From the Maxwell equations it is known that the solution is the wave which should be sent to all directions, but it is clear that the photon is a energy package that send the energy from a pointer to another pointer. How to put the photon to the solutions of the Maxwell equations?

However, the author believe the equations of photon should be the Maxwell equations or at least very close to the Maxwell equation, and further even in the microcosm the Maxwell equations can be deviated, but for the total fields or the field of infinite photons, which is the field in macrocosm should still satisfy the Maxwell equations. Hence the field in macrocosm should still satisfies the Poynting theorem.

The Poynting theorem is following,

$$-\oiint_{\Gamma}(\overrightarrow{E}\times\overrightarrow{H})\cdot\hat{n}d\Gamma=\iiint_{V}(\overrightarrow{J}\cdot\overrightarrow{E}+\partial u)\,dV \tag{1}$$

where $\overrightarrow{E}$ is the electric field; $\overrightarrow{H}$ is the magnetic H-field; $\overrightarrow{J}$ is the current intensity; Γ is the boundary surface of volume V; u is the energy intensity saved on the volume V; $\hat{n}$ is unit norm vector of the surface Γ; ∂u is defined as

$$\partial u\equiv\frac{\partial u}{\partial t}=\overrightarrow{E}\cdot\frac{\partial\overrightarrow{D}}{\partial t}+\overrightarrow{H}\cdot\frac{\partial\overrightarrow{B}}{\partial t} \tag{2}$$

where $\overrightarrow{D}=\epsilon\overrightarrow{E}$ is the electric displacement; $\overrightarrow{B}=\mu B$ is magnetic B-field; ϵ,μ are permittivity and permeability, which can be a scale value or a tensor; ∂u is the increase of the energy intensity. The above equation is the Poynting theorem, which tells that the energy current comes through the surface to the inside the region $-\oiint_{\Gamma}(\overrightarrow{E}\times\overrightarrow{H})\boldsymbol{.}\hat{n}d\Gamma$ is equal to the energy loss $\iiint_{V}(\overrightarrow{J}\boldsymbol{.}\overrightarrow{E})dV$ in the volume V and the increase of the energy inside the volume $\iiint(\partial u)dV$. In this article energy current is equivalent to energy flux. Energy current sounds more real and energy flux sounds more virtual, the authors think the energy is real and hence the energy current is chosen instead of energy flux. But actually energy current is just the energy flux.

It is known that form Poynting theorem all the reciprocity theorems can be derived[10]. It is also known that the Green function solution of the Maxwell equations can be derived from the reciprocity theorems. Hence, If all the solutions of the Maxwell equations can be derived, from principle, it should be possible do obtained Maxwell equations by induction. Hence even the Maxwell equation can not be derived from the Poynting theorem, but it is still can be said that the Poynting theorem contains nearly all the information of the Maxwell equations. Hence, if some field satisfies Poynting theorem, it will be said that this field almost satisfies the Maxwell equations. This point of view will be applied in the following sections of this article.

5 3D photon model in the time-domain with the mutual energy current

Assume the electron in a atom can create some current which randomly sends half retarded wave and half advanced wave. Assume there are two this kind electrons 1 and 2, the energy lever of 1 is higher than 2. Assume that these two electrons send the wave just be synchronized which means that when the retarded wave of 1 reaches the 2, the 2 just sends the advanced wave, hence the advanced wave will reaches 1 at the the time the 1 sent the retarded wave. In this case 1 will be referred as emitter and 2 will be referred as absorber. The energy sent from 1 to 2 is the photon. All the retarded wave and advanced wave which are not synchronized can be all omitted because they have know contribution to the energy transfer from emitter to absorber.

Assume the i-th photon is sent by an emitter 1 and received by an absorber 2. The current in the emitter can be written as $\overrightarrow{J}_{1i}$, the current in the absorber can be written as $\overrightarrow{J}_{2i}$. In the absorber theory of Wheeler and Feynman, the current is associated half retarded wave and half advanced wave. It is not taken here their choice in this moment, in the later of this article it will be discussed about this assumption. In this moment a very similar proposal is taken for the consideration. It is assumed that the emitter $\overrightarrow{J}_{1i}$ is associated only to a retarded wave and the absorber $\overrightarrow{J}_{2i}$ is associated only to an advanced wave. The photon should be the energy current sends from emitter to the absorber. For this proposal, it can be seen in Figure 1. It should be notice that in the following article there are two kinds of fields, one it the photon's field which will have the subscript i, and this is the microcosm field for example $\overrightarrow{J}_{1i}$, $\overrightarrow{E}_{1i}$, $\overrightarrow{H}_{1i}$. Another is the field without the subscript i, which is the macrocosm field, for example $\overrightarrow{J}_1$, $\overrightarrow{E}_1$.

Assume the advanced wave is existent same as retarded wave. Assume the current can be produced advanced wave and also retarded wave. In this case it is always possible to divide the current as two parts, one part created the advanced field and the other part created the retarded wave. Assume $\overrightarrow{J}_{1i}$ produces retarded wave $\xi_{1i} = [\overrightarrow{E}_{1i}, \overrightarrow{H}_{1i}]$. $\overrightarrow{J}_{2i}$ produces advanced wave $\xi_{2i} = [\overrightarrow{E}_{2i}, \overrightarrow{H}_{2i}]$.

Assume the total field is a superimposed field $\xi_i = \xi_{1i} + \xi_{2i}$. Substitute $\xi_i = \xi_{1i} + \xi_{2i}$ and $\overrightarrow{J}_i = \overrightarrow{J}_{1i} + \overrightarrow{J}_{2i}$ to Eq.(1). From Eq.(1) subtract the following self-energy items in the following,

$$-\oiint_{\Gamma}(\overrightarrow{E}_{1i}\times\overrightarrow{H}_{1i})\cdot\hat{n}d\Gamma=\iiint_{V}(\overrightarrow{J}_{1i}\cdot\overrightarrow{E}_{1i}+\partial u_{1i})\,dV \tag{3}$$

$$-\oiint_{\Gamma}(\overrightarrow{E}_{2i}\times\overrightarrow{H}_{1i})\cdot\hat{n}d\Gamma=\iiint_{V}(\overrightarrow{J}_{1i}\cdot\overrightarrow{E}_{1i}+\partial u_{1i})\,dV \tag{4}$$

which becomes

$$-\oiint_{\Gamma}(\overrightarrow{E}_{1i}\times\overrightarrow{H}_{2i}+\overrightarrow{E}_{2i}\times\overrightarrow{H}_{1i})\cdot\hat{n}d\Gamma=\iiint_{V}(\overrightarrow{J}_{1i}\cdot\overrightarrow{E}_{2i}+\overrightarrow{J}_{2i}\cdot\overrightarrow{E}_{1i})\,dV$$
$$+\iiint_{V}(\overrightarrow{E}_{1i}\cdot\partial\overrightarrow{D}_{2i}+\overrightarrow{E}_{2i}\cdot\partial\overrightarrow{D}_{1i}+\overrightarrow{H}_{2i}\partial\overrightarrow{B}_{1i}+\overrightarrow{H}_{2i}\overrightarrow{B}_{1i})\,dV \tag{5}$$

$\iiint_V(\overrightarrow{E}_{1i}\cdot\partial\overrightarrow{D}_{2i}+\overrightarrow{E}_{2i}\cdot\partial\overrightarrow{D}_{1i}+\overrightarrow{H}_{2i}\partial\overrightarrow{B}_{1i}+\overrightarrow{H}_{2i}\partial\overrightarrow{B}_{1i})dV$ is the increased mutual energy inside the volume V. Assume the photon is sent from $T=0$ and reached the absorber at $t=T$. Assume the photon is a short impulse with the time of Δt. Out side of the time window from the time $t=0$ to the end $t=T+\Delta t$, this mutual energy should be vanishes. This part of the energy can be shown as the energy move from emitter to the absorber and in a particular time the energy is stayed at a place between the emitter and the absorber. Hence there is,

$$\int_{-\infty}^{\infty}\iiint_{V}(\overrightarrow{E}_{1i}\cdot\partial\overrightarrow{D}_{2i}+\overrightarrow{E}_{2i}\cdot\partial\overrightarrow{D}_{1i}+\overrightarrow{H}_{2i}\partial\overrightarrow{B}_{1i}+\overrightarrow{H}_{2i}\partial\overrightarrow{B}_{11})\,dV\,dt=0 \tag{6}$$

and hence there is

$$-\int_{-\infty}^{\infty}\oiint_{\Gamma}(\overrightarrow{E}_{1i}\times\overrightarrow{H}_{2i}+\overrightarrow{E}_{2i}\times\overrightarrow{H}_{1i})\cdot\hat{n}d\Gamma\,dt=\int_{-\infty}^{\infty}\iiint_{V}(\overrightarrow{J}_{1i}\cdot\overrightarrow{E}_{2i}+\overrightarrow{J}_{2i}\cdot\overrightarrow{E}_{1i})\,dV\,dt \tag{7}$$

If we call Eq.(3 and 4) as self-energy items of Poynting theorem, the Poynting theorem Eq.(1) with $\xi=\xi_{1i}+\xi_{2i}$ are total field of the Poynting theorem. Then the above formula Eq.(7) can be seen as mutual energy items of Poynting theorem. It also can be referred as mutual energy theorem because it is so important which will be seen in the following sections.

Eq.(7) can be seen as the time domain mutual energy theorem. The self-energy part of Poynting theorem Eq.(3, 4) perhaps is no sense. This is because that the self-energy current in the left side of Eq.(3, 4) cannot be received by any other substance. It can hit some atoms, but the atom has a very small section area and this self-energy current is diverged, so the self-energy received by the atom is so small and hence cannot produce a particle like a photon even

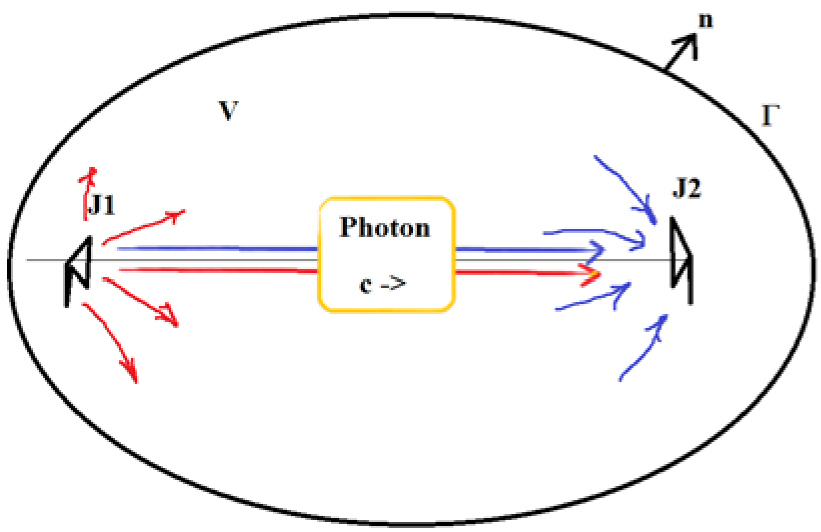

Figure 2: Photon model. There is an emitter and an absorber, emitter sends the retarded wave. The absorber sends the advanced wave. The photon is not vanishes at the time window between $t = 0$ and $t = t + \Delta t$. The photon has speed c. After a time T it travels to distance $d = cT$, where has an absorber. The figure shows in the time $t = \frac{1}{2}T$, the photon is at the middle between the emitter and the absorber. The length of the photon is $\Delta t * c$. The photon is shown with the yellow region.

with very long time. The authors do not accept the concept that the self-energy can collapse to some absorber. One of purpose of this article is to prove that without the concept of wave function collapse, the electromagnetic field theory can still be possible to explain the phenomenon of the photon.

Because photon is a particle, all its energy should eventually be received by the only one absorber. This part energy current (the self-energy item) is diverged and sent to infinite empty space. Since we cannot accept a photon model, in which energy is continually lost, the self-energy current items in the side of the Eq.(3, 4), ether does not existent or need to be returned in late time. This two possibility will be discussed later in this article. For the moment we just ignore these two self-energy items. Assume all energy is transferred only through the mutual energy current items. We know that $\xi_{1i} = [\overrightarrow{E}_{1i}, \overrightarrow{H}_{1i}]$ is retarded wave, $\xi_{2i} = [\overrightarrow{E}_{2i}, \overrightarrow{H}_{2i}]$ is advanced wave. On the big sphere surface Γ, ξ_{1i} is nonzero at a future time $t = [T_\Gamma, T_\Gamma + \Delta t]$. $T_\Gamma = \frac{R_\Gamma}{c}$, where c is light speed, R_Γ is the distance from the emitter to the big sphere surface. Δt is the life time of the photon (from it begin to emit to it stop to emit, in which $\overrightarrow{J}_{1i} \neq 0$). Assume the distance between the emitter and the absorber is d with $d \ll R_\Gamma$. $J_{2i} \neq 0$ is at time $[T, T + \Delta t]$, $T = \frac{d}{c} \ll T_\Gamma$. ξ_{2i} is an advanced wave and it is nonzero at $[T - T_\Gamma, T - (T_\Gamma + \Delta t)]$ on the surface Γ. Hence the following integral vanishes (ξ_{1i} and ξ_{2i} are not nonzero in the same time, on the surface Γ). One is in a time in the past and one is in a time in the future. In the above calculation we have assumed that T is very small compared with T_Γ, hence we can write $T \approx 0$. Hence ξ_1 and ξ_2 are not nonzero at the same time in the the surface $\Gamma$and hence there is,

$$-\oiint_{\Gamma} (\overrightarrow{E}_{1i} \times \overrightarrow{H}_{2i} + \overrightarrow{E}_{2i} \times \overrightarrow{H}_{1i}) \cdot \hat{n} d\Gamma = 0 \tag{8}$$

The left side of Eq.(9) is the sucked energy by advanced wave $\overrightarrow{E}_{2i}$ from $\overrightarrow{J}_{1i}$, which is the emitted energy of the emitter. $\iiint_V (\overrightarrow{J}_{2i} \cdot \overrightarrow{E}_{1i})\, dV$ is the retarded wave E_{1i} act on the current $\overrightarrow{J}_{2i}$. It is the received energy of J_{2i}.

