Self-energy principle with a time-reversal field is applied to photon and electromagnetic theory

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Abstract

The photon energy transfer is from point to point. But the wave according to the Maxwell equation spreads from the source point to the entire empty space. In order to explain this phenomenon the concept of wave function collapse is created. This concept is very rough, if there are many partition boards with small holes between the emitter charge and the absorber charge. The light is clear can go through all these small holes from emitter to the absorber. But according to the concept of the wave function collapse the wave must collapse N times if there are N holes on the partition boards. Collapse one is strange enough, if the wave collapse N times, that is unbelievable! In another article we have proved that the photon energy is actually transferred by the "mutual energy flow" which is point to point instead of spread to the entire space. Since energy can be transferred by the mutual energy flow, the concept of the wave function collapse is not necessary. In order to build the mutual energy flow it is required to build the self-energy flow also. The self-energy flow is spread to the entire empty space. What will do for the self-energy flow, it is possible the self-flow also collapse to the absorber. However if self-energy flow collapse we have also meet the same problem as the whole wave collapse that means if there are partition sheets with N holes, the self-energy flow has to collapse N times. In the article about mutual energy principle we have propose another possibility in which the self-energy flow instead collapse, we believe it is returned. It is returned with a time reversal process, hence the self-energy dose not contributed to the energy transfer of the photon. The return process can be seen as also a collapse process, however it is collapse to the source of the wave instead of the target of the wave. In this article we will discuss the self-energy flow and the time reversal process in details.

Keywords: wave function; collapse; Poynting; Maxwell; self-energy;Mutual energy; Mutual energy flow; time reversal; photon; electromagnetic; action-at-a-distance; advanced wave;advanced potential; absorber theory;

1 Introduction

There are two conflictive theories for electromagnetic fields. One is the theory of Maxwell equations, another one is action-at-a-distance. Maxwell's theory claim that the field can be send from its source. The field can be solved with Maxwell equations when the source is known. A single charge can create the electromagnetic field and this field can exist independent to its source. If we measured the field with a test charge, after the measurement when the test charge is removed, the field we have measured still exists and does not vanish. In other hand Schwarzschild, Tetrode and Fokker introduced the theory of action-at-a-distance, it is also referred as direct interaction[16, 7, 18]. In the theory of action-at-a-distance advanced wave is involved. Dirac has applied advanced wave to explain the force of a moving charge[6]. Wheeler and Feynman, designed the absorber theory according to the the principle of the action-at-a-distance. In the absorber theory the electromagnetic field has no its own freedom and the electron charge does not only sends the retarded waves to the future but also sends advanced wave to the past [1]. Wheeler and Feynman also introduced the concept of the adjunct field[2]. In the action-at-a-distance principle, the electromagnetic field has no its own freedom, the field is the action, which take place at least between two charges. With only one charge, it cannot define a action or a field. Hence we can measure a electromagnetic field with a test charge, but after the measurement, when the test charge is removed, according to the principle of the action-at-a-distance, the field is not defined, since the action can only be created by at least two charges, now there is only one charge, the source charge.

What about the measured electromagnetic field, after the test charge is removed? According to Maxwell's theory the measured field is still there, but according to action-at-a-distance the field is not defined or doesn't exist. Which theory is correct? Even there are many scientists supports the action-at-a-distance and the absorber theory, they still cannot deny the Maxwell's theory, because to answer this question cannot be done by a experiment, for example test the field by a single charge. None knows the electromagnetic field exist or not in the time we have removed the test charge. This question appears as a philosophy problem instead of a problem of physics.

This is major problem of the classical electromagnetic field theory. Many problem related this problem, for example, (1) wave and particle duality, (2) quantum entanglement, (3) is the superimposition principle correct or not? (4) the electromagnetic field is a real wave or a probability wave? advanced wave exist or not and wave function collapse.

This author endorse the concept of the action-at-a-distance and introduced the mutual energy principle[]. For sure we know that the Maxwell's theory has great value. Hence this author has combined the principle of action-at-a-distance and the Maxwell's theory together in the mutual energy principle. According to the mutual energy principle, the electromagnetic fields still can be produced by one charge. However the fields must satisfies the mutual energy principle instead of Maxwell equations. A electromagnetic field of a single charge cannot satisfy the mutual energy principle. In order to satisfy the mutual energy principle, there are at least has two charges, one is the emitter, another is the absorber. The emitter can sends the retarded wave. The absorber can send advanced wave, When these two wave take place in the same time or they are synchronized together, the mutual energy principle is satisfied and there are mutual energy flow which is produced between the emitter and the absorber. The mutual energy principle can be solved to find the retarded wave for the emitter and the advanced wave of the absorber. The two waves both the retarded wave and the advanced waves satisfy two groups of the Maxwell's equations. There must at least be two group Maxwell's equations, one is for the emitter and another is for the absorber. The time-integral of the mutual energy flow is just the transferring energy between the emitter and the absorber. The photon is nothing else, it is just the mutual energy flow between the emitter and the absorber. In the mutual energy principle, the field still created by emitter or by absorber alone this is like the Maxwell theory.

Another important origin of the mutual energy principle is from the mutual energy theorems. The work about the mutual energy theorems can be listed as following. W.J. Welch has introduced time-domain reciprocity theorem[19] in 1960. In 1963 Rumsey shortly mentioned a method to transform the reciprocity theorem to a new formula[15]. In early of 1987 this author has introduced the mutual energy theorem [10, 21, 20]. In the end of 1987 Adrianus T. de Hoop introduced the time domain correlated reciprocity theorem[5]. All these theories are same theory in different domain: Fourier domain or in time domain.

In 2014 this author wrote the online publication discussed the relationship between the reciprocity theorem, the mutual energy theorem and the Poynting theorem[11]. Among this work, this author noticed the book of Lawrence Stephenson[17] and read it with great interesting especially the topic about the advanced potential. Afterwords this author begin search the publications about advanced potential or advanced waves, and noticed the absorber theory of Wheeler and Feynman[1, 2, 8] and John Cramer's transactional interpretation for quantum physics [3, 4]. After read this publications, this author begin to work at building a photon model with classical electromagnetic filed theory[13, 12]. This author believe all these theorems are strongly related to the energy in physics instead of a mathematical theory only describe a relation or a transform, hence call these theorems all as the mutual energy theorem instead of some kind of reciprocity theorem.

All above this authors work is about the mutual energy, and mutual energy flow. However in the electromagnetic field in order to produce the mutual energy and mutual energy flow, the self-energy and the self-energy flow will be created as a side effect. The self-energy flow is the field of the single charge. This energy flow will spread to the entire space. This will cause that the energy of the charge will be lost and go out off our space. This is unbelievable. A guess to solve this problem is that this self-energy wave collapse to its target. The regarded wave from the emitter will collapse to the absorber. The advanced wave of the absorber will collapse to the emitter. This author do not support the concept about the wave function collapse. Since if there are partition board between the emitter and the absorber. If there is a hole in each partition board. The light can go through these holes from the emitter to the absorber. According to the wave function collapse, the wave must collapse at each holes. The wave collapse once at the absorber is strangle enough, if the wave collapse N times in all holes, that is unbelievable. Hence this author claim the self-energy flow collapse to its source that means the wave is returned. This return process is a time reversal process which can be described with time-reversal Maxwell's equations. The self-energy flow is returned with a time reversal process is referred as self-energy principle which will be discussed in details in this article.

In this article when we speak about Maxwell equations, we will explicitly distinguish the two different situations, the first is the Maxwell equations for N (many) charges and the second situation Maxwell equations is only for a single charge. The first is written as MCMEQ (many-charge Maxwell equations), the second is written as SCMEQ (single-charge Maxwell equations). If the electromagnetic fields can be superimposed, It is easy to prove MCMEQ from SCMEQ. Hence we do not need to distinguish these two concepts, however in this article we will question the superimposition principle, hence we have to distinguish these two situations.

2 Find bug in Poynting theorem and MEQN

2.1 Power of a system with N charges

If the charge move and has the speed $\overrightarrow{v}_i$, where i is the index of the charge, we know that,

$$\overrightarrow{J}_i = \rho_i \overrightarrow{v}_i \tag{1}$$

where $\overrightarrow{J}_i$ is the current intensity. ρ_i is the charge intensity. There is,

$$\rho_i = q\delta(\overrightarrow{x} - \overrightarrow{x}_i) \tag{2}$$

and hence the current of the charge is,

$$I_i \equiv \iiint\limits_V \overrightarrow{J}_i dV = \iiint\limits_V q\delta(\overrightarrow{x} - \overrightarrow{x}_i)\overrightarrow{v}_i dV = q\overrightarrow{v}_i \tag{3}$$

we know the power which of single charge is,

$$P(\overrightarrow{x}_i) = \overrightarrow{F}(\overrightarrow{x}_i) \cdot \overrightarrow{v}_i \tag{4}$$

