Wave and particle duality is solved by using the mutual energy and self-energy principles

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Abstract

The particle and wave duality is solved through the self-energy and the mutual energy principles. Welch has introduced the time-domain reciprocity theorem in 1960. The author have introduced the mutual energy theorem in 1987. It has been proved that the above two theorems are same theorem in time-domain or in Fourier domain. The author believe there is an energy flow from transmitting antenna to the receiving antenna. Hence this theorem is a energy theorem instead of a mathematical theorem i.e. the reciprocity theorem. The author found that the mutual energy is the part of additional energy when the two waves are superposed comparing to the situation if the two waves alone stayed in the space. It is often asked that if the two waves are identical what is the energy after the two waves are superposed, 4 or 2 times? The author's answer are 2 or 4 depending whether the sources of the waves are involved or not. However the author noticed that a more important situation, which is the superposition of two waves: one is retarded wave sent from the emitter, another is the advanced wave sent from the absorber. This situation actually described the photon. The author have found that, instead there are two photons the retarded photon and the advanced photon like some author believed, there is only one photon. The reason is that the two waves the retarded wave and the advanced wave they both bring one photon energy are sent to the space, but these energy are returned with the time-reversed waves. The additional energy because of the superpose process of the two waves is just with 1 photon's energy instead of 2 photon's energy. This energy is sent from the emitter to the absorber. These build the author's photon model. This photon model is proved by the author through the notice of the conflict between the energy conservation and both the superposition principle and the Maxwell equations for single charge. This conflict force the author introduced the mutual energy principle and the self-energy principle. Self-energy principle tell us the self-energy (the wave's energy before superposed) is time-reversal-return to its source and hence do not transfer any energy from emitter to the absorber. The mutual energy principle tell us that it is only the mutual energy flow which is responsible to transfer the energy from the emitter to the absorber. The author also proved that the mutual energy flow theorem, there is a mutual energy flow go through the emitter to the absorber. The energy transferred by

mutual energy flow is equal in any surface between the emitter to the absorber. The wave function collapse process is explained by the two processes together the first is the self-energy time-revesal-return to their sources (instead of the targets), the second is that the mutual energy flow brings a photon's energy package from emitter to the absorber. The wave's probability property is also explained that is because the Maxwell equations are only partially correct or correct with some probabilities. The photon energy is transferred only when the retarded wave (one of solution of Maxwell equations) and the advanced wave (another solution of the Maxwell equations) are synchronized, otherwise the two waves are returned by two time-reversal waves which are not satisfy Maxwell equations but satisfy the time-reversal Maxwell equations. Hence 4 additional equations are added to Maxwell equations which describe the two additional time-reversal-return waves. Hence, the photon's package wave is consist of 4 waves which have 4 corresponding self-energy flows. There are two additional energy flows, which are the mutual energy flow that is responsible for transferring the energy from emitter to the absorber, the time-reversal-return energy flow which is responsible to bring the energy back from the emitter to the absorber if the absorber only obtained a part of photon.

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

1.1 The wave and particle duality

It is know that the photoelectric effect tell us the light likes a energy packet. The energy of the light is discrete. The Compton effect tell us that the light same as particle when it is received or absorbed, the receive location is very small, the absorber received a moment, just equal to the moment when it is sent out from the emitter. This means when the light emitter and received behave completely like a particle. Hence we can say that the light is consists of the particle, i.e. photon. The photon also obey the third law of Newton that means when the photon is emitted, the emitter gives the photon an action, the photon gives an equal amount of the reaction with opposite direction to the emitter. When photon is received the photon will offer the absorber an action, the absorber will give the photon a reaction which has the same amount and with an opposite direction. Moreover the received action from photon is equal to the action from emitter give to the photon. The reaction received by the emitter from photon is equal to the reaction received by the photon at the place of the absorber. Hence action and reaction can be transferred correctly.

However we also know that when light go through the double slits, it can produce the interference pattern. We can reduce the intensity of light, hence, the photon is go through the double slits one by one, the interference patterns

still exists if the accumulating time is longer. Hence, light is also a wave. This is referred as the wave and particle duality.

This author is looking for a unified theory to explain the wave and particle duality. It is clear that it is not possible to explain the wave properties using particle theory. But perhaps it is possible to find a special wave that have the properties of particle. The author is looking for a wave it is at very small location when it is emitted or received. This wave should be possible to carry amount of energy and momentum from the emitter to the absorber. In the middle between the emitter and the absorber, the wave should be thick so it can go through the double slits simultaneously.