We can see that to prove the above surface integral vanishes is much easier in time domain compared to that in the Fourier domain[10], in the Fourier domain we have to prove all field compounds cancel each other. This cancellation to prove the two fields just in the opposite directions is not needed in time domain.

Notice that the above formula is very important, that means the mutual energy cannot be sent to the outside of our cosmos. In contrast for the self-energy current, see the left side of Eq.(3, 4), there are energy current which is sent to the outside of our cosmos. The energy sends to the outside of our cosmos will be lost which doesn't meet the energy conservation law. Later we have to deal the problem of the self-energy current. In this moment we just omit the self-energy current and glad with the result that the mutual energy current does not sent to the outside of our cosmos.

The above formula is only established when the ξ_1 and ξ_2 are one is retarded wave and another is advanced wave. If they are same wave for example both are retarded waves the above formula Eq.(8) can not be established. This is also the reason we have to choose for our photon model as that one is retarded wave and the other is advanced wave. Hence from Eq.(v) and (8) we have

$$-\int_{-\infty}^{\infty}\iiint_{V}(\vec{J}_{1i}\cdot\vec{E}_{2i})\,dV\,dt=\int_{-\infty}^{\infty}\iiint_{V}(\vec{J}_{2i}\cdot\vec{E}_{1i})\,dV\,dt \tag{9}$$

In the above formula the left side is the emitted energy of the emitter, the right side is the absorbed energy of the absorber. The above formula tell us the emitted mutual energy is equal to the absorbed energy. Considering our readers perhaps are not all electric engineers, the authors make clear here why it is said that the left of the Eq.(9) is the emitted energy and the right side is the absorbed energy. In electrics, if there is an electric element with voltage U and current I, and they have the same direction, we obtained a power IU. This power is the loss of the energy of this electric element. If U has the different direction with current I or it has 180 degree phase difference, this power is an output power to the system, i.e. this element actually is a power supply. In the case of the power consuming, $|IU|=IU$. In the case of power supply, the supplied power is $|IU|=-IU$. Hence $-IU$ express a power supply to the system. Similarly, $\iiint_{V}(\vec{J}_{2i}\cdot\vec{E}_{1i})\,dV$ is the power loss of absorber $\vec{J}_{2i}$. $-\iiint_{V}(\vec{J}_{1i}\cdot\vec{E}_{2i})\,dV$ is the energy supply of $\vec{J}_{1i}$.

Assume V_1 is a volume contains only the emitter $\vec{J}_{1i}$. In this case, since there is a part of advanced wave and retarded wave and the two waves are synchronous. There is energy current go along the line linked the emitter and absorber. The energy current along the other paths not close to the line linked the emitter and absorber has different phase in wave and hence has only small contribution to the total energy transfer. Hence this part of energy current should not vanish, i.e.,

$$\oiint_{\Gamma_1}(\vec{E}_{1i}\times\vec{H}_{2i}+\vec{E}_{2i}\times\vec{H}_{1i})\cdot\hat{n}\,d\Gamma\neq 0 \tag{10}$$

See Figure 3.

Eq.(7) can be rewritten as,

$$-\int_{-\infty}^{\infty}\iiint_{V_1}(\vec{J}_{1i}\cdot\vec{E}_{2i})\,dV\,dt=\int_{-\infty}^{\infty}\oiint_{\Gamma_1}(\vec{E}_{1i}\times\vec{H}_{2i}+\vec{E}_{2i}\times\vec{H}_{1i})\cdot\hat{n}d\mathbf{\Gamma}dt \tag{11}$$

In this formula, $-\iiint_{V_1}(\vec{J}_{1i}\cdot\vec{E}_{2i})\,dV$ is the emitted energy, this energy is the advanced wave $\vec{E}_{2i}$ sucked energy from the emitter current $\vec{J}_{1i}$. $\oiint_{\Gamma_1}(\vec{E}_{1i}\times$

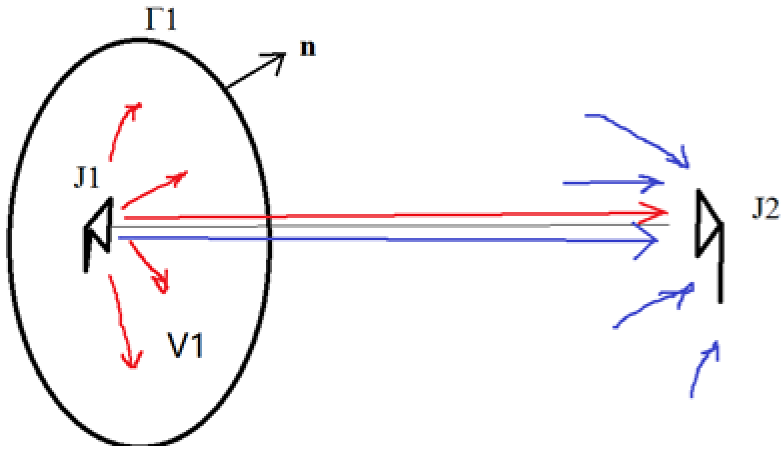

Figure 3: Red arrow is retarded wave, blue arrow is advanced wave. The direction of arrows show the directions of the energy currents. The emitter contains inside the volume V_1. Γ_1 is the boundary surface of V_1. The mutual energy current consist of the retarded wave and the advanced wave can not vanish..

$\overrightarrow{H}_{2i} + \overrightarrow{E}_{2i} \times \overrightarrow{H}_{1i}) \cdot \hat{n} d\Gamma$ is the energy current from the emitter to the absorber, it is referred as the mutual energy current.

In Figure 3, the red arrow is retarded wave, the blue arrow is the advanced wave. For retarded wave, the arrow direction is same as the wave direction. For the advanced wave the arrow direction is in the opposite direction of the wave. In the 3, we always draw the arrow in the energy current directions. For advance wave the energy current is at the opposite direction of the wave.

Assume V_2 is the volume which contains only the absorber $\overrightarrow{J}_{2i}$, Eq.(5) can be written as

$$\int_{-\infty}^{\infty} \iiint_{V_2} (\overrightarrow{J}_{2i} \cdot \overrightarrow{E}_1)\, dV\, dt = -\int_{-\infty}^{\infty} \oiint_{\Gamma_2} (\overrightarrow{E}_{1i} \times \overrightarrow{H}_{2i} + \overrightarrow{E}_{2i} \times \overrightarrow{H}_{1i}) \cdot \hat{n} d\Gamma dt \tag{12}$$

Substitute Eq.(11 and 12) to Eq.(9) we obtain,

$$\int_{-\infty}^{\infty} dt \oiint_{\Gamma_1} (\overrightarrow{E}_{1i} \times \overrightarrow{H}_{2i} + \overrightarrow{E}_{2i} \times \overrightarrow{H}_{1i}) \cdot \hat{n} d\Gamma$$

$$= \int_{-\infty}^{\infty} dt \oiint_{\Gamma_1} (\overrightarrow{E}_{1i} \times \overrightarrow{H}_{2i} + \overrightarrow{E}_{2i} \times \overrightarrow{H}_{1i}) \cdot (-\hat{n}) d\Gamma \tag{13}$$

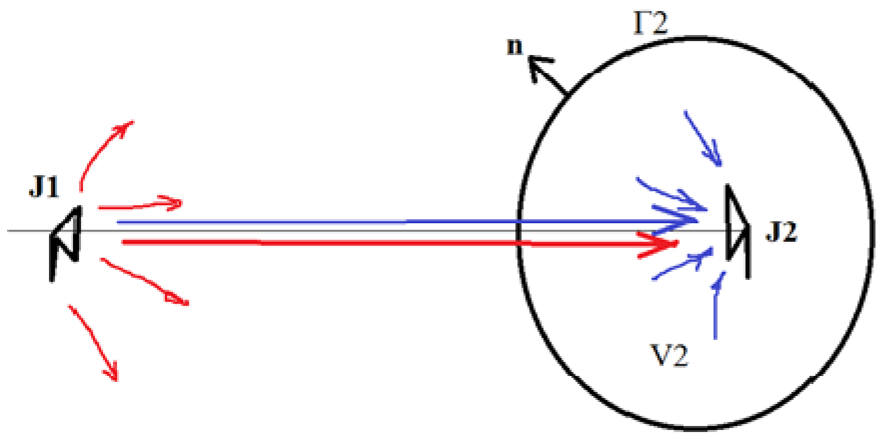

Figure 4: Choose the volume V_2 is close to the absorber. Red arrows are retarded wave, blue arrows are advanced wave. The direction of retarded wave is same as the direction of red arrow. The direction of advanced wave is at the opposite direction of the blue arrow. The arrow direction (red or blue) is always at the energy transfer direction.

The above formula tells us the all energy send out from Γ_1 flows into (please notice the minus sign in the right) the surface Γ_2. Consider the surface Γ_1 and Γ_2 is arbitrarily, that means in any surface between the emitter and the absorber has the same integral with same amount of the mutual energy current. Define

$$Q_{mi}=\oiint_{\Gamma_m}(\overrightarrow{E}_{1i}\times\overrightarrow{H}_{2i}+\overrightarrow{E}_{2i}\times\overrightarrow{H}_{1i})\cdot\hat{n}d\Gamma \tag{14}$$

here we change the direction of $\hat{n}$ to be as always from the emitter to the absorber, then we can get the following formula, see Figure 5.

$$\int_{t=-\infty}^{\infty}Q_{mi}dt=\int_{t=-\infty}^{\infty}Q_{1i}dt \qquad m=1,2,3,4,5 \tag{15}$$

From Figure 5 we can see that the time integral of the mutual energy current on an arbitrary surface are Γ_m are all the same, which are the energy transfer of the photon. In the place close to the emitter or absorber, the surface can be very small close to the size of the electron or atom. When energy is concentrated to a small region the momentum should also concentrated to that small region. In this case the energy of this mutual energy current will behaved like a particle. However, it is still the mutual energy current in 3D-space. Figure 5 and Eq.(15) tell us the energy transfer with the mutual energy current can be approximately seen as a 1-D plane wave i.e. a wave in a cylinder wave guide. The shape of the wave guide are with two sharp tips on the two ends of the wave guide and in

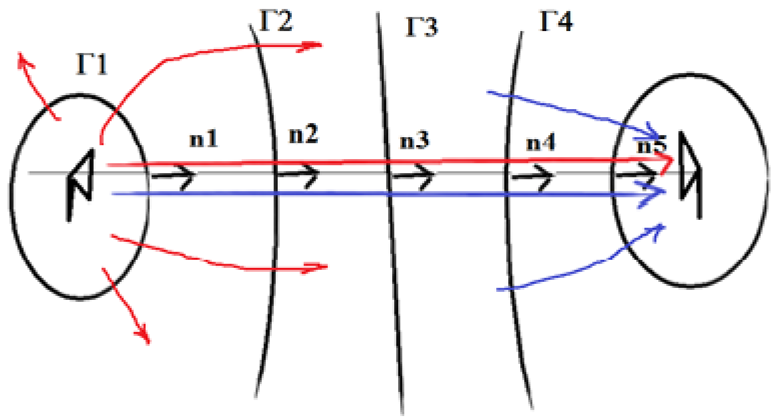

Figure 5: 5 surfaces are shown, the mutual energy current goes through each surface. The integrals of the mutual energy currents with time should be equal to each other in any of the above surface.

the middle of the wave guide it become very thick. But the wave is actually as 3D wave, this allow the wave can go through the space other than empty space, for example double stilts. The mutual energy current has no any problem to go through the double slits and produce interference in the screen after the slits. This offers a clear interpretation for particle and wave duality of the photon.

According the above discussion, the empty space can be used as a wave guide for the mutual energy current to transfer energy from the emitter to absorber. This kind of wave guide will be referred as the mutual energy wave guide. The mutual energy wave guide can be the whole empty space or just part of the empty space. For example if there is a wall between the emitter and the absorber and a hole on the wall, the mutual energy wave guide can not spread to the whole space and the hole restricts the thicknees of this kind of wave guide. In other hand if there are doubled slits on the wall, the wave guide can also be composed with the two paths through the two slits.

6 Self-energy items

Which equations photon should satisfy? First we think the Maxwell equations. But it is seems that the Maxwell equations can only obtain the continual solution. But photon is a particle, its all energy is sent to an absorber direction instead sent to the whole directions. How can we obtained the solution of energy transfer from emitter to the absorber from the Maxwell equation? The field of the solution should like solitary wave. Until now no one find this kind wave can be surported by Maxwell equation, that is the reason the comcept of the wave function collapse has been introduced. Does photon satisfy Schrodinger wave

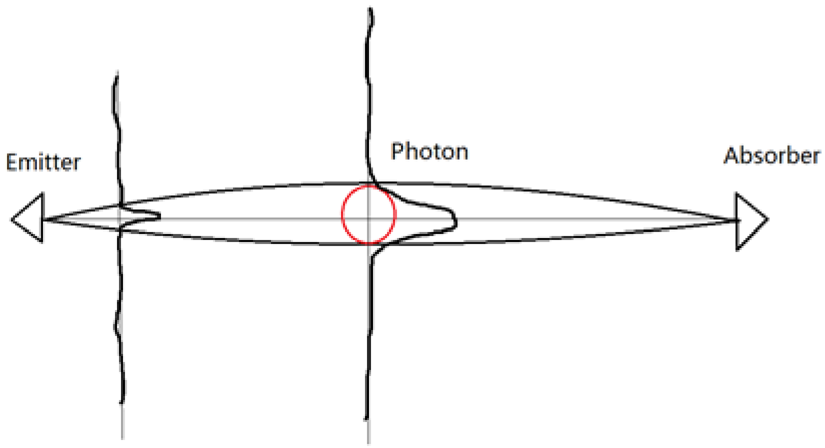

Figure 6: A photon in empty space, photon is just the mutual energy current. In some time, the photon is stayed at a place. This shows there is nothing about the concept of the wave function collapse. The mutual energy offers a 1-D cylinder wave guide which has two very sharp tips in the two ends. In the middle of the wave guide, it become very thick, it can be so thik even can occupy the whole space.

equation? Schrodinger wave equation is scale equation, when there are many photons, the superimposed fields are electromagnetic fields and satisfy Maxwell equations. The fields are vector fields. Hence the field of the photon should also be a vector field and hence it cannot satisfy Schrodinger wave equation.