$\overrightarrow{x}_i$ is the position of the charge. $\overrightarrow{F}(\overrightarrow{x}_i)$ is Coulomb's force on i-th charge, which can be given as following,

$$\overrightarrow{F}(\overrightarrow{x}_i) = \sum_{j=1,j\neq i}^{N} \frac{q_i q_j}{4\pi\epsilon_0} \frac{(\overrightarrow{x}_i - \overrightarrow{x}_j)}{||\overrightarrow{x}_i - \overrightarrow{x}_j||^3} \tag{5}$$

where q_i or q_j is amount of charge at the place $\overrightarrow{x}_i$ or $\overrightarrow{x}_j$, write,

$$E(\overrightarrow{x}_j, \overrightarrow{x}_i) = \frac{q_j}{4\pi\epsilon_0} \frac{(\overrightarrow{x}_i - \overrightarrow{x}_j)}{||\overrightarrow{x}_i - \overrightarrow{x}_j||^3} \tag{6}$$

which is the electric field of charge q_j to q_i. Hence, we have

$$\overrightarrow{F}(\overrightarrow{x}_i) = q_i \overrightarrow{E}(\overrightarrow{x}_i) \tag{7}$$

Hence power of charge i is,

$$P_i = q_i \overrightarrow{E}(\overrightarrow{x}_i) \cdot \overrightarrow{v}_i \tag{8}$$

Hence the power of the whole system with N charges is,

$$\begin{aligned} P = \sum_{i=1}^{N} P_i &= \sum_{i=1}^{N} \overrightarrow{E}(\overrightarrow{x}_i) \cdot (q_i \overrightarrow{v}_i) \\ &= \sum_{i=1}^{N} \sum_{j=1, j\neq i}^{N} \overrightarrow{E}(\overrightarrow{x}_j, \overrightarrow{x}_i) \cdot \overrightarrow{I}_i \end{aligned} \tag{9}$$

We find when we calculate the power of N charges, we have used the following summation.

$$\sum_{i=1}^{N} \sum_{j=1, j\neq i}^{N} \tag{10}$$

2.2 The Poynting theorem of N charges

According to the traditional electromagnetic field theory, The Poynting theorem[9] is give as following,

$$-\oint\!\!\!\oint_{\Gamma} (\overrightarrow{E} \times \overrightarrow{H}) \cdot \hat{n} d\Gamma = \iiint_{V} (\overrightarrow{E} \cdot \overrightarrow{J} + \overrightarrow{E} \cdot \partial \overrightarrow{D} + \overrightarrow{H} \cdot \partial \overrightarrow{B}) dV \tag{11}$$

where $\zeta = [\overrightarrow{E}, \overrightarrow{H}, \overrightarrow{J}, \overrightarrow{K}, \overrightarrow{D}, \overrightarrow{B}]$, is electromagnetic field system of N charges, $\overrightarrow{K} = 0$ is the magnetic current intensity. $\partial = \frac{\partial}{\partial t}$, t is time. $\overrightarrow{E}$ is electric field, $\overrightarrow{H}$ are magnetic H-field. $\overrightarrow{J}$ is current, $\overrightarrow{D}$ is electric displacement. $\overrightarrow{B}$ is magnetic B-field. According to the traditional definition, the electromagnetic field of N charges is,

$$\overrightarrow{E}(\overrightarrow{x}) = \sum_{i=1}^{N} \overrightarrow{E}(\overrightarrow{x}_i, \overrightarrow{x}) \tag{12}$$

$$\overrightarrow{H}(\overrightarrow{x}) = \sum_{i=1}^{N} \overrightarrow{H}(\overrightarrow{x}_i, \overrightarrow{x}) \tag{13}$$

It is same to, $\overrightarrow{D}(x)$ and $\overrightarrow{B}(x)$, hence we have,

$$-\oiint_{\Gamma}(\sum_{i=1}^{N}\sum_{j=1}^{N}\overrightarrow{E}(\overrightarrow{x}_i,\overrightarrow{x})\times\overrightarrow{H}(\overrightarrow{x}_j,\overrightarrow{x}))\cdot\hat{n}d\Gamma=\sum_{i=1}^{N}\sum_{j=1}^{N}\overrightarrow{I}_i\cdot\overrightarrow{E}(\overrightarrow{x}_j,\overrightarrow{x}_i)$$

$$+\iiint_V\sum_{i=1}^{N}\sum_{j=1}^{N}(\overrightarrow{E}(\overrightarrow{x}_i,\overrightarrow{x})\cdot\partial\overrightarrow{D}(\overrightarrow{x}_j,\overrightarrow{x})+\overrightarrow{H}(\overrightarrow{x}_i,\overrightarrow{x})\cdot\partial\overrightarrow{B}(\overrightarrow{x}_j,\overrightarrow{x}))dV \quad (14)$$

In the above second item, we have considered that,

$$\iiint_V(\overrightarrow{J}_i\cdot\overrightarrow{E}(\overrightarrow{x}_i,\overrightarrow{x}))dV=\iiint_V(\overrightarrow{I}_i\delta(\overrightarrow{x}-\overrightarrow{x}_i)\cdot\overrightarrow{E}(\overrightarrow{x}_j,\overrightarrow{x}))dV=\overrightarrow{I}_i\cdot\overrightarrow{E}(\overrightarrow{x}_j,\overrightarrow{x}_i) \quad (15)$$

In the above formula we have considered Eq.(1, 2, 3).

2.3 The bug in Poynting theorem and MEQN

We obtain Eq.(9) In the subsection 2.1, and we obtain Eq.(14) in last subsection. Inside the two formulas all have a items,

$$\overrightarrow{E}(\overrightarrow{x}_j,\overrightarrow{x}_i)\cdot\overrightarrow{I}_i \quad (16)$$

But the summations before it are different. This item together with the summation all express the interaction power of all charges in the system. From this comparison, this author believe the Poynting theorem has overestimated the power of all charges in the system.

Using the summation in Eq.(10) to replace the original summation in Eq.(14) we obtain,

$$-\oiint_{\Gamma}(\sum_{i=1}^{N}\sum_{j=1,j\neq i}^{N}\overrightarrow{E}_i\times\overrightarrow{H}_j)\cdot\hat{n}d\Gamma$$

$$=\iiint_V\sum_{i=1}^{N}\sum_{j=1,j\neq i}^{N}(\overrightarrow{E}_i\cdot\overrightarrow{J}_j)dV$$

$$\iiint_V\sum_{i=1}^{N}\sum_{j=1,j\neq i}^{N}(\overrightarrow{E}_i\cdot\partial\overrightarrow{D}_j+\overrightarrow{H}_i\cdot\partial\overrightarrow{B}_j)dV \quad (17)$$

In the above formula we have written $\overrightarrow{E}(\overrightarrow{x}_i,\overrightarrow{x})$ as $\overrightarrow{E}_i$ and we have considered Eq.(15) and replaced $\overrightarrow{I}_i$ by $\overrightarrow{J}_i$ with the integral. The corresponding differential formula is,

$$-\sum_{i=1}^{N}\sum_{j=1,j\neq i}^{N}\nabla\cdot\overrightarrow{E}_i\times\overrightarrow{H}_j$$

$$=\sum_{i=1}^{N}\sum_{j=1,j\neq i}^{N}(\overrightarrow{E}_i\cdot\overrightarrow{J}_j+\overrightarrow{E}_i\cdot\partial\overrightarrow{D}_j+\overrightarrow{H}_i\cdot\partial\overrightarrow{B}_j) \tag{18}$$

The above formula Eq.(17) is the rest items of the Poynting theorem Eq.(14) if all self items are taken away. The all self items are as following,

$$-\oiint_{\Gamma}(\sum_{i=1}^{N}\overrightarrow{E}_i\times\overrightarrow{H}_i)\cdot\hat{n}d\Gamma=\iiint_{V}(\sum_{i=1}^{N}(\overrightarrow{E}_i\cdot\overrightarrow{J}_i)dV$$

$$\iiint_{V}(\sum_{i=1}^{N}(\overrightarrow{E}_i\cdot\partial\overrightarrow{D}_i+\overrightarrow{H}_i\cdot\partial\overrightarrow{B}_i)dV \tag{19}$$

Eq.(18) can be referred as mutual energy formula, which is closed related the mutual energy theorems, [19],[10, 21, 20, 11]. and [5]. This mutual energy formula is correct in two ways. (1), it can be derived from MEQN or from Poynting theorem. If MEQN is correct this formula is also correct, it is easy to prove this. Because we take away all self items which also satisfy Poynting theorem for a single charge. From the Poynting theorem of N charges take away all corresponding Poynting theorem for single charges, this guarantees the rest items still correct if Poynting theorem is correct. Since Poynting theorem can be derived from MEQN, the rest items also satisfy MEQN. (2) The second way to show this formula is correct because it satisfies also the action-at-a-distance principle[7]. The action-at-a-distance principle actually tells us the action and reaction can only happens between two charges, there is no any action or reaction in space sends by single charge. The action-at-a-distance principle has been further developed to as the adjunct field theory of Wheeler and Feynman[2]. The mutual energy formula Eq.(18) is agreed with the action-at-a-distance theory and can be seen as a new definition of the so called adjunct field. Wheeler and Feynman did not point out this formula, they developed a new QED (theory quantum electrodynamics) from their adjunct field theory. Wheeler and Feynman try abandon the classical electromagnetic theory in quantum physics where only a few charges is involved (N is very small).

If someone claim he find a new theorem which is the above mutual energy formula, no any journals can accept it, because it just a direct deduction of Poynting theorem. However we will show that since Maxwell equation, Poynting theorem, superimposition principle all has problems, only this formula still correct, hence it should be applied as an axiom of the electromagnetic theory.