Up to now, the traditional wave, for example, the retarded wave of Maxwell equation do not satisfy the above requirement. We all know that the retarded wave solved from Maxwell equation spreads to all directions, hence when it is emitted, the total momentum is 0. However when it is received by an absorber, it is clear the wave is sent from the emitter to the absorber direction, hence the moment is not 0. This wave doesn't satisfy the momentum conservation. The energy send by the emitter does not all travel to the absorber. Most energy sent from emitter go to all direction of infinity instead of go to the absorber. The wave in the time it is received is also not focus to a very small region. Hence this kind wave cannot be used to describe a particle and hence is not what the author looking for.

1.2   Two different electromagnetic field theory

There are two different electromagnetic field theory. The first is the field theory which is first introduced by Faraday and latter introduced by Maxwell in 1865. The second is the action at a distance which are introduced by Weber 1848 [?] and later by Schwarzschild, Tetrode and Fokker [?, ?, ?]. It is clear that field theory from Faraday and Maxwell are mathematically convenient and hence produced a lot of good results for example, from which the wave equation is derived. The calculation from the theory of action-at-a-distance is not so convenient compare to the field theory, however it has the advantage to offer the correct mechanic properties. The action and reaction is equal and in the opposite direction (third law of Newton). It is said that the Maxwell equations can be derived from the Weber's electromagnetic theory [?]. Wheeler and Feynman also proved it is possible to obtains Maxwell equations from the action-at-a-distance theory of [?, ?, ?]. However it is strange that up to now no theory from the field of Faraday and Maxwell can obtained energy conservation, moment conservation, or Newton's third law for the photon.

In case there are two charges that are interaction, for example, if there are two charges one is emitter another is absorber. It is clear that the wave send out from the emitter spread to all directions, hence the total moment is 0. But in the place of absorber, the wave is from the emitter to the absorber and hence, the moment is nonzero. The moment has the direction from the emitter to the absorber. Hence, the momentum sends from the emitter does not equal to the momentum received from the absorber. Hence, the momentum is not conserved.

According to the field theory of Faraday and Maxwell, the energy received from the absorber is only part of the energy sends out from the emitter. Most of wave energy sends from the emitter goes out of our universe. The energy is not conserved. In order to make energy conserved, the concept of wave function collapse is introduced. The energy sends to the whole universe is collapsed to the absorber. The wave function collapse can make the energy conserved. However the wave function collapse as a physics process, there is no any mathematical description or formula can be given. Hence, this author does not accept the concept of the collapse of the wave function.

The field theory of Faraday and Maxwell can also also difficult to deliver the action and reaction. In the view of photon, we know that in the place of the emitter, the emitter gives the photon a action, the photon gives the emitter a reaction, in the place of absorber, the photon offers the absorber an action, the absorber offers the photon a reaction. Here, the action and the reaction is equal and in the opposite direction. And also the action of the emitter offers to the photon is sent by the photon to the absorber, hence, the absorber received the action, the reaction of the absorber to the photon is also offers to the emitter by the time emitter sends a photon. Hence, the Newton's third law is obeyed. Action is delivered from the emitter by the photon to the absorber. The reaction is delivered also from the absorber to the emitter by the photon. It is extremely difficult to explain the reaction the absorber give to the emitter by the retarded wave of Maxwell theory.

From the retarded wave theory of Faraday and Maxwell, field propagation is used between the emitter and absorber. In the beginning, the emitter sends the field, since the field is sent to all direction, the force of the total action is zero, the force of the total reaction of the field to the emitter is also zero. This is OK, Newton's third law is satisfied. When field is received by the absorber the action come from the direction of the emitter to the absorber. The force of the action to the absorber is not zero, the reaction is in the opposite direction. This is also OK, Newton's third law is satisfied. But the action from the emitter to the field is not equal to the action from the field to the absorber. The reaction of the absorber to the field is also not equal to the reaction of the field to the emitter. Hence, the action and the reaction is not delivered correctly like the photon does. Hence from current retarded field theory of Faraday and Maxwell, we cannot obtained the same effect same as the photon can offer.