We are interested to know which equations photon should satisfy. when the number of photon become infinity, from these equations the Maxwell equations or Poynting theorem should be derived. In the photon model of last section, if only the mutual energy current has been considerred, everything is fine and there is no thing can be referred as the wave function collapse. However, in the Poynting theorem there are also self-energy items, in this section we need to offer a detail discussion about the self-energy items. In this section we need to consider the self-energy items Eq.(3 and 4). The advanced wave and retarded waves send to all directions instead send to only along the line linked the emitter and the absorber. In this model the absorber doesn't absorb all retarded wave of the emitter. The emitter doesn't absorb all advanced wave from absorber. The self-energy current of the wave in Eq.(3 and 4) is sent to infinite space. The problem is what will happen for this self-energy current?

6.1 Self-energy current cannot vanish

If there is only one source for example either an emitter or an absorber, the self-energy curren can not vanish.

First we have to know that the self-energy current cannot vanish. If self-energy current vanishes, that from Poynting theorem Eq.(3) we can take a volume V_{ab} which is between two sphere surface Γ_a and Γ_b. In this volume there is no current hence we have,

$$-(\oiint_{\Gamma_b}(\overrightarrow{E}_{1i}\times\overrightarrow{H}_{1i})\cdot\hat{n}d\Gamma-\oiint_{\Gamma_a}(\overrightarrow{E}_{1i}\times\overrightarrow{H}_{1i})\cdot\hat{n}d\Gamma)=\iiint_{V_{ab}}\partial u_{1i}\,dV \tag{16}$$

The self-energy current $\oiint_{\Gamma_b}(\overrightarrow{E}_{1i}\times\overrightarrow{H}_{1i})\cdot\hat{n}d\Gamma = 0$ means the right side of the above formula is vanishes, that also means the left side of the above formula should vanish too. Hence we have

$$\iiint_{V_{ab}}\partial u_{1i}\,dV=0 \tag{17}$$

Where V_{ab} is the volume between the two surface Γ_a and Γ_b, or

$$\partial u_{1i}\equiv\frac{\partial u_{1i}}{\partial t}=\overrightarrow{E}_{1i}\cdot\frac{\partial\overrightarrow{D}_{1i}}{\partial t}+\overrightarrow{H}_{1i}\cdot\frac{\partial\overrightarrow{B}_{1i}}{\partial t}=0 \tag{18}$$

or

$$\overrightarrow{E}_{1i}\cdot\epsilon\frac{\partial\overrightarrow{E}_{1i}}{\partial t}=0 \tag{19}$$

$$\overrightarrow{H}_{1i}\cdot\mu\frac{\partial\overrightarrow{H}_{1i}}{\partial t}=0 \tag{20}$$

In the space the wave is nearly run in the direction as a line. In this situation $\overrightarrow{E}_{1i}(t)\sim\exp(-j\omega t)$, $\frac{\partial\overrightarrow{E}_{1i}}{\partial t}=-j\omega\overrightarrow{E}_{1i}(t)$. It is same to $\overrightarrow{H}_{1i}$. Hence that the above equation require,

$$\overrightarrow{E}_{1i}\cdot\overrightarrow{E}_{1i}=0 \tag{21}$$

$$\overrightarrow{H}_{1i}\cdot\overrightarrow{H}_{1i}=0 \tag{22}$$

That means the fields $\overrightarrow{E}_{1i}$, $\overrightarrow{H}_{1i}$ must all vanish. It is same to $\overrightarrow{E}_{2i}$, $\overrightarrow{H}_{2i}$ which should also vanish.

The above discussion shows that if there is only a singular emitter or a sinular absorber, if the self enerngy current vanishes, their field also vanishes. It sitll does not prove that in case there are emitter and absorber in the same time, the self-energy currents vanishes their fields also vanish. Even so, in this moment the self energy cannot vanish is assumed.

We can think the effect of the self-energy is to help the mutual energy current to transfer the energy from the emitter to the absorber. After mutual energy current has finished its work, the energy of photon has been sent from the emitter to the absorber, the self-energy sill stayed in the space. What this self-energy should do? If it doesn't return to the emitter or absorber, this energy will be continually lost to the outside of our universe. Our universe will continually loss energy that is also very strange. Hence we must think the possibility this energy can return to the emitter or the absorber.

For self-energy current we can assume,

(a) The self-energy items exist, they just send to infinity. Because for the whole system with an emitter and an absorber there are one advanced wave and a retarded wave both send to infinity, the pure total energy did not loss for the whole system. From the retarded wave the emitter loses some energy through the self-energy current, but from advanced wave the absorber lose the same amount of negative energy through the self-energy current. For the whole system including the emitter and the absorber, no energy is lost. The self energy is go from emitter to the absorber which loses some negtive energy means actually gains positive energy.

The part of self-energy sent by the emitter can be seen as it is transferred to the infinity. The self-energy sent by the absorber can be seen as some energy received from the infinity. In this case the self-energy contributed to the energy transfer process of the photon. In the later it will be proved that the self-ernergy currrent and the mutual energy current each contributes half of the energy transfer.

(b) Because self-energy current cannot be absorbed by any things if it doesn't collapse. It need to collapse to a point to be absorbed. When mutual energy current can transfer energy, there is no any requirement for the wave to collapse. We can think the emitter sends an advanced wave and also sends a retarded wave which made the emitter doesn't lose or increase the energy through the self-energy. The absorber is also similar to the emitter, it sends also the advanced wave and also retarded wave. The absorber doesn't lose or increase the energy through the self-energy current. Hence, the self-energy items have no contribution to the energy transfer.

(c) The self-energy current is existent. It helps the mutual energy to be sent from emitter to the absorber and hence the self-energy has come to the whole space. Afterwards, the self-energy return back to the emitter or absorber. Hence the self-energy current do not have any contribution to the energy transfer from emitter to the absorber. After the photon energy has been sent from emitter to the absorber through the mutual energy current, the energy sent by the emitter through self energy at the whole space returns back to the emitter and the energy sent by the absorber through self energy at the whole space returns back to the absorber. The reason we thought this part of self energy should return is that otherwise this part of energy will be lost to the outside of our universe and continuely losing the energy is violate the energy conservation.

(d) It is same as (c), but the return field of the self energy modified the original field of self-energy, a new field is produced which combine the original field of the emitter or absorber and the return field from the our universe. for the new field the self-energy current is vanishes, but the field itself doesn't vanish. This field can also create the mutual energy current through the emitter and the absorber.

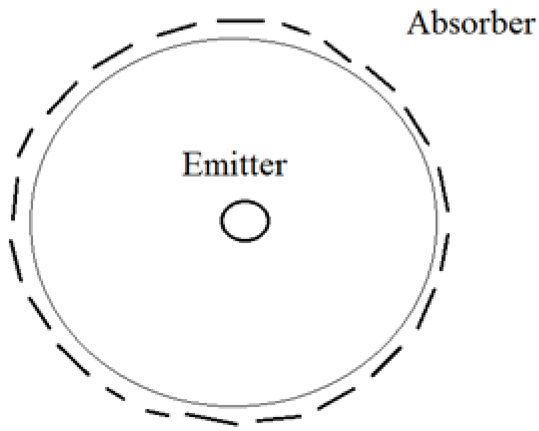

Figure 7: This shows emitters all at the center of the sphere. The absorbers are distributed at the surface of the sphere. The absorbers are the environment. We assume the absorbers are surrounded the emitters. This is our simplified macrocosm model.

(e) The self energy current of the emitter collapse to the absorber. The self energy of the absorber collapse to the emitter in the same meaning as the quantum physics of Copenhagen. By the wave, here only the self-energy current is collapsed, the mutual energy current still not collopse. In the interpretation of Copenhagen, all wave is collopsed.

The Figure 7 offers the authors' simplified macrocosm model. In this model the emitter is stay at the center of the sphere. In a big sphere there is many absorbers. This macrocosm model can be easily extended to more general situation where the emitter is not only stay at the center of the sphere but at a region close to the center. The absorber is also not only on the sphere but at all the place outside the sphere.

(f) In order to to compare, the interpretation of Copenhagen also list here. In this situation, there is no advanced wave and the mutual energy all energy is transferred by self energy of the emitter through the retarded wave.

6.2 The idea of (a)

First the idea of (a) is considered. The self-energy current which is retarded wave sent by the emitter is go to the infinity. The self-energy current sent by the absorber is also go to the infinity. This way the absorber obtained the energy which is equal to the lost energy of the emitter. Hence self-energy join the energy transfer. The energy is transferred not only by the mutual energy current but also by the self-energy current. We will prove in this situation the self-energy current and the mutual energy current each has half contribution to the total energy transferring.

If there is wave guide between the emitter to the absorber, the self-energy current is possible to transfer from the emitter to the absorber.

The only difficult for this kind of energy transfer is that if there is metal container, and if the emitter and the absorber are all inside the container, how the self-energy current to be sent to the infinity? We can think that the retarded self-energy current sends to the surface of metal container and become advanced wave of the absorber. But since the positions of emitter and absorber are in any places inside the container and the container can be any shape, there is no any electromagnetic theory can support this concept. Hence for this idea of (a) there is still some problem.

However, in the following we will still continue working at the idea (a), and omit the situation of a metal container. We will prove that the Poynting theorem is satisfied in macrocosm for this situation.

For idea (a) we can show even we throw away the self-energy items, it doesn't violate the Maxwell equations. After we throw away Eq.(3 and 4), there is only equation Eq.(5) left. We start from Eq.(5) to prove the Poynting theorem in macrocosm.

Assume the emitters send retarded wave randomly with time. In the environment there are many absorbers in all directions which can absorb this waves. This is our simplified macrocosm model see Figure 7. Assume the self-energy doesn't vanish corresponding to the idea (a), we actually endorse the idea (c), but first we check the idea (a), see if we don't worry about the situation in which the emitter and the absorber are all inside a metal container. We need to show that for (a) Maxwell equations are still satisfy for the macrocosm. Assume for the i-th photon the items of self-energy doesn't vanish, i.e.,

$$-\oiint_{\Gamma}(\overrightarrow{E}_{1i}\times\overrightarrow{H}_{1i})\cdot nd\Gamma=\iiint_{V}(\overrightarrow{J}_{1i}\cdot\overrightarrow{E}_{1i}+\partial u_{1i})\,dV \tag{23}$$

$$-\oiint_{\Gamma}(\overrightarrow{E}_{2i}\times\overrightarrow{H}_{2i})\cdot nd\Gamma=\iiint_{V}(\overrightarrow{J}_{2i}\cdot\overrightarrow{E}_{2i}+\partial u_{2i})\,dV \tag{24}$$

Assume for the i-th photon there is mutual energy current which satisfy:

$$-\oiint_{\Gamma}(\overrightarrow{E}_{1i}\times\overrightarrow{H}_{2i}+\overrightarrow{E}_{2i}\times\overrightarrow{H}_{1i})\cdot\hat{n}d\Gamma$$

$$=\iiint_{V}(\overrightarrow{J}_{1i}\cdot\overrightarrow{E}_{2i}+\overrightarrow{J}_{2i}\cdot\overrightarrow{E}_{1i})\,dV$$

$$+\iiint_{V}(\overrightarrow{E}_{1i}\cdot\partial\overrightarrow{D}_{2i}+\overrightarrow{E}_{2i}\cdot\partial\overrightarrow{D}_{1i}+\overrightarrow{H}_{2i}\partial\overrightarrow{B}_{1i}+\overrightarrow{H}_{2i}\partial\overrightarrow{B}_{1i})\,dV \tag{25}$$

These 3 formulas actually tell us the photon should satisfy Poynting theorem, from the above equations can derive the Poynting theorem for the photon,

$$-\oiint_{\Gamma}(\overrightarrow{E}_{1i}+\overrightarrow{E}_{2i})\times(\overrightarrow{H}_{1i}+\overrightarrow{\mathrm{H}}_{2i})\cdot\hat{n}d\Gamma$$

$$=\iiint_V(\overrightarrow{J}_{1i}+\overrightarrow{J}_{2i})\cdot(\overrightarrow{E}_{2i}+\overrightarrow{E}_{1i})\,dV$$

$$+\iiint_V(\overrightarrow{E}_{1i}+\overrightarrow{E}_{2i})\cdot\partial(\overrightarrow{D}_{1i}+\overrightarrow{D}_{2i})+(\overrightarrow{H}_{1i}+\overrightarrow{H}_{2i})\partial(\overrightarrow{B}_{1i}+\overrightarrow{B}_{2i})\,dV \tag{26}$$

Or we can take sum to the above formula it becomes,

$$-\sum_i\oiint_{\Gamma}(\overrightarrow{E}_{1i}+\overrightarrow{E}_{2i})\times(\overrightarrow{H}_{1i}+\overrightarrow{H}_{2i})\cdot\hat{n}d\Gamma$$

$$=\sum_i\iiint_V(\overrightarrow{J}_{1i}+\overrightarrow{J}_{2i})\cdot(\overrightarrow{E}_{2i}+\overleftrightarrow{E}_{1i})dV$$

$$+\sum_i\iiint_V(\overrightarrow{E}_{1i}+\overrightarrow{E}_{2i})\cdot\partial(\overrightarrow{D}_{1i}+\overrightarrow{D}_{2i})+(\overrightarrow{H}_{1i}+\overrightarrow{H}_{2i})\partial(\overrightarrow{B}_{1i}+\overrightarrow{B}_{2i})dV \tag{27}$$