About the the self-energy formula Eq.(19) which is the Poynting theorem for single charge. It need to be taken out that means this formula is problematic. If single charge has a current change $\overrightarrow{J}_i$, according to the Maxwell's theory there is a real physical wave sent from this current change. According to quantum physics double slit experiment, this wave is not a real wave but a probability wave. Experiments shows that the photon is only randomly received by the absorbers which can receive the wave sent out from the emitter charge with current change $\overrightarrow{J}_i$. Traditionally, the people thought that Maxwell's theory is only suitable to the wireless wave which has lower frequency, it is not suitable to the high frequency phenomena like photon. Photons needs quantum theory, quantum electrodynamics or quantum field theory to solve. This author believe the suitable revises from electromagnetic field theory of Maxwell can still keep this theory alive even with the photon's frequency. The key of this is to take out the self-energy items Eq,(19) from the Poynting theorem Eq.(14).

2.4 Comparison of the Poynting theorem and the mutual energy formula

In the following we compare the Poynting theorem Eq.(14) and the mutual energy formula Eq.(17) and see which is more meaningful. The left side of Eq.(17) is,

$$\oiint_{\Gamma}(\sum_{i=1}^{N}\sum_{j=1,j\neq i}^{N}\overrightarrow{E}_i\times\overrightarrow{H}_j)\cdot\hat{n}d\Gamma=0 \tag{20}$$

which is the power sends to outside of our space if Γ is big sphere contains our universe, it is the flux of the energy flow send to outside of the universe, it should vanish. If there is only N charge in a empty space, there should no energy flow go outside according to the action-at-a-distance principle. We have known from the mutual energy theorem[11, 12] if photon's field either retarded field for the emitter or advanced field from absorber, the mutual energy flow vanishes on the big sphere Γ, hence the left side of Eq.(17) vanishes. The second term in the right side of Eq.(17) is the system energy in the space. If started from some time there is no action or reaction to a end time there is also no action and reaction. The integral of this energy vanishes, i.e.,

$$\int_{t=-\infty}^{\infty}\iiint_{V}(\sum_{i=1}^{N}\sum_{j=1,j\neq i}^{N}(\overrightarrow{E}_i\cdot\partial\overrightarrow{D}_j+\overrightarrow{H}_i\cdot\partial\overrightarrow{B}_j)dVdt=0 \tag{21}$$

Substitute Eq.(20 and 21) to Eq.(17), we have the last term,

$$\int_{t=-\infty}^{\infty}\iiint_{V}\sum_{i=1}^{N}\sum_{j=1,j\neq i}^{N}(\overrightarrow{E}_i\cdot\overrightarrow{J}_j)dVdt=0 \tag{22}$$

These terms also vanish. The left side of above formula is the power we have obtained at Eq.(9). The above formula tell us for the whole system, all energy is conserved. There is no any energy sends to outside of our universe (if our universe is composed as N charges). Hence this a corrected formula. The above formula vanishes means that Eq.(17) satisfies the action-at-a-distance theory. The whole power of the system with all charges same as the subsection 2.1. It is much meaningful comparing to the Poynting theorem Eq.(14) in which it has the items,

$$\iiint\limits_V (\overrightarrow{E}_i \cdot \overrightarrow{J}_i) dV = \iiint\limits_V (\overrightarrow{E}(\overrightarrow{x}_i, \overrightarrow{x}) \cdot \overrightarrow{J}_i(\overrightarrow{x})) dV = \infty \tag{23}$$

Since if the charge is a point, there is $\overrightarrow{E}_i = \overrightarrow{E}(\overrightarrow{x}_i, \overrightarrow{x}) \to \infty$, if $\overrightarrow{x} \to \overrightarrow{x}_i$. It also has the items

$$-\oint\!\!\!\oint\limits_\Gamma (\overrightarrow{E}_i \times \overrightarrow{H}_i) \cdot \hat{n} d\Gamma \neq 0 \tag{24}$$

The system always has some energy go to outside even where is empty space without other charges. If the system is our universe, it must be opaque to receive all energy, otherwise our universe will have a continuous loss of energy. Up to now there is no any testimony that our universe is opaque. It is very strange. The following items in Poynting theorem,

$$\sum_{j=1}^{N} \sum_{i=1}^{N} (\overrightarrow{E}_i \cdot \overrightarrow{J}_j) \tag{25}$$

is not the power of the whole system of N charges. It is over estimated the power of a system with N charges! The problem of the Poynting theorem is the cause that a re-normalization process has to be done for quantum physics. This is a bug of the Poynting theorem with N charges. Poynting theorem is derived from MEQN. MEQN is derived from MEQS by apply the principle of superimposition principle. The bug in Poynting theorem is also a bug in either in superimposition principle or in MEQS or the both. We have not found any problem with mutual energy formula Eq.(17).

2.5 The confusion of the definition of the electromagnetic fields

Last subsection we have said, it is possible the superimposition principle has the problem. Now let us to see the concept of the electric and magnetic field. Assume there are N charges in the system, we can calculate the electric field in the place $\overrightarrow{x}$ by superimposition,

$$\overrightarrow{E}(\overrightarrow{x}) = \sum_{j=1}^{N} \overrightarrow{E}(\overrightarrow{x}_j, \overrightarrow{x}) \tag{26}$$

where $\overrightarrow{x}_j$ is the position of the charge q_j, $\overrightarrow{E}(\overrightarrow{x}_j, \overrightarrow{x})$ is the charge q_j produced field in the position $\overrightarrow{x}$, this definition looks good. However if we need to know the field at a the position of any charges, we can write,

$$\overrightarrow{E}(\overrightarrow{x}_i) = \sum_{j=1, j\neq i}^{N} \overrightarrow{E}(\overrightarrow{x}_j, \overrightarrow{x}_i) + \overrightarrow{E}(\overrightarrow{x}_i, \overrightarrow{x}_i) \tag{27}$$

but

$$\overrightarrow{E}(\overrightarrow{x}_i, \overrightarrow{x}_i) = \infty \tag{28}$$

if the charge is a point charge. Hence we have to change the definition of the field as following,

$$\overrightarrow{E}(\overrightarrow{x}) = \begin{cases} \sum_{j=1}^{N} \overrightarrow{E}(\overrightarrow{x}_j, \overrightarrow{x}) & \overrightarrow{x} \notin I \\ \sum_{j=1, j\neq i}^{N} \overrightarrow{E}(\overrightarrow{x}_j, \overrightarrow{x}) & \overrightarrow{x} \in I \end{cases} \tag{29}$$

$I = 1, \cdots i \cdots N$, it is the set of the index of the charges. The above definition does also not very satisfy. Many people will ague that is this correct that the field is extended to the any position without a test charge? According to the principle of action-at-a-distance, only the action and reaction force can be defined, hence the field can only be defined on the charge which is,

$$\overrightarrow{E}(\overrightarrow{x}) = \begin{cases} No\ difinition & \overrightarrow{x} \notin I \\ \sum_{j=1, j\neq i}^{N} \overrightarrow{E}(\overrightarrow{x}_j, \overrightarrow{x}) & \overrightarrow{x} \in I \end{cases} \tag{30}$$

Hence we have 3 version of the definition about the field, which is correct? The concept of superimposition of the fields is very confused. The magnetic field has the same problem we do not discuss it here.

The reason of this confusion is because that if we measure the field we need a test charge. But how can we know if the test charge is removed the measured field is still there? According to the principle of action-at-a-distance, if the test charge is removed, the field can not be defined as a real physics property. It is only an ability to give a force to the test charge, but it is not some thing real with energy in the space. It is also true for the radiation field, if the absorber received a photon, how can we know that the absorber is removed, the photon is still there? If the absorber is removed the retarded radiation field can only be a probability wave in quantum physics. It is not any wave with physical energy in the space. That is the reason many people will argue that after the removal of the test charge or the absorber, the field of the wave is not defined.

From this subsection we are clear that the concept of the field is very confused, actually this means the superimposition principle has problem. There not exist this kind of linear fields which can be simply added together in entire space. The superimposition can only be done at the place where there are a charge. And the electric field at the position of the charge is defined by the contribution of the other charges.

Without the superimposition principle, we can still define fields as a collection of all fields of their charges,

$$\overrightarrow{E}(\overrightarrow{x}) = [\overrightarrow{E}(\overrightarrow{x}_j, \overrightarrow{x}), \cdots E(\overrightarrow{x}_j, \overrightarrow{x}) \cdots] \tag{31}$$

or

$$\overrightarrow{E}(\overrightarrow{x}) = [\overrightarrow{E}_1 \cdots \overrightarrow{E}_j \cdots \overrightarrow{E}_N] \tag{32}$$

we have written $\overrightarrow{E}_j = \overrightarrow{E}(\overrightarrow{x}_j, \overrightarrow{x})$ for simplicity. In this article, we do not assume the superimposition as a principle. fortunately the mutual energy principle do not need the superimposition of the fields.