1.3 Power of a system with N charges

There are two conflictive theories for electromagnetic fields. One is the theory of Maxwell equations, another one is the theory of the 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[?, ?, ?]. In the theory of action-at-a-distance, single charge cannot send the wave out. Tetrode said, "If the sun stayed in empty space, it can not send light out". The sun can send light is because the absorber absorbs the light energy. The absorber can send advanced wave to receive the energy. Dirac has applied advanced wave to explain the damping force or self-force for the radiation of a moving charge[?]. 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 [?]. Wheeler and Feynman also introduced the concept of the adjunct field[?]. In the action-at-a-distance principle, the electromagnetic field is an adjunct field which has no its own freedom. This field is an action, which take place at least between two charges: the emitter and the absorber. With only one charge, it cannot define an action, hence, a field. Hence, we can measure an 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 if there is only one charge, the source charge, it cannot produce a action! Field can independent exist in the space or it is only bookmark for a action which can only exist at least between two charges, this debate has continued for 100 years until now. In this article the author will answer the question which is correct for this debate.

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 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 be 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 can be created by emitter or by absorber alone, this is like the Maxwell theory. But two fields are required to satisfy the mutual energy principle.

1.4 The mutual energy theorem

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[?] in 1960. In 1963 Rumsey shortly mentioned a method to transform the reciprocity theorem to a new formula[?]. In early of 1987 this author has introduced the mutual energy theorem [?, ?, ?]. In the end of 1987 Adrianus T. de Hoop introduced the time domain correlated reciprocity theorem[?]. All these theories are same theory in different domain: Fourier domain or in time domain.

1.5 The development of the concept of mutual energy

This author believe the mutual energy theorem is strongly related to the energy in physics instead of a mathematical theorem, for example the reciprocity theorem, which only describes a relation or a transform. Hence the author first call this theorem as mutual energy theorem instead of some kind of reciprocity theorem [?, ?, ?] in 1987. In that time the author spoke about the "mutual energy" is base on the fact in the formula there is the term $E_1(\omega) \cdot H_2^*(\omega)$ that is exactly what we have meet in electric engineering like $V(\omega)I(\omega)^*$, here $V(\omega)$ is voltage and $I(\omega)$ is the current, ω is frequency. In the theory about the transformator, there are also have the term like $V_1(\omega)I_2(\omega)^*$ which is corresponding to the power of the mutual inductance term. In order to illustrate the mutual energy theorem is really a energy theorem, the author also thought to prove the mutual energy theorem from Poynting theorem. It is known that the Poynting theorem is an energy theorem, if the mutual energy theorem can be proved from Poynting theorem, it can be sure also an energy theorem. If it is energy theorem, it should has more meaningful compare to the Lorentz reciprocity theorem. And because from the practice, the directivity diagram of a receiving antenna can be obtained from only the mutual energy theorem or reciprocity theorem instead of the the Poynting theorem, hence the mutual energy theorem should be also

more important at the energy transfer between two antenna, the transmitting antenna and the receiving antenna.

However the author failed to do so. Instead, the author derive the mutual energy theorem from modified reciprocity theorem[?]. This make the mutual energy theorem look like a sub-theorem of the Lorentz reciprocity theorem. This become a flaw in an otherwise perfect thing.

2014 the author comeback to the topic of the mutual energy theorem. First the author found a literature which is very close to the mutual energy theorem, the time domain correlated reciprocity theorem[?] writing by Adrianus T. de Hoop in the end of 1987. The author proved that after a Fourier transform, the time domain correlated reciprocity theorem become the mutual energy theorem. The mutual energy theorem was writing at early of 1987, hence it is also meaningful[?, ?, ?]. Later the author also found the article about time-domain reciprocity theorem[?], which is introduced by W.J. Welch in 1960. It is proved that the time-domain reciprocity theorem[?] is a special case of the time-domain correlated reciprocity theorem[?]. The author also found a article about the new reciprocity theorem [?] which is introduced by Rumsey In 1963 which is similar to the mutual energy theorem. Later this theorem has also been rediscovered many times, for example [?].