In another side, assume

$\overrightarrow{J}_1=\sum_i\overrightarrow{J}_{1i}$, $\overrightarrow{J}_2=\sum_i\overrightarrow{J}_{2i}$, $\overrightarrow{E}_1=\sum_i\overrightarrow{E}_{1i}$, $\overrightarrow{E}_2=\sum_i\overrightarrow{E}_{2i}$, and so on. Hence there is,

$$(\overrightarrow{E}_1+\overrightarrow{E}_2)\times(\overrightarrow{H}_1+\overrightarrow{H}_2)$$

$$=(\sum_i\overrightarrow{E}_{1i}+\sum_j\overrightarrow{E}_{2j})\times(\sum_m\overrightarrow{H}_{1m}+\sum_n\overrightarrow{H}_{2n})$$

$$=\sum_i\overrightarrow{E}_{1i}\times\sum_m\overrightarrow{H}_{1m}+\sum_i\overrightarrow{E}_{1i}\times\sum_n\overrightarrow{H}_{2n}+\sum_j\overrightarrow{E}_{2j}\times\sum_m\overrightarrow{H}_{1m}+\sum_j\overrightarrow{E}_{2j}\times\sum_n\overrightarrow{H}_{2n} \tag{28}$$

We have known the photon is a particle that means all energy of photon sends out from an emitter has to be received by only one absorber. Hence only the items with $i=j$ doesn't vanish. Hence we have

$$\sum_i\overrightarrow{E}_{1i}\times\sum_m\overrightarrow{H}_{1m}=\sum_{im}\overrightarrow{E}_{1i}\times\overrightarrow{H}_{1m}=\sum_i\overrightarrow{E}_{1i}\times H_{1i} \tag{29}$$

In the above, considering $\overrightarrow{E}_{1i}\times\overrightarrow{H}_{1m}=0$, if $i\neq m$. This means that the field of i-th absorber only act to i-th emitter. Similar to other items, hence we have

$$(\overrightarrow{E}_1+\overrightarrow{E}_2)\times(\overrightarrow{H}_1+\overrightarrow{H}_2)$$

$$= \sum_i (\overrightarrow{E}_{1i} \times \overrightarrow{H}_{1i} + \overrightarrow{E}_{1i} \times \overrightarrow{H}_{2i} + \overrightarrow{E}_{2i} \times \overrightarrow{H}_{1i} + \overrightarrow{E}_{2i} \times \overrightarrow{H}_{2i})$$

$$= \sum_i (\overrightarrow{E}_{1i} + \overrightarrow{E}_{2i}) \times (\overrightarrow{H}_{1i} + \overrightarrow{H}_{2i}) \tag{30}$$

And similarly we have,

$$(\overrightarrow{J}_1 + \overrightarrow{J}_2) \times (\overrightarrow{E}_1 + \overrightarrow{E}_2) = \sum_i (\overrightarrow{J}_{1i} + \overrightarrow{J}_{2i}) \times (\overrightarrow{E}_{1i} + \overrightarrow{E}_{2i}) \tag{31}$$

$$(E_1 + E_2) \cdot \partial(D_1 + D_2) = \sum_i (E_{1i} + E_{2i}) \cdot \partial(D_{1i} + D_{2i}) \tag{32}$$

$$(\overrightarrow{H}_1 + \overrightarrow{H}_2) \cdot \partial(\overrightarrow{B}_1 + \overrightarrow{B}_2) = \sum_i (\overrightarrow{H}_{1i} + \overrightarrow{H}_{2i}) \cdot \partial(\overrightarrow{B}_{1i} + \overrightarrow{B}_{2i}) \tag{33}$$

Considering Eq.(30), Eq.(27) can be written as,

$$- \oint\!\!\oint_\Gamma (\overrightarrow{E}_1 + \overrightarrow{E}_2) \times (\overrightarrow{H}_1 + \overrightarrow{H}_2) \cdot \hat{n} d\Gamma$$

$$= \iiint_V (\overrightarrow{J}_1 + \overrightarrow{J}_2) \cdot (\overrightarrow{E}_2 + \overrightarrow{E}_1) dV$$

$$+ \iiint_V (\overrightarrow{E}_1 + \overrightarrow{E}_2) \cdot \partial(\overrightarrow{D}_1 + \overrightarrow{D}_2) + (\overrightarrow{H}_1 + \overrightarrow{H}_2) \partial(\overrightarrow{B}_1 + \overrightarrow{B}_2)\, dV \tag{34}$$

If we take $V = V_1$ which only contains the current of J_1 that means the current of environment J_2 is put out side of the volume V_1, we have,

$$- \oint\!\!\oint_\Gamma (\overrightarrow{E}_1 + \overrightarrow{E}_2) \times (\overrightarrow{H}_1 + \overrightarrow{H}_2) \cdot \hat{n} d\Gamma$$

$$= \iiint_{V_1} \overrightarrow{J}_1 \cdot (\overrightarrow{E}_2 + \overrightarrow{E}_1) dV$$

$$+ \iiint_{V_1} (\overrightarrow{E}_1 + \overrightarrow{E}_2) \cdot \partial(\overrightarrow{D}_1 + \overrightarrow{D}_2) + (\overrightarrow{H}_1 + \overrightarrow{H}_2) \partial(\overrightarrow{B}_1 + \overrightarrow{B}_2)\, dV \tag{35}$$

Considering the total fields can be seen as the sum of the retarded wave and the advanced wave. In the macrocosm we do not know whether the field is produced by the retarded field of the emitter current $\overrightarrow{J}_1$ or is produced by the advanced wave of the absorbers in the environment. We can think all the fields are produced by the source current $\overrightarrow{J}_1$, hence we have $\overrightarrow{E} = \overrightarrow{E}_1 + \overrightarrow{E}_2$, $\overrightarrow{D} = \overrightarrow{D}_1 + \overrightarrow{D}_2$, $\overrightarrow{H} = \overrightarrow{H}_1 + \overrightarrow{H}_2$, $\overrightarrow{B} = \overrightarrow{B}_1 + \overrightarrow{B}_2$. Here the field $\overrightarrow{E}$,$\overrightarrow{H}$ are total electromagnetic field in macrocosm, which are thought to be produced by emitter J_1, hence we have

$$-\oiint_{\Gamma_1}(\overrightarrow{E}\times\overrightarrow{H})\boldsymbol{.}\hat{n}d\Gamma$$

$$=\iiint_{V}\overrightarrow{J}_1\boldsymbol{.}\overrightarrow{E}\,dV+\iiint_{V_1}(\overrightarrow{E}\boldsymbol{.}\partial\overrightarrow{D}+\overrightarrow{H}\boldsymbol{.}\partial\overrightarrow{B})\,dV \qquad (36)$$

This is the Poynting theorem in macrocosm. In this formula there is only emitter current $\overrightarrow{J}_1$. The field $\overrightarrow{E}$,$\overrightarrow{H}$ can be seen as retarded wave but it is actually consist of both the retarded waves and the advanced waves in microcosm.

We have started with assume the microcosm photon model where the field is produced from the advanced wave of the absorber and the retarded wave of the emitter. We assume that the self-energy items doesn't vanish, we also assume there is the mutual energy current between the emitter and the absorber. All this means that for a singular photon it satisfies the Maxwell equations. We obtained the macrocosm Poynting theorem, in which the field can be seen to be produced by the emitters. We know that Poynting theorem is nearly equivalent to the Maxwell equations. Although from Poynting theorem we cannot deduce Maxwell equations, but the Poynting theorem can derive all the reciprocity theorem[10], from the reciprocity theorem we can obtained the Green function solution of the Maxwell equations. From all solutions of Maxwell equations, the Maxwell equations should be possible to be induced from their all solutions.

We have shown that if photon consists of the self-energy and the mutual energy items of an advanced wave and a retarded wave, the macrocosm electromagnetic field which is summation of all fields of the emitters and absorbers still satisfy the Poynting theorem, and hence also the Maxwell equations in macrocosm. In our macrocosm model, the emitters are all at one point and all the absorbers are all on a sphere. However, this can be easily widened to more generalized situation in which the emitters are not only stay at one point and the absorbers are not only on a sphere surface but in the whole space.

Perhaps the reader is still confuse here, and ask what are you doing? Started from Maxwell equation and prove the system satisfies the Maxwell equation? The reason is doing so is because we believe that for the field of photon in microcosm, it doesn't require to satisfy the Maxwell equation exactly, but for the field in macrocosm, it have to satisfy the Maxwell equations.

The above derivation is that we believe in macrocosm, the Maxwell equation should be satisfied. If we cannot directly prove that the Maxwell equations is satisfied, at least the Poynting theorem should be satisfied in macrocosm. In microcosm which involves only the field of a singular photon, this field perhaps satisfies Maxwell equation, but perhaps not. In the above we have assumed the microcosm, the field also satisfies the Maxwell equations and hence the Poynting theorem for self-energy and the mutual energy theorem. We also assume that the field of the i-th emitter and the field of j-th absorber do not contribute to energy or energy current, if $i\neq j$, here i and j belong to different photon. This is also clear, the field of different photons can not contributed to the energy current. We also assume that the macrocosm field is the summation of all field of the emitter and also the absorber. The macrocosm field includes all fields include retarded field and also advanced field in the microcosm. From all these assumptions we obtains that the macrocosm field satisfies the Poynting theorem. From this we prove that this situation is a possible photon model.

The only problem of the idea (a) is that if there is a metal container, how the self-energy current can be transferred to the infinity?

6.3 For the idea of (b)

In this situation all the self-energy current items don't transfer energy. The energy of photon is transferred only through the mutual energy items.

We can assume the emitter also sends an advanced wave which have the same energy current as the retarded self-energy current, but has opposite direction of the energy transfer. Hence the total energy transfer of self-energy current for the emitter vanishes. We can assume for our universe the infinite far away in the future is connected to the infinite far away of the past. So the retarded self-energy current sent to the outside of our universe by the emitter will become the advanced wave and comeback to the emitter.

It is similar to the absorber. The absorber has advanced self-energy current items. We assume the absorber also sends a retarded wave out which has the same amount of the energy current as the self energy current of the absorber and has a opposite direction. Hence the total self energy of the absorber also vanish.

We assume the retarded wave and the advanced wave of the emitter is sent out in the time $t = 0$. We assume the advanced wave and the retarded wave of the absorber is sent out by the time of $t = T = \frac{R}{c}$. Where R is the distance from the emitter to the absorber. c is the light speed. In this case, the retarded wave of the emitter and the advanced wave of the absorber can be synchronized. Hence the mutual energy current of the retarded wave of the emitter and the advanced wave of the absorber can produce nonzero mutual energy current.

By the way, the retarded wave of the absorber begins at time $t = T$. When this wave reached to the emitter, it is time $t = 2T$. If the emitter sends the advanced wave also at $t = 2T$, these two waves can be synchronized. However, in the above when we speak about the emitter, it sends the retarded wave and also advanced wave, both waves are started at the time $t = 0$. The emitter sends the advanced wave at the same time as it sends the retarded wave. Hence, the retarded wave of the absorber and the advanced wave of the emitter cannot be synchronized and hence cannot produce any mutual energy current. There is only the mutual energy current between the retarded wave of the emitter and the advanced wave of the absorber. There is no any mutual energy current of the retarded wave of the absorber and the advanced wave of the emitter. Hence we have,

$$-\oiint_{\Gamma}(\overrightarrow{E}^{a}_{1i}\times\overrightarrow{H}^{r}_{2i}+\overrightarrow{E}^{r}_{2i}\times\overrightarrow{H}^{a}_{1i})\cdot nd\Gamma=0$$

We will study the situation there is only the mutual energy items which contributed to the energy current. The self-energy current have no contribution to the energy transferring. The mutual energy current is also only the retarded wave of the emitter and the advanced wave of the absorber, which can contribute to the energy transferring.

Assume one of the current of emitters is $\overrightarrow{J}_{1i}$, which is at the origin and the current of the corresponding absorber is $\overrightarrow{J}_{2i}$, which is at the sphere, see Figure 7, here $i = 0, 1, \ldots N$. $\overrightarrow{J}_{1i}$ will produce retarded wave and advanced wave, to make thins simple we assume that

$$\overrightarrow{J}^r_{1i} = \overrightarrow{J}^a_{1i} = \overrightarrow{J}_{1i} \tag{37}$$

$$\overrightarrow{J}^r_{2i} = \overrightarrow{J}^a_{2i} = \overrightarrow{J}_{2i} \tag{38}$$

where $\overrightarrow{J}^r_{1i}$ and $\overrightarrow{J}^r_{2i}$ can only produce retarded waves. $\overrightarrow{J}^a_{1i}$ and $\overrightarrow{J}^a_{2i}$ can only produce advanced waves. The subscript 1 is corresponding to emitter. The subscript 2 is corresponding to absorber. $\overrightarrow{J}_{1i}$ can be replaced by $\overrightarrow{J}^r_{1i}$ and $\overrightarrow{J}^a_{1i}$. $\overrightarrow{J}_{2i}$ can be replaced by $\overrightarrow{J}^r_{2i}$ and $\overrightarrow{J}^a_{2i}$. According to the above discussion that the mutual energy current happens only between $\overrightarrow{J}^r_{1i}$ and $\overrightarrow{J}^a_{2i}$, which is,

$$\begin{aligned} -\oint\!\!\!\oint_{\Gamma} (\overrightarrow{E}^r_{1i} \times \overrightarrow{H}^a_{2i} + \overrightarrow{E}^a_{2i} \times \overrightarrow{H}^r_{1i}) \cdot n d\Gamma \\ = \iiint_V (\overrightarrow{J}^r_{1i} \cdot \overrightarrow{E}_{2i}) dV + \iiint_V (\overrightarrow{J}^a_{2i} \cdot \overrightarrow{E}_{1i}) dV \\ + \iiint_V (\overrightarrow{E}^r_{1i} \cdot \partial \overrightarrow{D}^a_{2i} + \overrightarrow{E}^a_{2i} \cdot \partial \overrightarrow{D}^r_{1i} + \overrightarrow{H}^a_{2i} \partial \overrightarrow{B}^r_{1i} + \overrightarrow{H}^a_{2i} \partial B^r_{1i}) dV \end{aligned} \tag{39}$$