3 The self-energy principle and the mutual energy principle

According to the above discussion, we introduce the two new principles:

3.1 The self-energy principle

$$-\oiint_{\Gamma}(\sum_{i=1}^{N}\overrightarrow{E}_i \times \overrightarrow{H}_i)\cdot \hat{n} d\Gamma = \iiint_{V}(\sum_{i=1}^{N}(\overrightarrow{E}_i \cdot \overrightarrow{J}_i) dV$$
$$\iiint_{V}(\sum_{i=1}^{N}(\overrightarrow{E}_i \cdot \partial\overrightarrow{D}_i + \overrightarrow{H}_i \cdot \partial\overrightarrow{B}_i) dV$$
$$= 0 \tag{33}$$

The self energy principle tell us that all self-energy items,

(1) Self-power: $\iiint_V(\overrightarrow{E}_i \cdot \overrightarrow{J}_i)dV = 0$

(2) Self-energy increase in the space: $\iiint_V(\overrightarrow{E}_i \cdot \partial\overrightarrow{D}_i + \overrightarrow{H}_i \cdot \partial\overrightarrow{B}_i)dV = 0$

(3) Self-energy flow $\oiint_\Gamma(\overrightarrow{E}_i \times \overrightarrow{H}_i)\cdot \hat{n} d\Gamma = 0$.

The self-energy items all vanishes, is the results of our guess from the following reason.

(1) If the self-energy flow doesn't vanish, the energy will spread to the entail empty space. This energy will be leaving our universe, that is very strange.

(2) If the self-energy flow doesn't leaving our universe, the concept wave function collapse should be introduced. However we have know the energy can be transferred by the mutual energy principle, we will try to avoid the wave function collapse, since wave function collapse process cannot be described by any equation.

(3) If self-power$\iiint_V(\sum_{i=1}^{N}(\overrightarrow{E}_i \cdot \overrightarrow{J}_i)dV \neq 0$, that means the self-field of the charge can produce a force to the current of this charge $\overrightarrow{J}_i$. This do not satisfy the Newton's mechanics law that any object cannot apply a force to itself. A few physicist believe in the electromagnetic field theory this mechanics law should be broken. However this author fell this mechanic law should be insisted.

(4) Absorber theory[1, 2] and a-action-at-distance[16, 7, 18] all do not support the idea the force of a charge can apply a force to itself.

(5) In last section we have found the Poyting theorem of N charges has a over estimation of the power of the system also suggested that the self-energy flow should vanish.

We will discuss this principle more details in later sections. Now we just accept it.

3.2 The mutual energy principle

In the electromagnetic field, from the low frequency bound for example wireless wave to the high frequency bound for example light or x-ray, there is the following mutual energy principle,

$$-\oiint_{\Gamma}(\sum_{i=1}^{N}\sum_{j=1,j\neq i}^{N}\overrightarrow{E}_i\times\overrightarrow{H}_j)\cdot\hat{n}d\Gamma$$

$$=\iiint_{V}\sum_{i=1}^{N}\sum_{j=1,j\neq i}^{N}(\overrightarrow{E}_i\cdot\overrightarrow{J}_j)dV$$

$$\iiint_{V}\sum_{i=1}^{N}\sum_{j=1,j\neq i}^{N}(\overrightarrow{E}_i\cdot\partial\overrightarrow{D}_j+\overrightarrow{H}_i\cdot\partial\overrightarrow{B}_j)dV \tag{34}$$

A important situation is there are only two charges in the system, the other charge do not involved. One charge is the emitter, another charge is the absorber, the above mutual energy principle for the two charge can be written as following,

$$-\nabla\cdot(\overrightarrow{E}_1\times\overrightarrow{H}_2+\overrightarrow{E}_2\times\overrightarrow{H}_1)=\overrightarrow{E}_2\cdot\overrightarrow{J}_1+\overrightarrow{E}_1\cdot\overrightarrow{J}_2$$

$$+\overrightarrow{E}_1\cdot\partial\overrightarrow{D}_2+\overrightarrow{E}_2\cdot\partial\overrightarrow{D}_1+\overrightarrow{H}_1\cdot\partial\overrightarrow{B}_2+\overrightarrow{H}_2\cdot\partial\overrightarrow{B}_1 \tag{35}$$

This is the case of photon. Photon is a two-charge system. One charge is the emitter, another charge is the absorber. Assume the emitter randomly send retarded wave out and the absorber randomly send the advanced wave out.

3.3 The field of the emitter and the absorber

The mutual energy principle for two charges which is an emitter and an absorber can be changed as following,

$$-\nabla\times\overrightarrow{E}_1\cdot\overrightarrow{H}_2+\nabla\times\overrightarrow{H}_2\cdot\overrightarrow{E}_1-\nabla\times\overrightarrow{E}_2\cdot\overrightarrow{H}_1+\nabla\times\overrightarrow{H}_1\cdot\overrightarrow{E}_2$$

$$=\overrightarrow{E}_2\cdot\overrightarrow{J}_1+\overrightarrow{E}_1\cdot\overrightarrow{J}_2$$

$$+\overrightarrow{E}_1\cdot\partial\overrightarrow{D}_2+\overrightarrow{E}_2\cdot\partial\overrightarrow{D}_1+\overrightarrow{H}_1\cdot\partial\overrightarrow{B}_2+\overrightarrow{H}_2\cdot\partial\overrightarrow{B}_1 \tag{36}$$

Or

$$-(\nabla\times\overrightarrow{E}_1+\partial\overrightarrow{B}_1)\cdot\overrightarrow{H}_2+(\nabla\times\overrightarrow{H}_1-\overrightarrow{J}_1-\partial\overrightarrow{D}_1)\cdot\overrightarrow{E}_2$$
$$-(\nabla\times\overrightarrow{E}_2+\partial\overrightarrow{B}_2)\cdot\overrightarrow{H}_1+(\nabla\times\overrightarrow{H}_2-\overrightarrow{J}_2-\partial\overrightarrow{D}_2)\cdot\overrightarrow{E}_1$$

$$= 0 \tag{37}$$

From the above equations we can obtained the conclusions, that if $\xi_1 = [\overrightarrow{E}_1, \overrightarrow{H}_1] = 0$, then $\xi_2 = [\overrightarrow{E}_1, \overrightarrow{H}_1]$ can take,

$$\begin{cases} \nabla \times \overrightarrow{E}_2 + \partial \overrightarrow{B}_2 = arbitrary < \infty \\ \nabla \times \overrightarrow{H}_2 - \overrightarrow{J}_2 - \partial \overrightarrow{D}_2 = arbitrary < \infty \end{cases} \tag{38}$$

This means $\xi_2 = [\overrightarrow{E}_2, \overrightarrow{H}_2]$ can take arbitrary values. Vice versa, if $\xi_2 = [\overrightarrow{E}_2, \overrightarrow{H}_2] = 0$, then $\xi_1 = [\overrightarrow{E}_1, \overrightarrow{H}_1]$ can take arbitrary values. All these are not the physics solutions we are looking for. Hence ξ_1 and ξ_2 must nonzero in the simultaneously.

We know the MEQS are the sufficient conditions of the mutual energy principle, hence we can got the solution of the mutual energy principle by solving the MEQS. One of the solution of the above photon equation is MEQS solutions which is,

$$\begin{cases} \nabla \times \overrightarrow{E}_1(t) = -\partial \overrightarrow{B}_1(t) \\ \nabla \times \overrightarrow{H}_1(t) = +\overrightarrow{J}_1(t) + \partial \overrightarrow{D}_1(t) \end{cases} \tag{39}$$

and

$$\begin{cases} \nabla \times \overrightarrow{E}_2(t) = -\partial \overrightarrow{B}_2(t) \\ \nabla \times \overrightarrow{H}_2(t) = +\overrightarrow{J}_2(t) + \partial \overrightarrow{D}_2(t) \end{cases} \tag{40}$$

It must notice that we are looking the solutions $\zeta_1 = [\overrightarrow{E}_1, \overrightarrow{H}_1, J_1]$, $\zeta_2 = [\overrightarrow{E}_2, \overrightarrow{H}_2, J_2]$ nonzero simultaneously. Here we use ζ to express field together with the source and ξ to express only the field. In the above discussion, if $\xi_1 = [\overrightarrow{E}_1, \overrightarrow{H}_1] = 0$, $\xi_2 = [\overrightarrow{E}_2, \overrightarrow{H}_2] \neq 0$, this is not a physical solution of the mutual energy principle and which is not what we are looking for. However we if $\xi_1 = [\overrightarrow{E}_1, \overrightarrow{H}_1] = 0$, $\xi_2 = [\overrightarrow{E}_2, \overrightarrow{H}_2] \neq 0$ and still satisfy the above MEQS Eq.(40), we will say that the $\xi_2 = [\overrightarrow{E}_2, \overrightarrow{H}_2] \neq 0$ is a probability wave. The solution $\xi_2 = [\overrightarrow{E}_2, \overrightarrow{H}_2] \neq 0$ is not exist as physics solution but it still can be a mathematical solution. Vice versa, $\xi_2 = [\overrightarrow{E}_2, \overrightarrow{H}_2] = 0$, $\xi_1 = [\overrightarrow{E}_1, \overrightarrow{H}_1] \neq 0$ and satisfy MEQS Eq.(39) can be seen as a mathematical solution with the interpretation of probability. This way we have offers a very good explanation about the probability interpretation about MEQS. This means if we take the mutual energy principle as axiom of electromagnetic field theory, very naturally obtained that the solution MEQS is a probability wave. This also shows the advantage that take the mutual energy formula as the axiom of the electromagnetic theory than MEQS.