It become clear that all other people call the mutual energy theorem as some kind reciprocity theorem. Only the author call it a energy theorem, hence I have to prove it is really a energy theorem. In 2014 this author wrote the online publication discussed the relationship between the reciprocity theorem, the mutual energy theorem and the Poynting theorem[?], in which the author proved the mutual energy theorem from the Poynting theorem. Another important thing is that the author also noticed that, if $f_1(t)$ and $f_2(t)$ are waves for example the retarded wave, then a correlation formula $\int_{t=-\infty}^{\infty} f_1(t + \tau)f_2(t)dt$ is a multiplication of this two forward waves with a time difference. Hence two wave are all move forward. However the convolution $\int_{t=-\infty}^{\infty} f_1(\tau - t)f_2(t)dt$ is a multiplication of a forward wave with the time-shift back-ward wave. In the Fourier domain or (frequency domain), the correlation $\mathcal{F}\{\int_{t=-\infty}^{\infty} f_1(t + \tau)f_2(t)dt\} = f_1(\omega)f_2^*(\omega)$, which is corresponding a output power. It is reasonable that a output power is corresponding to a multiplication with conjugation of two retarded waves. In contrast, the Fourier transform of the convolution of two waves $\mathcal{F}\{\int_{t=-\infty}^{\infty} f_1(\tau - t)f_2(t)dt\} = f_1(\omega)f_2(\omega)$ are multiplication without conjugation. Hence it is clear, that in the mutual energy theorem, the multiplication is with conjugation which is corresponding to two wave move in the same direction. But in the Lorentz reciprocity theorem the multiplication of two waves are without conjugation which is corresponding two wave one is forward and another is backward. For example, in the circuit, if voltage V and current I have the multiplication with conjugate $V(\omega)I(\omega)^*$ which is corresponding to two forward waves and hence corresponding to a power or energy output. In contract, $V(\omega)I(\omega)$ is corresponding a forward wave and backward wave which is nothing to do with the power and energy. Now it is clear the following mutual energy theorem is a energy theorem,

$$- \oiint_{\Gamma} (\boldsymbol{E}_1 \times \boldsymbol{H}_2^* + \boldsymbol{E}_2^* \times \boldsymbol{H}_1) \cdot \hat{n} d\Gamma = \iiint_{V} (\boldsymbol{E}_2^* \cdot \boldsymbol{J}_1 + \boldsymbol{E}_1 \cdot \boldsymbol{J}_2^*) dV \qquad (1)$$

But the Lorentz reciprocity theorem[?, ?, ?],

$$\oiint_{\Gamma} (\boldsymbol{E}_1 \times \boldsymbol{H}_2 - \boldsymbol{E}_2 \times \boldsymbol{H}_1) \cdot \hat{n} d\Gamma = \iiint_{V} (\boldsymbol{E}_2 \cdot \boldsymbol{J}_1 - \boldsymbol{E}_1 \cdot \boldsymbol{J}_2) dV \qquad (2)$$

is not a energy theorem.

After it is clear to the author the mutual energy theorem is an energy theorem, the author know begin to understand that why we can calculate the directivity diagram of the receiving antenna by using the reciprocity theorem instead of Poynting theorem. It is because the mutual energy theorem actually described the energy transferring from the transmitting antenna to the receiving antenna. Since the reciprocity theorem is can be obtained by a conjugate transform from mutual energy theorem, it can offer the same directivity diagram of the receiving antenna. The calculation of directivity diagram is also can be done by directly apply the mutual energy theorem. Apply mutual energy theorem not only can obtained the directivity diagram of the receiving antenna but also can calculate the current on the receiving antenna. On the contrast, the reciprocity theorem cannot be applied to calculate the current distribution on the receiving antenna $\boldsymbol{J}_2$. The triumph of the mutual energy theorem also decrease the value of Poynting theorem as a energy theorem. At lease the energy transfer between the transmitting antenna to the receiving antenna, is correctly described by the mutual energy theorem instead of the Poynting theorem.

The author also notice that in the proof of the surface integral are 0, W.J. Welch introduced the concept of advanced wave. He point out the retarded wave $\xi_1 = \{\boldsymbol{E}_1, \boldsymbol{H}_1\}$ and the advanced wave $\xi_2 = \{\boldsymbol{E}_1, \boldsymbol{H}_1\}$ cannot reach in infinite big sphere Γ in the same time and hence the surface integral in the following time domain reciprocity theorem will vanish.

$$- \int_{t=-\infty}^{\infty} \oiint_{\Gamma} (\boldsymbol{E}_1 \times \boldsymbol{H}_2 + \boldsymbol{E}_2 \times \boldsymbol{H}_1) \cdot \hat{n} d\Gamma dt$$

$$= \int_{t=-\infty}^{\infty} \iiint_{V} (\boldsymbol{E}_2 \cdot \boldsymbol{J}_1 + \boldsymbol{E}_1 \cdot \boldsymbol{J}_2) dV dt \qquad (3)$$