Or we can sum it to i,

$$\begin{aligned} -\oint\!\!\!\oint_{\Gamma} \sum_i (\overrightarrow{E}^r_{1i} \times \overrightarrow{H}^a_{2i} + \overrightarrow{E}^a_{2i} \times \overrightarrow{H}^r_{1i}) \cdot n d\Gamma \\ = \iiint_V \sum_i (\overrightarrow{J}_{1i} \cdot \overrightarrow{E}_{2i}) dV + \iiint_V \sum_i (\overrightarrow{J}^a_{2i} \cdot \overrightarrow{E}_{1i}) dV \\ + \iiint_V \sum_i (\overrightarrow{E}^r_{1i} \cdot \partial \overrightarrow{D}^a_{2i} + \overrightarrow{E}^a_{2i} \cdot \partial \overrightarrow{D}^r_{1i} + \overrightarrow{H}^a_{2i} \partial \overrightarrow{B}^r_{1i} + \overrightarrow{H}^a_{2i} \partial B^r_{1i}) dV \end{aligned} \tag{40}$$

$\overrightarrow{J}^a_{1i}$ and $\overrightarrow{J}^r_{2i}$ do not produce any mutual energy current because this two fields are not synchronized. We assume the field of emitter $\overrightarrow{J}^r_{1i}$ can only be received by the absorber $\overrightarrow{J}^a_{2i}$, here $i = 1, \ldots, N$. This requirement is asked because that the photon is a particle and all its energy must be received by only one absorber. That means for example, assume that $\overrightarrow{J}_1^r = \sum_i \overrightarrow{J}_{1i}^r$ and $\overrightarrow{J}_2^a = \sum_j \overrightarrow{J}_{2j}^a$, $\overrightarrow{E}_1^r = \sum_i \overrightarrow{E}_{1i}^r$, $\overrightarrow{E}_2^a = \sum_i \overrightarrow{E}_2 i^a$, consider this, Eq.(40) becomes

$$-\oiint_\Gamma (\overrightarrow{E}_1^r \times \overrightarrow{H}_2^a + \overrightarrow{E}_2^a \times \overrightarrow{H}_1^r) \cdot n d\Gamma$$

$$= \iiint_V (\overrightarrow{J}_1^r \cdot \overrightarrow{E}_2^a) dV + \iiint_V (\overrightarrow{J}_2 \cdot \overrightarrow{E}_1^r) dV$$

$$+ \iiint_V (\overrightarrow{E}_1^r \cdot \partial \overrightarrow{D}_2^a + \overrightarrow{E}_2^a \cdot \partial \overrightarrow{D}_1^r + \overrightarrow{H}_2^a \partial \overrightarrow{B}_1^r + \overrightarrow{H}_2^a \partial \overrightarrow{B}_1^r) dV \tag{41}$$

In the above formula we have considered that

$$\sum_{ij} \overrightarrow{E}_{1i}^r \times \overrightarrow{H}_{2j}^a = 0 \tag{42}$$

This means that only the field of the i-th emitter and the i-th absorber can have nonzero energy transfer. The energy will be as a whole package and only sends from i-th emitter to the i-th absorber. And hence, there is,

$$\sum_i \overrightarrow{E}_{1i}^r \times \sum_J \overrightarrow{H}_{2j}^a = \sum_{ij} \overrightarrow{E}_{1i}^r \times \overrightarrow{H}_{2j}^a = \sum_i \overrightarrow{E}_{1i}^r \times \overrightarrow{H}_{2i}^a \tag{43}$$

Similarly to other items. We assume all the advanced waves average should close to the retarded wave that is,

$$\sum_i \overrightarrow{E}_{1i}^r = \sum_i \overrightarrow{E}_{2i}^a \equiv \frac{1}{2} \overrightarrow{E} \tag{44}$$

$$\sum_i \overrightarrow{H}_{1i}^r = \sum_i \overrightarrow{H}_{2i}^a \equiv \frac{1}{2} \overrightarrow{H} \tag{45}$$

The above formula tell us that the total retarded wave field $\sum_i \overrightarrow{E}_{1i}$ is half of the macrocosm field. The total advanced waves from all photons $\sum_i \overrightarrow{E}_{2i}$ is the half of the macrocosm field. Where "≡" means "is defined as". Considering the above formula, we obtain,

$$-\frac{1}{2} \oiint_\Gamma (\overrightarrow{E} \times \overrightarrow{H}) \cdot \hat{n} d\Gamma$$

$$= \frac{1}{2} \iiint_V (\overrightarrow{J}_1^r \cdot \overrightarrow{E})\, dV + \frac{1}{2} \iiint_V (\overrightarrow{J}_2^a \cdot E) dV + \frac{1}{2} \iiint_V (\overrightarrow{E} \cdot \partial \overrightarrow{D} + \overrightarrow{H} \cdot \partial \overrightarrow{B})\, dV \tag{46}$$

Comparing to Eq.(36), the above formula has a factor $\frac{1}{2}$ which tell us that since the self-energy doesn't contributes to the Poynting theorem in macrocosm, the energy current related Poynting vector will reduced to it's half compare to Eq.(36) where the self-energy also contributed to the energy current in macrocosm. The above factor $\frac{1}{2}$ appears at all items of the formula and can be factor out.

$$-\oiint_{\Gamma}(\overrightarrow{E}\times\overrightarrow{H})\cdot\hat{n}d\Gamma$$
$$=\iiint_{V}(\overrightarrow{J}^{r}_{1}\cdot\overrightarrow{E})\,dV+\iiint_{V}(\overrightarrow{J}^{a}_{2}\cdot E)dV+\iiint_{V}(\overrightarrow{E}\cdot\partial\overrightarrow{D}+\overrightarrow{H}\cdot\partial\overrightarrow{B})\,dV \qquad (47)$$

We can choose V as V_1 which is very small volume close to emitter, in that case, $\overrightarrow{J}_2$ is at outside of V_1 and the middle item in the right of the above formula vanishes, and hence we obtain,

$$-\iiint_{V_1}(\overrightarrow{J}_1\cdot\overrightarrow{E})\,dV=\oiint_{\Gamma_1}(\overrightarrow{E}\times\overrightarrow{H})\cdot\hat{n}d\Gamma+\iiint_{V_1}(\hat{E}\cdot\partial\hat{D}+\overrightarrow{H}\cdot\partial\overrightarrow{B})dV \qquad (48)$$

Comparing to Eq.(1), the above equation, it is the Poynting theorem in Macrocosm. It is noticed that, the self-energy items of the emitter,

$$-\oiint_{\Gamma}(\overrightarrow{E}^{r}_{1i}\times\overrightarrow{H}^{r}_{1i})\cdot\hat{n}d\Gamma=\iiint_{V}(\overrightarrow{J}^{r}_{1i}\cdot\overrightarrow{E}^{r}_{1i}+\partial u^{r}_{1i})\,dV \qquad (49)$$

is canceled with the advanced items,

$$-\oiint_{\Gamma}(\overrightarrow{E}^{a}_{1i}\times\overrightarrow{H}^{a}_{1i})\cdot nd\Gamma=\iiint_{V}(\overrightarrow{J}^{a}_{1i}\cdot\overrightarrow{E}^{a}_{1i}+\partial u^{a}_{1i})dV \qquad (50)$$

The advanced items of the absorber

$$-\oiint_{\Gamma}(E^{a}_{2i}\times H^{a}_{2i})\cdot nd\Gamma=\iiint_{V}(J^{a}_{2i}\cdot E^{a}_{2i}+\partial u^{a}_{2i})dV \qquad (51)$$

is canceled with a retarded item,

$$-\oiint_{\Gamma}(\overrightarrow{E}^{r}_{2i}\times\overrightarrow{H}^{r}_{2i})\cdot nd\Gamma=\iiint_{V}(\overrightarrow{J}^{r}_{2i}\cdot\overrightarrow{E}^{r}_{2i}+\partial u^{a}_{2i})dV \qquad (52)$$

Here they cancel each other means the pure energy contribution to the emitter from the self-energy current vanishes. The pure energy contribution to the absorber from the self-energy current vanishes.

In this situation the Poynting theorem is still satisfied in macrocosm. However this Poynting theorem in macrocosm is derived only from the mutual energy current in microcosm. This means in macrocosm is possible the contribution of the infinite mutual energy currents produced the the Poynting theorem in macrocosm. The macrocosm self-energy current $\oiint_{\Gamma_1}(\overrightarrow{E}\times\overrightarrow{H})\cdot\hat{n}d\Gamma$ is noting to do with the microcosm self-energy current $\oiint_{\Gamma_1}(\overrightarrow{E}_{1i}\times\overrightarrow{H}_{1i}).\hat{n}d\Gamma$ and $\oiint_{\Gamma_2}(\overrightarrow{E}_{2i}\times\overrightarrow{H}_{2i}).\hat{n}d\Gamma$. Microcosm self-energy currents have canceled each other.

Among the 4 ideas (a), (b), (c), (d) and (e), the photon model of this idea (b) is the closest one to the photon model of Wheeler and Feynman in 1945, see Figure 1. However there is also the difference. In the photon model of Wheeler and Feynman, the retarded wave of the emitter is only send to left and the advanced wave is sent to the right, in the idea (b), the retarded wave and the advanced wave are all sent to the whole space. In photon model of Wheeler and Feynman also need the advanced wave of the emitter must has 180 degree phase difference to the advanced wave of the absorber and the retarded wave of the absorber must has 180 degree phase difference to the retarded wave of the emitter. All this kind strange assumptions have been removed in the idea (b).

6.4 The idea (c)

In the above idea (b) the retarded self-energy current and advanced self-energy current all send to the infinity. It looks like the retarded wave is sent the energy to outside of our universe and the advanced wave is bring some energy from outside of our universe. Even energy is balanced to the emitter and the absorber, but some energy is lost to infinite space and some energy is obtained from the from infinite space. The lost energy is at the future. The gained energy is obtained from the past. The energy is not balanced at the future and the past. Unless in our universe at the infinity, the future is actually connected to the past. The future is connected to the past is Buddhism concept. If we do not like to accept this very strange concept, we have to find other possibilities. That is the reason we consider the idea (c). In the idea (c) we assume the energy transfers are same as above the idea (b), it is transferred by the mutual energy current, but after the mutual energy current having finished the job to transfer the energy from the emitter to the absorber, the self energy of the retarded wave in the space will return back to the emitter and the self energy of the advanced wave will also return back to the absorber.

In the idea (c), we assume the retarded self-energy current send to the space, that helps the mutual energy current sends to the absorber. After the mutual energy is sent to the absorber, the retarded self-energy current returns back to the emitter. It is same to the absorber, the the self-energy of the advanced wave of the absorber returns back to the absorber. All the formula in the idea (c) is same to the idea (b) in the last subsection and will not be given here again. We only emphasis that the self-energies of the emitter and the absorber isn't involved to the process of energy transfer of the photon.

About the fields returned back, $\xi_{1i}^b=[\overrightarrow{E}_{1i}^b,\overrightarrow{H}_{1i}^b]$, it is possible some electromagnetic filed satisfies Maxwell equations,

$$\nabla\times\overrightarrow{E}_{1i}^b=-\mu\partial\overrightarrow{H}_{1i}^b \tag{53}$$

$$\nabla\times\overrightarrow{H}_{1i}^b=\epsilon\partial\overrightarrow{E}_{1i}^b \tag{54}$$

where $\partial = \frac{\partial}{\partial t}$. The superscript "$b$" means "back wave". But if the Maxwell equations do not support this returned backed field, the returned field perhaps satisfies time reversed Maxwell equations which is defined as flowing,

$$\nabla \times \overrightarrow{E}^b_{1i} = \mu \partial \overrightarrow{H}^b_{1i} \tag{55}$$

$$\nabla \times \overrightarrow{H}^b_{1i} = -\epsilon \partial \overrightarrow{E}^b_{1i} \tag{56}$$

The time reversed Maxwell equation is obtained through substituting $t = -t'$ to the Maxwell equations Eq.(53,54), and then replace t' using t. It also can be obtained by substitute $[\epsilon, \mu] = [-\epsilon', -\mu']$ to the Maxwell equation and then replace $[\epsilon', \mu']$ using $[\epsilon, \mu]$. The time reversed wave can also be obtained by exchange $[E, \epsilon]$ with $[H, \mu]$. In the infinity the electric field become magnetic field and returned. In the last section we have mentioned that the field of the microcosm is allowed to have some deviation from Maxwell equations, as long as the field in macrocosm is still satisfy the Maxwell equations. The return backed wave will not have any influence to the field of the macrocosm, hence even it doesn't satisfy Maxwell equations, is still allowed.

Any way we need the returned field produce a self energy $Q^b_{1i} = \oiint_\Gamma (\overrightarrow{E}^b_{1i} \times \overrightarrow{H}^b_{1i}).\hat{n} d\Gamma$ which is point to the emitter and has opposite value to $Q^r_{1i} = \oiint_\Gamma (\overrightarrow{E}^r_{1i} \times \overrightarrow{H}^r_{1i}).\hat{n} d\Gamma$, i.e.

$$Q^b_{1i} = -Q^r_{1i} \tag{57}$$

For the absorber, there is similarly discussions, hence

$$Q^b_{2i} = -Q^a_{2i} \tag{58}$$

By the way, here we have spoken about returned waves, this returned wave is not the collapsed wave of the Copenhagen interpretation of the quantum physics. In the Copenhagen interpretation wave sent from emitter is collapsed to the absorber. Here the wave sent from emitter is return back to the emitter. It is no thing to do with the absorber.

In the the Copenhagen interpretation of the quantum physics when we speak about wave collapse, it doesn't tell us which equation the collapse field should satisfy. Here the returned wave at least it satisfies a time-reversed Maxwell equations.