4 Mutual energy theorem and the mutual energy flow

4.1 W.J. Welch's time domain reciprocity theorem

Assume $\xi_1 = [\overrightarrow{E}_1, \overrightarrow{H}_1]$ is retarded wave, $\xi_2 = [\overrightarrow{E}_2, \overrightarrow{H}_2]$ are advanced wave. Assume the electromagnetic field waves are only short time impulses. ξ_1 and ξ_2 satisfy Eq(39,40) and are synchronized.

In the beginning the electromagnetic energy in the space are 0. The energy in the space is increased in the time there is energy transfer between the emitter(transmitter) or the absorber(receiver). When the impulse finish, the energy in the space decrease to 0 again, hence there is,

$$\int_{-\infty}^{\infty} \iiint_V (\overrightarrow{E}_1 \cdot \partial \overrightarrow{D}_2 + \overrightarrow{E}_2 \cdot \partial \overrightarrow{D}_1 + \overrightarrow{H}_1 \cdot \partial \overrightarrow{B}_2 + \overrightarrow{H}_2 \cdot \partial \overrightarrow{B}_1) dV dt = 0 \qquad (41)$$

Considering the above formula in Eq.(35) we have,

$$\begin{aligned} & -\int_{-\infty}^{\infty} \oiint_\Gamma (\overrightarrow{E}_1 \times \overrightarrow{H}_2 + \overrightarrow{E}_2 \times \overrightarrow{H}_1) \cdot d\Gamma dt \\ & = \int_{-\infty}^{\infty} \iiint_V (\overrightarrow{E}_2 \cdot \overrightarrow{J}_1 + \overrightarrow{E}_1 \cdot \overrightarrow{J}_2) dV dt \end{aligned} \qquad (42)$$

When the radius of the surface Γ is much large the the distance of the emitter to the absorber, the retarded wave reach the surface Γ in a future time. The advanced wave reach the surface Γ in a past time. The two wave can not nonzero in the surface simultaneously. Hence there is,

$$\oiint_\Gamma (\overrightarrow{E}_1 \times \overrightarrow{H}_2 + \overrightarrow{E}_2 \times \overrightarrow{H}_1) \cdot d\Gamma = 0 \qquad (43)$$

Considering the above two formula, we have

$$\int_{-\infty}^{\infty} \iiint_V (\overrightarrow{E}_2 \cdot \overrightarrow{J}_1 + \overrightarrow{E}_1 \cdot \overrightarrow{J}_2) dV dt = 0 \qquad (44)$$

Or

$$-\int_{-\infty}^{\infty} \iiint_V \overrightarrow{E}_2 \cdot \overrightarrow{J}_1 dV dt = \int_{-\infty}^{\infty} \iiint_V \overrightarrow{E}_1 \cdot \overrightarrow{J}_2 dV dt \qquad (45)$$

This is W.J. Welch's time domain reciprocity theorem[19]. The above time domain reciprocity theorem is suitable to the signal with very short time, for example the photon situation.

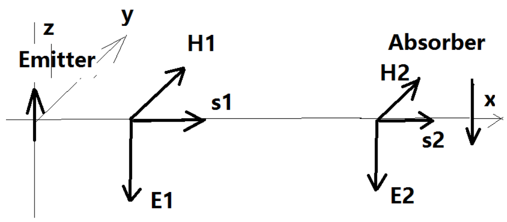

Figure 1: photon model, in this model the field $\zeta_1 = [\overrightarrow{E}_1, \overrightarrow{H}_1, \overrightarrow{J}_1]$,$\zeta_2 = [\overrightarrow{E}_2, \overrightarrow{H}_2, \overrightarrow{J}_2]$ all satisfy SCMEQ.

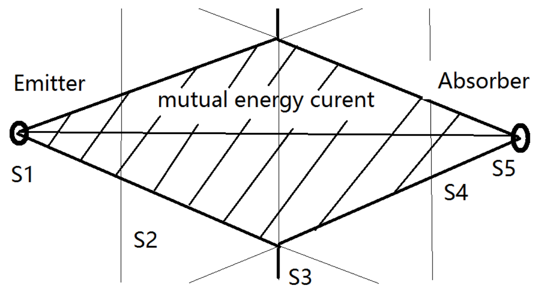

Figure 2: The mutual energy flow only exists at the overlap place of the two solutions of the SCMEQ. The field of the emitter is retarded wave. The field of the absorber is advanced wave.

4.2 Photon and mutual energy flow

Figure 1 shows the photon model of this kind solution. The emitter and absorber can be think as small antenna inside a atom. They also has their currents $\overrightarrow{J}_1$ and $\overrightarrow{J}_2$.

Assume we have put a metal plate between the emitter and the absorber. We make a hole to allow the light can go through it from the emitter to the absorber. The mutual energy flow (will be defined in Eq.(47)) is exist only on the overlap of the two fields $\zeta_1 = [\overrightarrow{E}_1, \overrightarrow{H}_1]$ and $\zeta_1 = [\overrightarrow{E}_2, \overrightarrow{H}_2]$, see Figure 2 (it is possible there is still a little bit mutual energy flow outside the overlap region, but it become very very weak). This overlap region create a perfect wave guide for light wave. Inside this wave guide the normal TE (Transverse electric) and TM (Transverse magnetic) wave can be supported and they are perpendicular to each other and hence the polarization include linear and circle polarization of the waves all can be supported.

The disadvantage of this photon model is that it can only send the wave with linear polarization. If we need the photon as circular polarized field, we have to make the current $\overrightarrow{J}_1$ and $\overrightarrow{J}_2$ have two components for example along axis y and axis z, or to make the currents rotating along x axis. This is perhaps possible, because the electron is at spin, their current is also possible to have spin. In this way the radiate wave becomes circular polarization.

We can take the volume V only includes the emitter or only includes only the absorber, this way we can prove that the flux of the mutual energy flow go through each surface S_1, S_2, S_3, S_4 and S_5 are all equal, see [14, 12], that is,

$$-\int_{t=-\infty}^{\infty}\iiint_{V_1}(\overrightarrow{E}_2\cdot\overrightarrow{J}_1)$$
$$=Q_1=Q_2=Q_3=Q_4=Q_5$$
$$\int_{t=-\infty}^{\infty}\iiint_{V_2}(\overrightarrow{E}_1\cdot\overrightarrow{J}_2)dV \tag{46}$$

where Q_i is the flux of the mutual energy flow integral with time,

$$Q_i=\int_{t=-\infty}^{\infty}\oiint_{S_i}\cdot(\overrightarrow{E}_1\times\overrightarrow{H}_2+\overrightarrow{E}_2\times\overrightarrow{H}_1)\cdot\hat{n}d\Gamma dt \qquad i=1,2,3,4,5 \tag{47}$$

where $\hat{n}$ is normal vector of the surface S_i, the direction the normal vector is from the emitter to the absorber. This formula clear tells us the photon's energy flow is just the mutual energy flow. The mutual energy flow integral with time is equal at the 5 different surfaces or any other surfaces. We know that the surface S_1 and S_5 are very near to the emitter or absorber. This surface becomes so small, hence the wave beam is concentrated to a very small point. It looks very like a particle. In the middle, the wave beam is very thick. We can put other kind plate for example the metal plate with two slits. In this case the wave will produce interference patterns. This can explain the duality character of the photon. In the two slits situation the above formula Eq.(46) is still established. The above formula can be referred as the mutual energy flow theorem.

The left of the formula Eq.(46) can be seen as the energy sucked by the advanced wave $\xi_2=[\overrightarrow{E}_2,\overrightarrow{H}_2]$ from the emitter's current $\overrightarrow{J}_1$. The right of the formula Eq.(46) can be seen as the current of the absorber $\overrightarrow{J}_2$ received the energy from the retarded wave $\xi_1=[\overrightarrow{E}_1,\overrightarrow{H}_1]$. Integral of this energy with time is equal to each other and all equal to the integral of mutual energy flow in each surface S_i. The mutual energy flow is produced with retarded wave and advanced wave together. The two waves must synchronized. The retarded wave can be referred as emitting wave of the emitter. The advanced wave can be referred as receiving wave of the absorber.

5 Self-energy principle and the time reversal waves

From the above discussion we have known that the photon is a system with two charges. One is the emitter the another is the absorber. The electromagnetic fields of the two charges both can randomly jump up to high energy level or jump down to the lower energy level. If it is jump down it will send retarded wave. If it is jump up it will send advanced wave. Only when one charge sends retarded wave and another sends the advanced wave in the same time, i.e. the two waves are synchronized, the mutual energy principle can be satisfied. The charge which sends retarded wave is referred as the emitter. The charge which sends the advanced wave is referred as the absorber.

Since the field of the charge still satisfy the Maxwell equations. If the field of the charge satisfies Maxwell equation, the field of the charge should satisfies the Poynting theorem which is conflict to the self-energy principle33.

5.1 The details for the self-energy principle

We have found the self-energy principle, however there is still some difficulty. First if the self energy items all vanish, the electromagnetic fields

$$\oiint_{\Gamma} (\overrightarrow{E}_i \times \overrightarrow{H}_i) \cdot \hat{n} d\Gamma = 0$$

We will get either

$$\overrightarrow{E}_i = 0$$

$$\overrightarrow{H}_i = 0$$

or

$$\overrightarrow{E}_i || \overrightarrow{H}_i$$

"||" means parallel.

if $\overrightarrow{E}_i = 0, \overrightarrow{H}_i = 0$, the all electromagnetic field will be 0. And in this situation the mutual energy flow vanishes and cannot transfers the energy.

If $\overrightarrow{E}_i || \overrightarrow{H}_i$ the electromagnetic field cannot propagated the way that electric field produce the magnetic field, the magnetic field produce the electric field. Hence we still assume that the electric field and Magnetic field do not parallel to each other.

Exist the mutual energy flow require that the electromagnetic fields should not vanish, which in turn require that the self-energy flow should not vanish. However we have know that the self-energy flow must vanish. In order to solve this conflict, we assume that, here is a time reversal process, which can cancel the self-energy electromagnetic fields.

5.2 A guess about the return of the self energy flow

In above our electron magnetic theory only the mutual energy flow is involved. What about the self energy flow? It does not carry any energy. It is a probability wave like in quantum physics. This is often difficult to be understand. The engineer would like to think the wave is a real wave instead a probability wave.

We found that a wave it exist but do not carry energy perhaps can be explained as that the wave is actually sent out with energy but later it is returned to its source, the pure effect is that the self energy flow vanishes.

Most electromagnetic engineers believe that the electromagnetic wave especially the retarded wave is a real wave and does not like the wave in quantum physics which is probability wave. In this article we have shown that the electromagnetic wave, the retarded wave and the advanced wave do not carry any energy if it is alone. The energy is carried through the mutual energy flow which needs the retarded wave and advanced wave together and have been synchronized. Hence in principle, if there is only one wave for example the retarded wave, it can not offer a ability to transfer the energy. The really transfer energy needs an advanced wave to react to it. Hence the retarded wave still not a real wave with energy on itself all the time. It can be interpreted as ability wave or probability wave. If you do not satisfy this result, perhaps you can think the retarded wave is still a real wave carries the energy and transferred the energy in the space, but if there is no advanced wave to receive it, this energy is returned to its source, i.e the emitter. Hence the retarded wave returns to emitter and the advanced wave returns to the absorber if they are not synchronized. This is similar to the transactional process in the bank, if some thing wrong, the money can not be transferred from bank A to bank B, then the money must return to bank A. Energy is same as money if it can not be transferred from A to B, the energy conserved law do not allow it disappear in the space. Hence this energy no way to go and it must return to its source. This way it can guarantee for the whole system the energy is still conserved.

We can assume the emitters and absorbers all can randomly send the retarded waves and advanced waves. Now this waves are real physical waves. If in the time of the retarded wave sends out just has a advanced wave match it. The energy is transferred through the mutual energy flow from the emitter to the absorber. Otherwise the energy in the retarded wave or in the advanced wave just returns. The wave returning is a time reverse process, which cannot satisfy by Maxwell equations, but can perhaps satisfy time-reversed Maxwell equations, which will be derived as following. Since time reversal process is a very confused to us. The following this author will discussed in extremely detail.

It should be notice even the retarded wave of the emitter and the advanced wave of the absorber are synchronized and there are mutual energy flow goes from the emitter to the absorber, the self-energy flow need also to be returned. That means the self-energy flow always returns no matter the mutual energy flow is produced or not.

Assume $\mathbf{R}$ is time reversal operator, it is defined as

$$\mathbf{R}[\overrightarrow{E}(t), \overrightarrow{H}(t), \overrightarrow{D}(t), \overrightarrow{B}(t), t]$$

$$[\overrightarrow{E}(-t), \overrightarrow{H}(-t), \overrightarrow{D}(-t), \overrightarrow{B}(-t), -t] \tag{48}$$

The time reversal operator act on the following Maxwell equations:

$$\oint \overrightarrow{E} \cdot d\overrightarrow{l} = -\frac{d}{dt}\iint \overrightarrow{B} \cdot \hat{n} dA$$

$$\oint \overrightarrow{H} \cdot d\overrightarrow{l} = \iint \overrightarrow{J} \cdot \hat{n} dA + \frac{d}{dt}\iint \overrightarrow{D} \cdot \hat{n} dA \tag{49}$$

For single charge the above Maxwell equations can be written as

$$\oint \overrightarrow{E} \cdot d\overrightarrow{l} = -\frac{d}{dt}\iint \overrightarrow{B} \cdot \hat{n} dA \tag{50}$$

$$\oint \overrightarrow{H} \cdot d\overrightarrow{l} = q\frac{d\overrightarrow{x}}{dt} + \frac{d}{dt}\iint \overrightarrow{D} \cdot \hat{n} dA \tag{51}$$

We have considered that,

$$\iint \overrightarrow{J} \cdot \hat{n} dA = I \cdot \hat{v} = q\overrightarrow{v} = q\frac{d\overrightarrow{x}}{dt} \tag{52}$$

where $\hat{v}$ is the vector of speed of the charge $\overrightarrow{v}$. after the time reversal operator, the above equations becomes,

$$\oint \overrightarrow{E}(-t) \cdot d\overrightarrow{l} = -\frac{d}{dt}\iint \overrightarrow{B}(-t) \cdot \hat{n} dA$$

$$\oint \overrightarrow{H}(-t) \cdot d\overrightarrow{l} = q\frac{d\overrightarrow{x}}{dt} + \frac{d}{dt}\iint \overrightarrow{D}(-t) \cdot \hat{n} dA \tag{53}$$

In the above equation, since we have applied the time reversal operator, the time t is directed in negative direction. t is directed to the past.

$$\oint \overrightarrow{E}(-t) \cdot d\overrightarrow{l} = \frac{d}{d(-t)}\iint \overrightarrow{B}(-t) \cdot \hat{n} dA$$

$$\oint \overrightarrow{H}(-t) \cdot d\overrightarrow{l} = -q\frac{d\overrightarrow{x}}{d(-t)} - \frac{d}{d(-t)}\iint \overrightarrow{D}(-t) \cdot \hat{n} dA \tag{54}$$

assume $\tau = -t$, τ become the normal time. directs the future.

$$\oint \overrightarrow{E}(\tau) \cdot d\overrightarrow{l} = \frac{d}{d\tau}\iint \overrightarrow{B}(\tau) \cdot \hat{n} dA$$

$$\oint \overrightarrow{H}(\tau) \cdot d\overrightarrow{l} = -q\frac{d\overrightarrow{x}}{d\tau} - \frac{d}{d\tau}\iint \overrightarrow{D}(\tau) \cdot \hat{n} dA \tag{55}$$

Change the time variable τ as t we obtains,

$$\oint \overrightarrow{E}(t) \cdot d\overrightarrow{l} = \frac{d}{dt}\iint \overrightarrow{B}(t) \cdot \hat{n} dA$$

$$\oint \overrightarrow{H}(t) \cdot d\overrightarrow{l} = -q\frac{d\overrightarrow{x}}{dt} - \frac{d}{dt}\iint \overrightarrow{D}(t) \cdot \hat{n} dA \tag{56}$$

Written as differential equation as following,

$$\nabla \times \overrightarrow{E}(t) = \frac{\partial}{\partial t}\overrightarrow{B}(t)$$
$$\nabla \times \overrightarrow{H}(t) = -\overrightarrow{J}(t) - \frac{\partial}{\partial t}\overrightarrow{D}(t) \tag{57}$$

or

$$\nabla \times \overrightarrow{E} = \partial \overrightarrow{B}$$
$$\nabla \times \overrightarrow{H} = -\overrightarrow{J} - \partial \overrightarrow{D} \tag{58}$$

Since the above equation is not Maxwell equations, we cannot call this returned field also as electromagnetic field. We will use another symbol to describe them.

$$\nabla \times \overrightarrow{E}' = \partial \overrightarrow{B}'$$
$$\nabla \times \overrightarrow{H}' = -\overrightarrow{J}' - \partial \overrightarrow{D}' \tag{59}$$

$[\overrightarrow{E}', \overrightarrow{H}', \overrightarrow{D}', \overrightarrow{B}']$ are the returned fields. which is not normal electromagnetically field. $\overrightarrow{J}'$ is returned current density.

5.3 The corresponding Poynting theorem for the time reversal Maxwell equations

$$\begin{aligned}
-\nabla \cdot (\overrightarrow{E}' \times \overrightarrow{H}') = & -(\nabla \times \overrightarrow{E}' \cdot \overrightarrow{H}' - \overrightarrow{E}' \cdot \nabla \times \overrightarrow{H}') \\
& -\partial \overrightarrow{B}' \cdot \overrightarrow{H}' + \overrightarrow{E}' \cdot (\overrightarrow{J} - \partial \overrightarrow{D}') \\
= & -\overrightarrow{E}' \cdot \overrightarrow{J}' - (\partial \overrightarrow{B}' \cdot \overrightarrow{H}' + \overrightarrow{E}' \cdot \partial \overrightarrow{D}')
\end{aligned} \tag{60}$$

or the corresponding Poynting theorem for the time reversal electromagnetic field is,

$$\begin{aligned}
& -\oiint\oiint (\overrightarrow{E}' \times \overrightarrow{H}') \cdot \hat{n} dA \\
= & -\iiint_V \overrightarrow{E}' \cdot \overrightarrow{J}' dV - \iiint_V (\partial \overrightarrow{B}' \cdot \overrightarrow{H}' + \overrightarrow{E}' \cdot \partial \overrightarrow{D}') dV
\end{aligned} \tag{61}$$

From this Poynting vector it is clear that the Poynting vector $\overrightarrow{E}' \times \overrightarrow{H}'$is direct to the inside of the volume.