The returned wave is also not the wave reflected at a metal surface at infinity, the retarded wave returned from a big metal surface at the infinity will still a retarded wave of the big sphere, it needs infinite time to return to the emitter. Here the returned wave is a advanced wave corresponding to the big sphere and hence it can synchronized to the retarded wave of the emitter. From the point view of the emitter, this wave is also a retarded wave, but the energy transfer is at opposite direction and hence, can cancel the retarded self energy of the emitter. Similarly, the returned wave corresponding to the advanced wave of the absorber can cancel the self energy of the advanced wave.

It assumed here that the returned wave is not returned immediately but just a very short time later, this offers a chance that the returned wave doesn't influence to the field of the mutual energy current.

6.5 The idea (d)

In the last sub-section the situation the returned wave doesn't change the field of the mutual energy current have been considered. In this section the situation it changes the field of the mutual energy current will be considered.

To the emitter, it sends retarded waves. The returned wave can be seen as the waves produced by the current which is at infinite big sphere. This returned wave to the infinite big sphere is advanced wave. But this returned wave to the emitter, it looks like a retarded wave. The retarded self-energy current wave can be written as,

$$Q_{1i} = \oiint_{\Gamma} (\overrightarrow{E}_{1i}^{r} \times \overrightarrow{H}_{1i}^{r}) . \hat{n} d\Gamma \tag{59}$$

The returned wave can be written as

$$Q_{1i}^{b} = \oiint_{\Gamma} (\overrightarrow{E}_{1i}^{b} \times \overrightarrow{H}_{1i}^{b}) . \hat{n} d\Gamma \tag{60}$$

Where $\overrightarrow{E}_{1i}^{b}$, $\overrightarrow{H}_{1i}^{b}$ are returned field for the emitter. Q_{1i}^{b} is returned self energy current of the emitter. We assume the field of the emitter are

$$\overrightarrow{E}_{1i} = \overrightarrow{E}_{1i}^{r} + \overrightarrow{E}_{1i}^{b} \tag{61}$$

$$\overrightarrow{H}_{1i} = \overrightarrow{H}_{1i}^{r} + \overrightarrow{H}_{1i}^{b} \tag{62}$$

We assume that for the above superimposed field, the self-energy current vanishes, i.e.,

$$Q = \oiint_{\Gamma} (\overrightarrow{E}_{1i} \times \overrightarrow{H}_{1i}) . \hat{n} d\Gamma = 0 \tag{63}$$

In order to meet the above formula, we can further assume that,

$$\nabla . \overrightarrow{E}_{1i} \times \overrightarrow{H}_{1i} = 0 \tag{64}$$

We can further assume that

$$\overrightarrow{E}_{1i} \times \overrightarrow{H}_{1i} = 0 \tag{65}$$

This require that

$$\overrightarrow{E}_{1i} || \overrightarrow{H}_{1i} \tag{66}$$

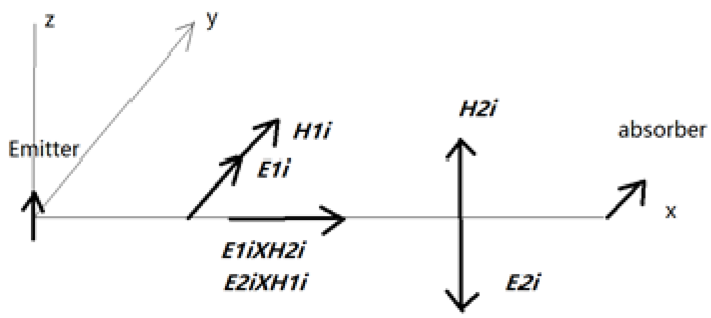

Figure 8: The photon model. The current of the absorber must be perpendicular to the current of the emitter. The electric field and the magnetic field of the emitter must have the same direction. The electric field of the absorber has in the direction of perpendicular to the current of the emitter.

Where "||" means "parallel to". Hence the electric field $\overrightarrow{E}_{1i}$ should parallel to the magnetic field $\overrightarrow{H}_{1i}$. For this wave the field of the emitter, it is not vanish, but the total self-energy current vanishes. Similar we can have,

$$\overrightarrow{E}_{2i}||\overrightarrow{H}_{2i} \tag{67}$$

The mutual energy current is possible still same as formula Eq.(61), i.e.,

$$Q_{12i} = \oiint_{\Gamma} (\overrightarrow{E}_{1i}^{r} \times \overrightarrow{H}_{2i}^{a} + \overrightarrow{E}_{2i}^{a} \times \overrightarrow{H}_{1i}^{r}) \cdot n d\Gamma$$

In this subsection, the total field $\overrightarrow{E}_{1i}$ and $\overrightarrow{H}_{1i}$ produce zero self-energy current. All energy transfer is still only by the mutual energy current. Hence the formula about the energy transfer is same as last second sub-section the idea (b).

In this situation the electric field must parallel to the magnetic field, Figure 8 shows the photon model corresponding to this situation. In this situation the emitter must perpendicular to the absorber.

It is notice, even the author has started this situation with the concept of the self energy is returned, but actually, this is not necessary. We can just started with the condition Eq.(63), that means to look the possibility that the field is nonzero but the self-energy currents vanish. The mutual energy current doesn't vanish.

6.6 The idea (e)

In this situation we assume the self-energy current of the emitter collapse to the absorber. The self-energy current of the absorber is collapsed to the emitter. The self-energy current offers half of energy transfer. The another half is offered by the mutual energy current. All formula about energy transfer of this idea is same as the idea (a), and hence will not give again.

By the way in the sub-section the wave collapse is similar to the Copenhagen interpretation of quantum physics, but there is still some difference. the Copenhagen interpretation when speak about wave collapse that means all wave is collapsed. Here only the self energy currents are collapsed, but the mutual energy current doesn't collapse. Hence this idea still better then the Copenhagen interpretation.

The authors cannot accept the concept that the wave function can be collapsed. If it can be collapsed, what is the equation of this collapse process should satisfy? The author believe this idea (e) has the smallest possibility become real among all the ideas in this section.

6.7 Summary

In this section we have introduced 5 possible situations to deal with the self-energy current items of the energy transfer. First one the idea(a) is that the self-energy current transfers part of energy from emitter to the absorber. The self-energy current of the retarded wave of the emitter sends to infinity and the wave "reflected" at the end of the universe, becomes the advanced wave of the absorber, hence this energy is sent from the emitter to the absorber. The self-energy items transferred half the total energy, the other half of energy is transferred by the mutual energy current. The only problem of this assumption is that if the emitter and the absorber are not at infinite empty space but inside a metal container, we still have to assume the self-energy items can be sent to the infinity, this seems isn't possible. If the metal container is a wave guide, the self energy can also be sent from emitter to the absorber. But if between the emitter and the absorber there is only a hole which is clear the photon can go through it, but what about the self-energy current which is a diverged wave, how it can go through a hole? It is no problem for the the mutual energy current to go through a hole or double slits.

Hence we made another assumption the idea (b), in which, the self-energy doesn't have any contribution to the energy transfers. The self-energy current items are canceled. This assumption is similar to the model J. A. Wheeler and R. P. Feynman. Any currents will produce half-retarded wave and half advanced wave for both the emitter and the absorber. We assume that the mutual energy current is the only energy current produced between the emitter and the absorber. The difficulty of idea is that the future and the past has to be connected at infinity. Otherwise the self energy send to the future is lost. Some energy is obtained for past. The energy is not balance in the future and the past even it is balance to the emitter and the absorber.

We also introduced another possibility idea (c) that the self-energy current is return to the emitter and the absorber. In this situation we assume the returned field is happened after the mutual energy current transferred the energy from emitter to the absorber, hence the returned field doesn't modified the fields for the mutual energy current. The problem of this idea is that it need the returned field has to be hold in the infinity for a very short time and then returns. Why nature will hold the field for a moment? this is also a little bit strange.

In another situation, the idea (d) it is possible the returned field also join to the field to produce the mutual energy current. In this situation electric field of the emitter must be perpendicular to the corresponding magnetic field. Similar to the absorber the electric field of the absorber must be perpendicular to the corresponding magnetic field. In this situation the current of the absorber must also perpendicular to the current of the emitter. The author believe this idea has biggest possibility to become real. It perhaps can made some excrement to test whether or not the emitter and the absorber are perpendicular.

The last possibility the idea (e) is that the self-energy currents of the emitter is collapsed to the absorber and the self energy current of the absorber is collapsed to the emitter. The authors doesn't accept the concept of the wave function collapse. One of the purpose of this article is shown that without the wave function collapse, the energy still possible to transfer from the emitter to the absorber and to interpret the photon.

J. Cramer introduced the concept of continually collapse that means 3D wave continually collapse to a 1-D wave [3-5][4, 5]. In the authors' photon model, the energy transfer through the mutual energy current is also very close to a 1-D wave. The transferred energy current in any surface is same. In the authors' photon models the concept of the wave function collapse or continually wave function collapse are not required.

Among the 5 ideas, in the idea (b), (c) and (d), the self-energy currents have no contribution to the energy current. We have proved that the macrocosm Poynting theorem can be derived from this photon model. Even the self-energy current in microcosm vanishes, the self-energy items in macrocosm which is the energy current related to the Poynting vector do not vanish. In macrocosm the self-energy items of the Poynting theorem actually is produced by a summation of many mutual energy current items. Hence we can say the macrocosm self energy current or the Poynting energy current is produced by the microcosm mutual energy currents.

For the mutual energy current, the energy transfer is centered at the line linked the emitter and the absorber. However, we derived it from a 3D radiation picture. The mutual energy current can go any other path road, for example the double slits. The energy current can go many different paths, but only the path close to the line linked the emitter and the absorber are all synchronized, other path are out of phase and has very small contribution. Hence the mutual energy current and the mutual energy wave guide described in this article actually offers the behind scenes of the Feynman path integral principle of quantum physics.

We believe that the wave function collapse in quantum physics actually caused by the misunderstandings that the wave energy is transferred by Poynting energy current or self-energy current. In that case the retarded energy transferred from emitter must be collapsed to the absorber. The advanced wave transfer negative energy from absorber to the emitter has to be collapsed to the emitter. However, we have proved that the mutual energy current can transfer the energy too, in this case we can throw away the self-energy current items, let the mutual energy current to take over the task originally should be done by self-energy current. The concept of the wave function collapse of the Copenhagen interpretation doesn't need any more in the authors' photon model theory.

This section tells us, if photon is composed as an emitter and an absorber, and the emitter sends retarded wave and the absorber send advanced wave, and photon satisfy mutual energy theorem in microcosm, then the system with infinite photons also satisfy the Poynting theorem in macrocosm. This is very important, because this means that even the Poynting theorem can not offers the concrete position of a singular photon but it still can provide the possibility where the photon should be. This offers the reason of the possibility is appeared in quantum physics. In our photon model the possibility is still there but it has more grounded basis.

We stared from the mutual energy theorem in microcosm, proved that in the macrocosm the Poynting theorem is satisfied, in turn this means that it satisfies the Maxwell equations (We have said that Poynting theorem is nearly equivalent to Maxwell equations in practical). This means that the mutual energy current, the mutual energy theorem are more fundamental concepts than the self-energy current and Poynting theorem in microcosm. The Poynting theorem in macrocosm is different concept compare to the self-energy current related to the Poynting vector of the emitter's field or the absorber's field.

7 The polarization or spin of the photon

In the quantum physics, it is said the photon has spin, the photon have the energy $E = \nu h$, where ν is the frequency, h is plank constant. This formula cannot obtained from traditional Maxwell electromagnetic field theory. This should be the result of quantum physics. The emitter and absorber can only receive and transmit package energy νh. But with the mutual energy theorem it is clear that how the energy is transferred in the free space.

It is similar, it is said the the angular momentum of the spin of the photon can only be $J = \hbar$, where $\hbar = \frac{h}{2\pi}$. This result cannot be obtained from the electromagnetic field theory. This is the result of the emitter and absorber. The emitter and absorber can only change their angular momentum as integer times of $\hbar$, hence photon can only have the spin momentum of $J = (-1, 0, +1)\hbar$. The concept of spin is related the the concept of polarization. The electromagnetic field theory should be possible to offer how the linear and circular polarization of fields.

According the discussion of foregoing section about the mutual energy current we can offer 2 kind of polarization model for photon.

7.1 TE and TM mode of electromagnetic field

According to the foregoing theory of mutual energy current, the energy is transferred by mutual energy current. The field of the mutual energy current is looks like the wave in a wave guide. The two ends of this wave guide are two sharp tips. The middle of the wave guide become very wide. The wave inside the this so called mutual energy current wave guide can also have TE and TM mode of waves like normal round cylinder wave guide. Hence there are two kind of mutual energy current

$$Q_{12i}^{TE} = \oiint_{\Gamma} (\overrightarrow{E}_{1i}^{TE} \times \overrightarrow{H}_{2i}^{TE} + \overrightarrow{E}_{2i}^{TE} \times \overrightarrow{H}_{1i}^{TE}) \cdot \hat{n} d\Gamma$$

$$Q_{12i}^{TM} = \oiint_{\Gamma} (\overrightarrow{E}_{1i}^{TM} \times \overrightarrow{H}_{2i}^{TM} + \overrightarrow{E}_{2i}^{TM} \times \overrightarrow{H}_{1i}^{TM}) \cdot \hat{n} d\Gamma$$

where $\overrightarrow{E}_{1i}^{TE}, \overrightarrow{H}_{1i}^{TE}$ are TE wave of the emitter. $\overrightarrow{E}_{1i}^{TM}, \overrightarrow{H}_{1i}^{TM}$ are TM wave of the emitter. It is same to the absorber there are also TE and TM wave. The TE and TM wave are perpendicular to each other. Hence the TE and TM wave can produce the the linear and circular polarization. The circular polarization can cause the photon spin.