Compare the above formula to the Poynting theorem which is

$$\begin{aligned}
-\nabla(\overrightarrow{E} \times \overrightarrow{H}) = & -(\nabla \times \overrightarrow{E} \cdot \overrightarrow{H} - \overrightarrow{E} \cdot \nabla \times \overrightarrow{H}) \\
& +\partial \overrightarrow{B} \cdot \overrightarrow{H} + \overrightarrow{E} \cdot (\overrightarrow{J} + \partial \overrightarrow{D}) \\
= & +\overrightarrow{E} \cdot \overrightarrow{J} + (\partial \overrightarrow{B} \cdot \overrightarrow{H} + \overrightarrow{E} \cdot \partial \overrightarrow{D})
\end{aligned} \tag{62}$$

or the Poynting theorem is,

$$-\oiint(\overrightarrow{E}\times\overrightarrow{H})\cdot\hat{n}dA$$
$$=\iiint\limits_V \overrightarrow{E}\cdot\overrightarrow{J}dV+\iiint\limits_V(\partial\overrightarrow{B}\cdot\overrightarrow{H}+\overrightarrow{E}\cdot\partial\overrightarrow{D})dV \tag{63}$$

For the Poynting theorem,
$-\oiint\oiint(\overrightarrow{E}\times\overrightarrow{H})\cdot\hat{n}dA$ is the energy flow come to the inside the volume V.
$\iiint_V \overrightarrow{E}\cdot\overrightarrow{J}dV$ the energy changed to become the heat inside the volume V.
$\iiint_V(\partial\overrightarrow{B}\cdot\overrightarrow{H}+\overrightarrow{E}\cdot\partial\overrightarrow{D})dV$ the energy increase inside the volume V.
For the Poynting theorem corresponding to the time reversal field is,
$-\oiint\oiint(\overrightarrow{E}'\times\overrightarrow{H}')\cdot\hat{n}dA$The energy flow to the outside of the volume V.
$-\iiint_V \overrightarrow{E}'\cdot\overrightarrow{J}'dV$ This is a energy power source which produce energy.
$-\iiint_V(\partial\overrightarrow{B}'\cdot\overrightarrow{H}'+\overrightarrow{E}'\cdot\partial\overrightarrow{D}')dV$ the field energy decrease inside.
Hence it is clear all of these items just cancel each other,

$$-\oiint\oiint(\overrightarrow{E}\times\overrightarrow{H})\cdot\hat{n}dA-\oiint(\overrightarrow{E}'\times\overrightarrow{H}')\cdot\hat{n}dA=0 \tag{64}$$

$$\iiint\limits_V(\partial\overrightarrow{B}\cdot\overrightarrow{H}+\overrightarrow{E}\cdot\partial\overrightarrow{D})dV-\iiint\limits_V(\partial\overrightarrow{B}'\cdot\overrightarrow{H}'+\overrightarrow{E}'\cdot\partial\overrightarrow{D}')dV=0 \tag{65}$$

$$\iiint\limits_V \overrightarrow{E}\cdot\overrightarrow{J}dV-\iiint\limits_V \overrightarrow{E}'\cdot\overrightarrow{J}'dV=0 \tag{66}$$

Hence all the self-energy items are canceled. Hence the self-energy item do not have any contribution for the transferring of the the energy. This is updated self-energy principle compare to the Eq.(33). Eq.(33) conflict with Maxwell equation and Poynting theorem. Eq.(64,65,66) have no that problem.

The self energy return process can be described with the above equations, it can be seen as a collapse process, the wave collapsed to it's source, either emitter or the absorber. This collapsed process is different to the wave function collapse in quantum physics, in which the retarded wave collapse to the absorber. The advanced wave is collapse to the emitter. Hence it can be called to collapse at the target. None offers a equation to describe the collapse process for the collapse to the target. The wave is returned has not been proved by the experiment, just like the wave function collapse has not been proved in experiment, but it still can applied to interpret of the light waves.

Hence the interpretation that wave is returned with the above time-reversal process is better than that the wave function collapse which cannot be described with any equations.

It should be noticed that if the retarded wave is a real wave with energy in space, it must be returned if there is no the transactional advanced wave. Actually even there is a photon sends out, that is only the mutual energy flow,

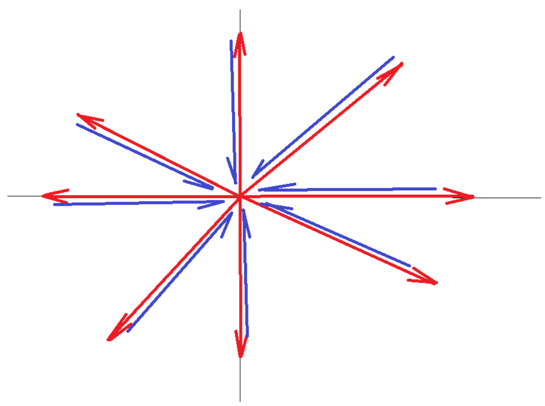

Figure 3: For an emitter, it send retarded wave to the entire space. This retarded wave is referred as self-energy flow. No matter the mutual energy flow is produced or not, the self energy flow will return to its source, i.e. the emitter. It is same to the advanced wave, the absorber sends the advanced wave to the entire space, no matter the mutual energy flow is produced or not the self-energy flow of the advanced wave have to be return to its source which is the absorber.

the self-energy flow is still in the space and it also needs be returned. The self-energy flow help the mutual energy transfer the energy in the space. After the transfer energy process, either the energy is transferred or not, the self-energy flow of the emitter has to return to the emitter and the self-energy flow of the advanced wave need to return to the absorber.

In the above discussion about the mutual energy principle, we do not care the self energy flow which dos not carry energy in physics. But we can also assume it carry energy but it returns hence also no energy is transferred through self-energy flow.

5.4 There is no mutual energy for the time-reversal fields

We assume that the the time-reversal field $[\overrightarrow{E}', \overrightarrow{H}', \overrightarrow{D}', \overrightarrow{B}']$ do not produce mutual energy flow. It is clear if the time-reversal field for the retarded wave and the time-reversal field for the advanced wave can be interfered together. It will produced a mutual energy flow which will be just a inverse of the normal mutual energy flow (produced by the normal retarded field and normal advanced field. Then the normal mutual flow will be canceled.

$[\overrightarrow{E}', \overrightarrow{H}', \overrightarrow{D}', \overrightarrow{B}']$ is just our guess, it is not a real fields. Hence the two kind of this field one is corresponding to emitter and another is corresponding to absorber cannot interfere.

5.5 Summary of the 4 different fields

(1) The retarded wave, the wave direction is from now to the future. This wave satisfies Maxwell equations. The source of this wave is the emitter.

(2) The advanced wave. The wave direction is from now to the past. This wave satisfies Maxwell equations. The source of this wave is the absorber.

(3) The time reversal field for the the retarded field, which actually is also a kind of advanced wave. The wave direction is from future to now. This wave satisfies the time reversal Maxwell equations.

(4) The time reversal field for the advanced field, which actually is also a kind of the retarded wave. The wave direction is from past to now. This wave satisfies the time reversal Maxwell equations.

The retarded wave and the advanced wave can interfere each other and produce the mutual energy flow.

The time reversal field of the retarded field and the time reversal field of the advanced field cannot be interfere each other.

The time reversal field of the retarded field can cancel the retarded self-energy flow.

The time reversal field of the advanced field can cancel the advanced self-energy flow.

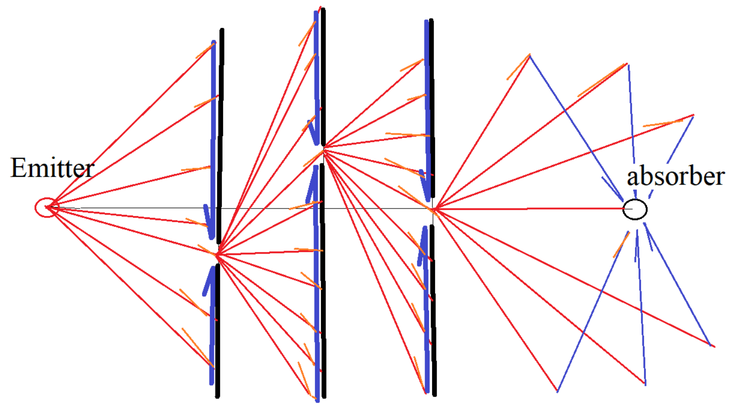

Figure 4: There is a emitter and absorber. Between the emitter and the absorber there are a few partition boards. On the partition boards there is a hole for each board to allow light to go through. The self-energy flow can go through this system and return. This figure shows the retarded wave collapse in every hole. Red line is the retarded wave. Blue line is the collapsed wave function. The retarded wave collapse on the holes at each partition board. In the end the wave collapses at the absorber. This is unbelievable.