7.2 Electric field and magnetic field parallel to each other

In last section Figure 8 has shown, it is possible that the electric field and the magnetic field of the emitter are parallel to each other. In this situation the self-energy current vanishes (actually the returned self-energy current cancel the original self-energy current. The total self-energy of the original self-energy current and the returned self-energy current vanishes). But the electric field and magnetic field of the emitter and the absorber doesn't vanish. In this time the electric field must parallel to the magnetic field, see Figure 8. The mutual energy current there is,

$$Q_{12i} = \oiint_{\Gamma} (\overrightarrow{E}_{1i} \times \overrightarrow{H}_{2i} + \overrightarrow{E}_{2i} \times \overrightarrow{H}_{1i}) \cdot \hat{n} d\Gamma$$

We assume that the current of the emitter is at the direction of $\hat{z}$ and the absorber is at the direction of $\hat{x}$, see figure 8. This can guarantee the two magnetic fields $\overrightarrow{H}_{1i}$ and $\overrightarrow{H}_{2i}$ are perpendicular. If the above two magnetic field are perpendicular, the electric field $\overrightarrow{E}_{1i}$ and $\overrightarrow{E}_{2i}$ will also be perpendicular or at least close to perpendicular. there are two items in the above formula, $\overrightarrow{E}_{1i} \times \overrightarrow{H}_{2i}$ and $\overrightarrow{E}_{2i} \times \overrightarrow{H}_{1i}$, from Figure 8 we know along the line between the emitter to the absorber, $\overrightarrow{E}_{1i}$ just perpendicular to $\overrightarrow{E}_{2i}$, this made them perfectly to build a polarized field. If $\overrightarrow{E}_{1i} \times \overrightarrow{H}_{2i}$ has the same phase with the item $\overrightarrow{E}_{2i} \times \overrightarrow{H}_{1i}$, we obtain a linear polarized field. If the two items have 90 degree in phase difference, we will obtain a circular polarized field. If it is circle polarization, then it can be seen as spin. $\overrightarrow{E}_{1i} \times \overrightarrow{H}_{1i}$ and $\overrightarrow{E}_{2i} \times \overrightarrow{H}_{2i}$ to produce the polarization.

Now the above model tells us the two electric fields $\overrightarrow{E}_{1i}$ and $\overrightarrow{E}_{2i}$ are perpendicular if the current of absorber is perpendicular to the current of the emitter.

It is interesting to notice this two items $\overrightarrow{E}_{1i} \times \overrightarrow{H}_{2i}$ and $\overrightarrow{E}_{1i} \times \overrightarrow{H}_{1i}$ are both with the retarded field and the advanced wave. If the electric field is retarded wave of the emitter, then the corresponding magnetic field is advanced wave of the absorber and vice versa. Hence to the polarization or spin of the photon the emitter and the absorber must all involved. For the polarization or spin, the absorber is involved which is the actually the reason of the delayed choice experiment of the J. A. Wheeler [18]. We do not make assumption that the current of the absorber is caused by the retarded wave. Instead we assume the absorber sends advanced wave randomly and automatically same as the emitter. If the current of the absorber is caused by the retarded wave of the emitter, we have to answer the question that why this absorber react to the retarded wave instead of the other absorber. We believe the absorber should be same as the emitter if the emitter can randomly and automatically sends the retarded wave, the absorber will also randomly and automatically sends the advanced wave. None is the absolute cause and none is the absolute result.

8 Results

We often say photon has spin. The spin angular momentum is 0 or $\pm\hbar$. This perhaps is caused by the atom or electron system which can only loss or increase 0 or $\pm\hbar$ amount.

8.1 Mutual energy theorem

The retarded wave of the emitter and the advanced wave of the absorber together produce the mutual energy current. For the photon, the energy transfer from emitter to the absorber can be done only by the mutual energy current.

8.2 Self-energy current theorem

Self-energy currents of the emitter and absorber cannot vanish, we need self-energy current to cooperate with the mutual energy current to send the energy from the emitter to the absorber. The self-energy current is sent to infinity. But after the energy transfer process finish, the self-energy current must return to their sources, otherwise, the system with emitter and absorber will lose the energy, and this energy is sent to outside of our universe, that is not possible. According the above discussion, there is 5 possibility for the self-energy currents.

(a) The retarded self-energy current of the emitter is sent to infinity and the advanced self-energy current of the absorber is sent to the infinity. Hence, the absorber obtains the energy from the self-energy current. The self-energy current and the mutual energy current each has contributed half of the energy transfer from emitter to the absorber.

(b) The retarded wave of the emitter is canceled by the advanced wave of the emitter. The advanced wave of the absorber is canceled by the retarded wave of the absorber. Hence, the self-energy current of the emitter and absorber doesn't transfer any energy.

(c) the retarded self-energy current of the emitter return to the emitter. The advanced self-energy current returns to the absorber. The self-energy currents do not have any contribution to the energy transferring from emitter to the absorber.

(d) Same as (c) but the returned field modified the field of the mutual energy current. In this situation, the self energy current has no contribution to the energy transfer, but since the fields is modified, the current of the absorber and the current of the emitter must perpendicular. This made the electric field of the emitter is parallel to the magnetic field of the emitter and made the electric field of the absorber is parallel to the magnetic field of the absorber. In microcosm, self-energy current doesn't transfer any energy.

(e) Self energy current of emitter collapse to the absorber. Self energy current of absorber collapsed to the emitter.

All the above discussion are at the empty space. Now if we think a special situation, the emitter and the absorber is separated by a wall. In the wall there is small hole. Hence light can go through the hole from emitter to the absorber. In this situation the most of the self energy current cannot go through the hole, hence the self-energy current cannot be received by the absorber. It is even not possible to collapse to the absorber. In this situation seems it is not possible for the self energy current to reach from emitter to the absorber, hence the idea (a) and (e) should be removed from the possible candidates of the photon models. The idea (b) require to send the self-energy current to the infinity. But if the emitter is inside a metal box, there is a small hole on the wall of the box. The self-energy current can not reach from the inside of the box to the infinity. Hence there is only the idea of (c) and (d) left. Hence (c) and (d) is the most possible possibility of the photon model. Both these two situation, the self-energy current in microcosm has no contribution to the self-energy current of macrocosm which is the energy current related to the Poynting vector.

Among the (c) and (d) the authors more like the the idea of (d), since for (c) there need to support TE and TM waves in the mutual energy current wave guide. According to our experience in microwave technology, to produce a TE and TM wave need two perpendicular currents of sources, which make things more complicate. In the emitter, the current which a electron spring from a high level to a lower level energy, should only run in one direction. In the idea (d), the current of the emitter and absorber only runs at one direction and hence is better to be accept. Even in the case the electron in free space, the current of the electron is also only in one direction. To restrict the currents of the emitter and the absorber to be perpendicular to each other, makes the pair of the emitter and absorber more difficult to be synchronized. It needs not only synchronized in the time window but also need a current direction window. This can reduce the possibility too many absorbers can synchronized with one emitter. In that case we have to deal which absorber wins the emitter.

8.3 Photon current

In idea (b) of the last subsection, the emitter and absorber all sends retarded wave and advanced wave. To make things simple, we can assume the emitter has a retarded current and an advanced current. The retarded current only produces retarded wave. The advanced current only produces advanced wave. It is same to the absorber. The absorber has an advanced current and retarded current. The advanced current of the absorber can only produce advanced wave. The retarded current of the absorber only produces the retarded wave. The advanced self-energy current of the emitter/absorber can cancel the retarded self-energy current of the emitter/absorber. We can assume that the retarded current of the emitter/absorber is equal to the advanced current of the emitter/absorber, but the two current equal each other is not obligatory.

8.4 The electric and magnetic fields

In the subsection 8.2, even the self-energy currents cancel each other, it is possible the electric and magnetic fields of the emitter and the absorber do not vanish. For example, if the electric field and magnetic field are parallel to each other, they do not vanish and have no contribution to the self-energy current. The electric and magnetic doesn't vanish, which will guarantee that the mutual energy current can be transferred.

8.5 Maxwell equations

We have assumed that in the microcosm the fields of the photon model largely satisfies the Maxwell equations. Here we speak largely is because we actually modified the Maxwell equation some how.

1. the absorber theory actually conflict with Maxwell equation. From the Maxwell equations we can deduce that singular photon can emit the energy. But the absorber theory tell us that there must have an emitter and am absorber otherwise it cannot have the emitting process. The emitting process is a result there are a simultaneously absorb process.

2. For example in idea(a) we have assume the future infinity is connected to the past infinity. This requirement cannot derived from the Maxwell equations.

3. In idea (c) we assumed that there exists a return wave. The return wave needs time-reversed Maxwell equations. Hence we have to modify the Maxwell equation.

4. In idea(d), we assume there is no self energy current. The self-energy current vanishes. This also violate the Maxwell equations. Self-energy current is a result of Maxwell equations for singular electron system. In this case we have to assume that there at least two electrons, one is emitter the other is absorber. It is possible there are more electrons involved, for example at the situation there are two or more photons in the system in which they are entangled. In this more electrons' system all the self energy currents vanishes. In this situation that the modified Maxwell equation should be,

We can assume that our modified Maxwell equation is the following,

$$\nabla \times (\overrightarrow{H}_1 + \overrightarrow{H}_2) = (\overrightarrow{J}_1 + \overrightarrow{J}_2) + \partial(\overrightarrow{D}_1 + \overrightarrow{D}_2) \tag{68}$$

$$\nabla \times (\overrightarrow{E}_1 + \overrightarrow{E}_2) = -\partial(\overrightarrow{B}_1 + \overrightarrow{B}_2) \tag{69}$$

Since, this function has more variable, it has infinite solution, we can continue offer some conditions to restrict the solutions. We chose the self-energy vanish conditions,

$$\nabla \cdot (\overrightarrow{E}_1 \times \overrightarrow{H}_1) = 0 \tag{70}$$

$$\nabla \cdot (\overrightarrow{E}_2 \times \overrightarrow{H}_2) = 0 \tag{71}$$

$$\iiint (\overrightarrow{E}_1 \cdot \overrightarrow{J}_1) dV = 0 \tag{72}$$

$$\iiint (\overrightarrow{E}_2 \cdot \overrightarrow{J}_2) dV = 0 \tag{73}$$

From Eq.(68,69), we still have Poynting theorem as following for an photon with one emitter and one absorber,

$$-\oint\!\!\!\!\oint_{\Gamma} (\overrightarrow{E}_1 + \overrightarrow{E}_2) \times (\overrightarrow{H}_1 + \overrightarrow{H}_2) d\Gamma = \iiint (\overrightarrow{E}_1 + \overrightarrow{E}_2)(\overrightarrow{J}_1 + \overrightarrow{J}_2) dV$$

$$\iiint [(\overrightarrow{E}_1 + \overrightarrow{E}_2) \cdot \partial(\overrightarrow{D}_1 + \overrightarrow{D}_2) + (\overrightarrow{H}_1 + \overrightarrow{H}_2) \cdot \partial(\overrightarrow{B}_1 + \overrightarrow{B}_2)] dV$$

However considering self energy vanishing conditions Eq.(70-73) we obtained that the mutual energy formaula.

$$-\oint\!\!\!\!\oint_{\Gamma} (\overrightarrow{E}_1 \times \overrightarrow{H}_2) d\Gamma = \iiint (\overrightarrow{E}_1 \cdot \overrightarrow{J}_2 + \overrightarrow{E}_2 \cdot \overrightarrow{J}_1) dV$$

$$\iiint \overrightarrow{E}_1 \cdot \partial\overrightarrow{D}_2 + \overrightarrow{E}_2 \cdot \partial\overrightarrow{D}_1 + \overrightarrow{H}_1 \cdot \partial\overrightarrow{B}_2 + \overrightarrow{H}_2 \cdot \partial\overrightarrow{B}_1] dV$$

$$\iiint \overrightarrow{E}_1 \cdot \partial\overrightarrow{D}_1 dV + \iiint \overrightarrow{E}_2 \cdot \partial\overrightarrow{D}_2 dV$$

$$\iiint \overrightarrow{H}_1 \cdot \partial\overrightarrow{H}_1 dV + \iiint \overrightarrow{H}_2 \cdot \partial\overrightarrow{H}_2 dV$$

We would like to add following self energy vanish to the above formula, in that case it be come the mutual energy formula.

$$\iiint \overrightarrow{E}_1 \cdot \partial\overrightarrow{D}_1 dV = 0 \tag{74}$$

$$\iiint \overrightarrow{E}_2 \cdot \partial \overrightarrow{E}_2 dV = 0 \tag{75}$$

$$\iiint \overrightarrow{H}_1 \cdot \partial \overrightarrow{H}_1 dV = 0 \tag{76}$$

$$\iiint \overrightarrow{H}_2 \cdot \partial \overrightarrow{B}_2 dV = 0 \tag{77}$$

However that means E_1, H_1 and $E_1$and H_2 all must vanish. That is not possible, so we do not assume the above formula. Hence in the mutual enery formula there also have self energy increase items. Howver the energy in the space will vanish after the photon has transferred the energy from emitter to the absorber. We donot need to care these items. If we make a intergral with time, it is clear there is,

$$\int_{t=-\infty}^{\infty} \{ \iiint \overrightarrow{E}_1 \cdot \partial \overrightarrow{D}_2 + \overrightarrow{E}_2 \cdot \partial \overrightarrow{D}_1 + \overrightarrow{H}_1 \cdot \partial \overrightarrow{B}_2 + \overrightarrow{H}_2 \cdot \partial \overrightarrow{B}_1] dV$$
$$\iiint \overrightarrow{E}_1 \cdot \partial \overrightarrow{D}_1 dV + \iiint \overrightarrow{E}_2 \cdot \partial \overrightarrow{D}_2 dV$$
$$\iiint \overrightarrow{H}_1 \cdot \partial \overrightarrow{H}_1 dV + \iiint \overrightarrow{H}_2 \cdot \partial \overrightarrow{H}_2 dV \} = 0$$

The above formula is that before the photon is send out the photon energy in the space is 0, after the photon is sent from the emitter the energy in the space also must decrease to 0, hence the integral with time vanishes. This means the mutual energy theorem still can be established,

$$-\int_{t=-\infty}^{\infty} \oiint_{\Gamma} (\overrightarrow{E}_1 \times \overrightarrow{H}_2) d\Gamma \, dt = \int_{t=-\infty}^{\infty} \iiint (\overrightarrow{E}_1 \cdot \overrightarrow{J}_2 + \overrightarrow{E}_2 \cdot \overrightarrow{J}_1) dV \, dt$$

A possible situation is the following,

$$\nabla \times \overrightarrow{H}_1 = \overrightarrow{J}_1 + \partial \overrightarrow{D}_2 \tag{78}$$

$$\nabla \times \overrightarrow{H}_2 = \overrightarrow{J}_2 + \partial \overrightarrow{D}_1 \tag{79}$$

$$\nabla \times \overrightarrow{E}_1 = -\partial \overrightarrow{B}_2 \tag{80}$$

$$\nabla \times \overrightarrow{E}_2 = -\partial \overrightarrow{B}_1 \tag{81}$$

have ask the self energy has to return which perhaps need a the field satisfies the time unversed Maxwell equation instead of the Maxwell equation itself. In macrocosm we have proved that the field satisfies the Poynting theorem. In macrocosm satisfies the Poynting theorem will mean that the field nearly satisfies the Maxwell equation.

$$\nabla \times \nabla \times \overrightarrow{H}_1 = \nabla \times \overrightarrow{J}_1 + \partial \epsilon \nabla \times \overrightarrow{E}_2 \tag{82}$$

$$\nabla \times \nabla \times \overrightarrow{H}_1 = \nabla \times \overrightarrow{J}_1 - \epsilon \mu \partial \partial \overrightarrow{H}_1 \tag{83}$$

Similarly there is

$$\nabla \times \nabla \times \overrightarrow{H}_2 = \nabla \times \overrightarrow{J}_2 - \epsilon \mu \partial \partial \overrightarrow{H}_2 \tag{84}$$

This means the magnetic field is still satisfy wave equations.