6 The collapse of the wave function

The time-reversal field is very like the wave function collapse, the wave function collapse is that the wave collapse to its target. That means the energy is transferred from a point and ended at another point. The time-reversal field is a collapse process that it collapses to its source instead to its target, i.e. the wave collapse to its starting point.

When a wave collapse to its target, for example a retarded wave send out from the emitter has to collapse to its absorber, an advanced wave send from absorber should collapse to its emitter. For this kind collapse process none can offer a mathematical equation to describe it. It is a guess even cannot be mathematically modeled.

A deadliness problem for the concept of wave function collapse is that if there are a few partition boards with a hole on it, between the emitter and the absorber, it is clear that light can go through these holes from the emitter to the absorber. However according to the concept of wave function collapse, the wave has to collapse at each hole so that the light can go through these holes on the partition boards and to reach the target which is the absorber. Even we can accept that the wave collapse to its target, i.e. the absorber, we are still difficult to accept that the wave collapse at each holes on the partition boards. See Figure 4.

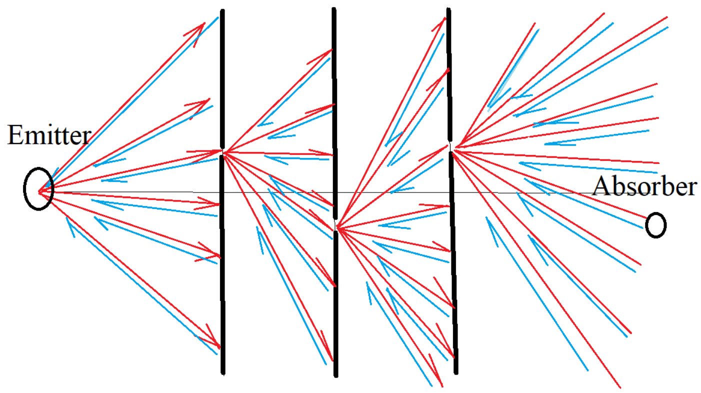

Figure 5: There is a emitter and absorber. Between the emitter and the absorber there are a few partition boards. On the partition board there is a hole to allow light to go through. The self energy flow can go through this system and return to its source. This figure shows the retarded wave return to the emitter. Red line is the retarded wave. Blue line is the time-reversal wave which will return to the emitter.

In other hand the mutual energy flow can go through this holes without problem. The self energy flow can easily return to its source. See Figure 5.

We have mentioned there is a power over estimation for a system with N charges. This over estimation suggest us that there should be no any contribution to the energy transfer by self-energy flow. If self-energy flow is collapse to its target, then it is clear the self-energy flow will play a role for transferring the energy. This also suggest the self energy should not collapse to its target but should collapse its source. This kind of wave function collapse is the return process with a time-reversal process.

7 Why we need to introduce the two new principle?

From the above discussion, it looks that we still need Maxwell equations why we introduce the two other principles, i.e. self-energy principle and Mutual energy principle?

Actually we still can keep Maxwell equations as the axioms of electromagnetic field. But there are some difficulties which are too difficult to overcome. Maxwell equations have two solutions one is retarded wave, another is advanced wave. From Maxwell equations it is difficult to know what is the relation between the two waves. For a photon, there are two charges involved one is the emitter and another is the absorber. If we take Maxwell equation as axiom then the emitter will continually sends out the retarded wave. The absorber will continually sends the advanced wave. This two things are not related and hence it is difficult to obtained the result that the retarded wave and the advanced wave have to synchronized. Starting form Maxwell equations most people cannot accept the advanced wave and will think it is noncausality. And hence every thing is just stop there. In other hand if we started from mutual energy principle, it automatically ask that the two waves the retarded wave and the advanced wave must synchronized, here we have assume that for the light wave is a very short impulse which are randomly send out by the emitter and absorber. Only the synchronized retarded wave and advanced wave can be the nonzero solution of the mutual energy principle. This force people to accept the advanced wave. The two wave synchronized is a random events that is because the emitter randomly sends the retarded wave and the absorber randomly sends the advanced wave. This also explain that why the photon appears always with the probability.

People cognize the electromagnetic field is a step to step process. In the beginning there are Faraday's law of induction, Ampere's low, and two gauss's law. Maxwell found these four laws are not selfconsistent and introduced the concept of displacement current. After adding the displacement current items to the Ampare's law, it become Maxwell equations.

The Poynting theorem can be derived from the Maxwell equations. The superimposition principle is also accept as a law which is not related from Maxwell equations. Apply the Maxwell equation and the superimposition principle the author found the Poynting theorem for N charges has a over estimation for the power of system with N charges. Let all over estimated items are self-energy items as zero, this is referred as self-energy principle. Considering the self-energy principle, we can take away the items of all over estimation we get the mutual energy principle. The author solved the mutual energy principle and obtains Maxwell equations. Not all the solution of the Maxwell equations are the solution of the mutual energy principle. There are two kind of solutions, one is retarded wave another is advanced wave. Mutual energy principle only allow that one solution is a retarded wave and another is advanced wave and they must synchronized. When the two waves are synchronized the two waves can produce the mutual energy flow which can carry the energy from the emitter to the absorber and which is the photon. The author found in order to support the mutual energy flow, there should be also self-energy flow. This conflict to the self-energy principle which says that all this self-energy items should vanish.

We know that the self-energy flow spread their energy to the entire space, originally we will perhaps think that there is a wave function collapse process hence the self-energy flow will also transfer part of energy. For example in a two-charge photon system (in which there is an emitter and an absorber, a photon energy is sent form the emitter to the absorber) the self-energy flow of the retarded wave and the self-energy of the advanced wave will transfer part of the photon energy. The photon energy will not only be transferred by the mutual energy. However from above self-energy principle, it tell us that all self-energy items should vanish. all self-energy items do not carry energy. This force the author to think that the self-energy flow is not collapse but it returns. The self-energy flow corresponding to retarded wave and advanced wave both return through a time-reversal process.

Hence the whole theory of electromagnetic field is built. This author also check in case of wireless or microwave situation. In that case the wave is continual signal. The transmitting antenna sends a continual wave out and in the environment there are infinite absorber can absorb this continual wave. Hence the number of charge N in the system is close to infinite. This will case the self-energy items are infinite small to compare to the mutual energy items. This further cause the mutual energy principle of N charges is very close to the Poynting theorem of N charges. This also further cause the Maxwell equations for N charges are also approximately established. It should be noticed that we have derived the Maxwell equations from the principle for the two charges, which Maxwell equation means the Maxwell equation for single charges. Now we got the Maxwell equations of N charges. In classical electromagnetic field theory, there are superimposition principle, hence deriving the Maxwell equations of N charge from the Maxwell equations of single charge is trivia. But in the author's theory, the superimposition principle is problematic and hence do not available. Hence both the Maxwell equations for single charge or for many charges are not equivalent. However since for the mutual energy principle for 2 charges or N (many) charges, are all still same mutual energy principle. We have proved that the mutual energy principle are suitable to the classical electromagnetic field theory. After this the mutual energy principle and the self-energy principle successfully united the two fields (1) the theory for wireless wave or microwave, (2) the theory for light wave.

8 Conclusion

This article discuss the self-energy principle in details. First we notice there is a over estimation for the power of a system with N charges. This over estimation leads to all self-energy items in Poynting theorem for N charges vanishes which in turn leads to the mutual energy principle. The mutual energy principle is suitable to a electromagnetic system with at least two charges. The mutual energy principle for a system with only two charges can explain a normal photon. A photon is a electromagnetic system with two charges. One is the emitter and one is the absorber. Form the mutual energy principle we have know that if the emitter randomly send retarded wave and the absorber randomly send advanced wave, when the two waves synchronized, the mutual energy flow is produced which is the photon. Since the emitter and the absorber satisfy the Maxwell equations which leads to that the self-energy flow should not vanish which in turn conflict with the self-energy principle. This conflict in turn leads this author to introduce a return wave which is a time reversal process and hence should satisfy the time reversal Maxwell equations. This return wave cancel all self-energy flow and self-energy items. This also avoid this author to introduce a wave function collapse process. After this two principles the whole electromagnetic theory includes the wireless frequency band and light frequency band are all united.

After we have introduced the self-energy principle, in which the time reversal process for the retarded wave and advanced wave are introduced, all the waves are physical waves, which satisfy the mutual energy principle and the self-energy principle. The probability phenomenon of probability of photon is also offered a good explanation. Photon is a system with two charges, one is the emitter, another is the absorber. The emitter from higher energy level jump to lower energy level and randomly sends the retarded wave. The absorber from lower energy level jump to higher level and randomly sends the advanced wave. These waves are very short time signal. In case the retarded wave and the advanced wave just take place in the same time, the two waves are synchronized, the mutual energy flow is produced which is the photon. No mater the mutual energy flow is produced or not the self-energy is returned with a time-reversal process which satisfy time-reversal Maxwell equations.

In this electromagnetic theory, the superimposition principle for the electromagnetic fields are not assumed since it is problematic. Maxwell equations is also not used as axioms, since the relationship of the two solutions retarded wave and advanced wave cannot be clearly obtained from them. Instead the self-energy principle and the mutual energy theorem become the axioms of the electromagnetic theory. This theory will cover all frequency bands for example wireless wave, microwave, light wave, x-ray wave and gamma wave and so on.

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