8.6 Poynting theorem

1.In microcosm the Poynting theorem is problematic. First the self-energy is diverged for the items with current

$$\iiint\limits_V \overrightarrow{J} \cdot \overrightarrow{E} dV$$

Assume V is a sphere. $V = \frac{4\pi}{3} R^3$. In above formula if $\overrightarrow{E} = constent$, when $R \to 0$, $\overrightarrow{J} \sim R^{-3}$, hence $\iiint_V \overrightarrow{J} dV$ is constant which is the current of the emitter. However we know that the electric field of the emitter $\overrightarrow{E} \to \infty$. Hence the above integral

$$\lim_{R \to 0} \iiint\limits_V \overrightarrow{J_1} \cdot \overrightarrow{E_1} dV = \infty$$

In the idea(d) we have to assume the the self energy current vanishes which means that

$$\oiint\limits_\Gamma (\overrightarrow{E}_1 \times \overrightarrow{H}_1) \cdot \hat{n} d\Gamma = 0$$

If the above self energy current doesn't vanish, we have assume it is returned or send to infinity. But in the infinity the future must connected to the past which is also very strange.

In macrocosm, Poynting theorem described the relation between the self-energy current and the current of the emitter. This macrocosm self-energy current is actually caused by infinite mutual currents in microcosm. The microcosm self-energy current is possible all canceled and hence has no any contribution to the macrocosm self-energy current. The microcosm mutual energy theorem is the foundation to the macrocosm Poynting theorem. The mutual energy theorem is more fundamental compare to the Poynting theorem in microcosm. The macrocosm field of infinite more photons satisfies Poynting theorem means that this field also satisfies Maxwell equations allmostly.

The macrocosm Poynting theorem is satisfied is only on the statiscal meanings. The electromagentic field in macrocosm is a all the sumation of superimposed the fields from all photons. Here the photons' field inculdes the advanced field and the retarded field.

The microcosm Poynting theorem is established, that gurantees the microcosm Maxwell equations. Hence Maxwell equation is also only satisfied in statiscal meanings.

8.7 The probability interpretation

The probability interpretation of quantum physics or the Copenhagen interpretation of quantum physics is based the theory of divergence wave. The divergence wave is because of the macrocosm Poynting theorem. After we know the microcosm Poynting theorem is caused by the infinite contributions of the mutual energy current of the photons, we have find the reason of the Copenhagen interpretation for the photon and the quantum. If we use Poynting energy current to describe the energy current of the photon, which is actually is the mutual energy current, the energy current related to the Poynting vector can only offer a probability for the mutual energy current. Here the electromagnetic field of macrocosm satisfies the Poynting theorem and the field of microcosm satisfies only the mutual energy theorem. All this kind filed are physics fields, no any field here are mathematical field like Copenhagen interpretation.

8.8 Polarization and spin theorem

The wave for mutual energy current very like to transfer in a wave guide, this wave guide has very special shape, it has two ends with very sharp tips, it is very wide in the middle. This wave guide is same as the normal wave guide can transfer TE and TM waves. The two electric fields $\overrightarrow{E}^{TE}$ and $\overrightarrow{E}^{TM}$is perpendicular to each other and hence can transfer linear and circular polarized waves.

There is also another possibility, that the current of absorber must perpendicular to the current of the emitter, only in this way the two magnetic fields produced by the emitter and produced by the absorber can be perpendicular to each other. This made the corresponding two electric fields also perpendicular. The two items in the mutual energy current produce the two items of the polarization. If the two items have no phase difference, it produces the linear polarization. If there is 90 degree difference in phase, the circle polarization is produced. The circle polarization is corresponding to the spin of the photon.

For the polarization in the above two situations, the absorber plays an important role similar to the emitter. This is the really reason for the experiment of delayed choice[7, 18]. In this theory any polarization for example circle polarization, linear polarization and eclipse polarization are all allowed. The authors do not oppose the concept the polarization of photon is only left/right circle polarization. But this theory is a classical electrical theory and hence can not derive quantum effect for the polarization. This theory only tell it is possible to have polarization for photons.

8.9 Synchronization theorem

The mutual energy current must synchronized. That means only when the retarded wave of the emitter reaches the absorber, in this particle time the absorber just sends its advanced wave out, the two waves produce the mutual energy current. The two waves must have same frequency. Perhaps needs that the current of the absorber must be perpendicular to the current of the emitter. We can assume the emitter and absorber always send the self-energy current out, if there is no any mutual energy produced by the above mentioned synchronization, the self-energy (positive or negative) will return to the emitter or absorber, and hence can not have any influence to others. Only when the time windows, frequency of waves, the directions of current of the absorber and emitter, all this conditions are satisfied, the mutual energy current can happens. The photon is just this mutual energy current. The Poynting theorem in macrocosm offers the the possibility the photon will appear in which place. There is the possibility that two or more absorbers satisfy the above conditions simultaneously. However, we assume this possibility is very low. If the two absorbers satisfy the same condition, why only one can wins and to produce the mutual energy and become a photon? John Cramer introduced the concept of transaction [4, 5]. However why has this transaction. This question is still open.

8.10 Mutual energy theorem

If this photon model is correct, the mutual energy theorem in Fourier domain is a real physics theorem. The Lorentz reciprocity theorem is only a mathematical deformation of the mutual energy theorem. The mutual energy theorem is actually more fundamental compare to the Poynting theorem and the Lorentz reciprocity theorem. Even the Lorentz reciprocity theorem is so popular in the electromagnetic field theory and the mutual energy theorem has not win the popularity.

8.11 The frequency and speed of the light

We have speak the light speed is c. Actually if in a light beam there are two photons which are received by two different absorbers. Assume these two absorbers with different speeds to move along the direction of the light beam, compare to a world coordinates. Assume the emitter is fixed inside the world coordinates. Since the retarded wave of the emitter have to synchronized with the advanced wave of the absorbers, the two photons' will have different frequencies, which are decided by the two absorbers. The speed of the light is also fixed with to the absorbers.

ideas\conditions	I	II	III	IV	V	VI	VII
(a)	Y	Y	Y	N	Y	N	N
(b)	Y	Y	Y	N	Y	Y	N
(c)	Y	Y	Y	Y	Y	Y	N
(d)	Y	Y	Y	Y	Y	Y	Y
(e)	N	N	Y	N	Y	N	N
(f)	N	N	Y	N	Y	N	N

Table 1: Comparison of different self energy situations. In the table (a) The self energy current contributes the half of the energy transfer. (b) The electron(emitter or absorber) send the retarded wave in the same time send advanced wave hence self energies do not contributes the energy transfer. (c) The self energy return to the emitter or absorber, self energies do not contribute to the energy transfer. (d) Self energy current vanishes. (e) The self energy of the emitter collapsed at the absorber, the self energy of the absorber collapse to the emitter. I is satisfying the Maxwell equations. II The electromagnetic field must converges. III energy current should be possible to go through double slits. IV the light source should be possible to be put inside of a metal container and the photon energy current should be possible to go through a hole on the wall of the container. V the macrocosm field should satisfies the Poynting theorem. VI support polarization or spin. VII the current must simple. VIII the wave do not collapse.

8.12 Comparison of difference self energy situations

The mutual energy can transfer the energy it seems no problem according the discussion of this articles, however for the self energy we have offers 5 different situations (a),(b), $\cdots$,(e) in the sub-section **??**.. In sub-section **??** I,II, $\cdots$,VII. The following table offers the results. It is seem the (e) is the best to meet all the conditions from I to VII. In the (e), there is no the self-energy current. There is only the mutual energy current, the mutual energy current transfers the energy. The current source of (e) also support simple current, in which the current is only one direction. (c) and (d) is the second best ideas, in which the only problem is they require a little bitter complicate current sources for the emitter and the absorber. Please see the result in table 1. (I) The electromagnetic field of the photon model should satisfies Maxwell equations.

(II) The electromagnetic fields of the photon model should not be diverged. If the field is diverged like the water waves, it need a concept of wave function collapse. We do not support the concept of wave function collapse, hence we seeks the solution which support converged wave that the wave is allowed to be spread out in the beginning but it has to b converged in the end, so the absorber can receive it without any wave function collapse. This wave somehow like the solitary particles.

(III) The photon should be possible to go through a hole or double slits.

(IV) The light sources or emitter should be possible put inside a metal container with a hole. The photon should be possible to send out from this hole.

(V) The macrocosm field which is the total contribution of the field of many photons should satisfy the Poynting theorem and hence produce a diverged field. In (II) we have said that the field of microcosm can not be diverged, but the macrocosm field must be diverged like the water waves.

(VI) The field of photon model have to support the polarization that means it must have two items and for the two items the electric fields are perpendicular, and for two items should be possible to allow a phase difference -90 to 90 degrees.

(VII) the current of the emitter and the absorber must very simple, which have only one directions. Here we do not allow the complicated sources for example like a antenna arrays. The current of the emitter or absorber should be just have only in one direction.

From table 1 the idea (d) is the best candidate for the correct photon model. In (d) the self energy current doesn't exist. Be cause it meet all the condition from I to VII. The second one is (c), in (c) the self energy current emits and then returns, the only shortcoming is the current source must a little bit complicate, i.e doesn't meet the condition VII. Next candidates are (a) and (b), that need the self energy current to be sent to infinity, which cannot support by condition IV (there is a metal container). (e) and (f) need the wave function collapse, they do not meet nearly all conditions, between (e) and (f), (e) still better the (f). In (e) there is the collapse for the self-energy current, the mutual energy current doesn't not collapse. In this situation we still can think energy current is transferred through the mutual energy current, after it happens, there is some reason the self energy collapse to the mutual energy. In (f) all energy current collapses.

From the above comparison we have known that actually the Maxwell equation can offers the very good model to support the photon model. The concept of the wave function collapse actually is not necessary. The idea (d) actually is the solitary wave, the wave energy doesn't spread out. It is even better than the the solitary wave, because so called solitary wave is the wave not spreading out, but the idea (d) offers a wave first spreads out then converge to a point. It is not easy for a solitary wave to go through the double slits. The wave supported by idea d) has no problem to go through the double slits.

9 Conclusion

The photon model is built. The photon model is composed as an emitter and an absorber. The emitter sends the retarded wave and the absorber sends the advanced wave. The retarded wave of the emitter and the advanced wave of the absorber together produces the mutual energy current. In one situation, the self-energy current has contribution to the energy transfer of the photon. The emitter send the retarded energy to the infinity and the absorber send negative energy energy to the infinity. This makes the self-energy carries a part of energy from emitter to the absorber. The mutual energy current also transfers energy. The self-energy and mutual energy each carries a half-energy from the emitter to the absorber.

In another situation, we have assumed that the current of the emitter and the absorber all send half retarded wave and half advanced wave. The self-energy items are canceled, because the pure energy gain or loss are zero. In the microcosm self-energy items have no any contribution to the energy transfer of the photon. The self-energy current items in macrocosm are the contribution of all mutual energy current of infinite photons. In microcosm, the self-energy current which is the energy current corresponding to Poynting vector has no contribution to energy transferring. However, we have proved that if the mutual energy theorem established in microcosm for photons, the Poynting theorem is established also in macrocosm. We also obtain the equations photon should satisfy, which is just the Maxwell equations. In this situation the wave for mutual energy current can be seen as the wave in a special guide, which has two very sharp tips in the two ends, and very wide in the middle. This wave guide can support TE and TM waves. The linear and circle wave polarization can be supported by this TE and TM waves.

Another situation is the self-energy current is return back from infinity. Hence, the mutual energy current is the only one can transfer energy. Since the self-energy current returns, the total self-energy current vanishes, but the electromagnetic field did not vanishes. In this situation the electric field is parallel to the magnetic field. From this equation we can find a solution in which the absorber is perpendicular to the emitter. The mutual energy current has two items which can be applied to interpret the line polarization / circle polarization and hence interpret the concept of spin of the photon.

The above photon models is derived from electromagnetic field with Maxwell theory, but it is possible this theory is also suitable to the wave of other particles, for example electrons.

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