This proof is much nature compare when author to prove the surface integral vanish compare in Fourier domain to prove the surface integral in Eq.(1) vanishes. The proof in the Fourier domain looks like it just very lucky the surface integral vanished. The author has the felling if for example the frequency of the signal just change a little bit the theorem will be violated. However advanced wave is difficult to be understood. In order to apply this theorem to the antenna, the first question to the author is that does the receiving antenna really

sends the advanced waves? The author originally has the concept that a wave can converge to a point, this wave can be called receiving wave, or convergent wave. The different from the convergent wave to the advance wave is that for a convergent wave the current J_2 can only influence by the wave, but for an advanced wave the current J_2 is the source, it will influence the wave when the wave is sent out. Since this wave is sent to the past, a current event can influence a past event. This violate the causality.

Even their has some confusion to the author, the author believe the energy transfer for two antenna the transmitting antenna and the receiving antenna is done through the mutual energy theorem. The author also thought about the photon, which actually is a mall system of two antenna, the emitter is a small transmitting antenna, the absorber is a small receiving antenna. The energy is transferred from emitter to the absorber through these two small antennas. The transferred energy is the photon.

In the middle of 2015, this author begun to search the publications about advanced potential, advance field and advanced wave. Among this kind of work, this author noticed the book of Lawrence Stephenson[?] and read it with great interesting especially the topic about the advanced potential and his talk about the reciprocity theorem. To this author his talk about the reciprocity theorem, the author knows actually should be for the mutual energy theorem. Afterwords this author noticed the absorber theory of Wheeler and Feynman[?, ?, ?] After read all these publications, the author begin to understand the advanced wave and believe it is a real thing in physics. This author begun to work at building a photon model with classical electromagnetic filed theory[?, ?]. In the same time the author noticed the work of John Cramer's transactional interpretation for quantum physics [?, ?]. He has many interesting idea ahead and similar to the author.

After it is clear to the author that the antenna energy is transferred by the mutual energy, the author have to ask if there is a energy flow go from the emitter to the absorber? It is not prove there is a mutual energy flow[?, ?]. The time integral of the mutual energy flow is equal at any surface between two antenna, the transmitting antenna and the receiving antenna. The author call this the mutual energy flow theorem, this is a theorem further stronger the mutual energy theorem, it further prove the energy transfer from the transmitting antenna to the receiving antenna is through the mutual energy flow theorem.

All above this author's 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 has been 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 retarded 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

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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 trend that the self-energy flow collapse to its source that means the wave is time-reversal returned. About the thought and sought the what about effect about the self-energy flow is also written on the photon model of the author [?, ?].

In April of 2016 when the author begin to check the Poynting theorem energy output of N charges, the author noticed that the formula obtained from N charges has a over estimation about the energy. The author immediately realized that there is bug of Poynting theorem and also the bug of current the theorem of the retarded wave of Maxwell. The author have upload one online publication[?]. By solving this bug, it is clear to the author that the self-energy flows described by the Poynting theorem are time-reversal-returned, instead of collapse to its target. This time-reversal-returning process is a time reversal process which can be described with time-reversal Maxwell's equations.

In the same time the author also made some other online publication which are one article to check whether the reciprocity theorem is correct or the mutual energy theorem is correct in lossy media[?]. The conclusion is that the mutual energy theorem can be extended to the lossy media, but the reciprocity theorem cannot. The author also wrote an article about photon and particle duality [?].

The theory about mutual energy, mutual energy theorem, mutual energy principle and mutual energy flow, self-energy principle are also widen to quantum physics theory [?]. A new interpretation for quantum physics, the mutual energy flow[?].

The author also introduced a method to test the advanced wave [?].

1.6 Self-energy, mutual energy and time-reversal-return process

If there are two fields, when they are superposed, there are

$$\boldsymbol{E} = \boldsymbol{E}_1 + \boldsymbol{E}_2 \tag{4}$$

$$\boldsymbol{H} = \boldsymbol{H}_1 + \boldsymbol{H}_2 \tag{5}$$

As a example we assume that $\xi_1 = [\boldsymbol{E}_1, H_1]$ are retarded field and $\xi_2 = [\boldsymbol{E}_2, H_2]$ is advanced field. The Poynting vector are,

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

$$= \boldsymbol{E}_1 \times \boldsymbol{H}_1 + \boldsymbol{E}_2 \times \boldsymbol{H}_2 + (\boldsymbol{E}_1 \times \boldsymbol{H}_2 + \boldsymbol{E}_2 \times \boldsymbol{H}_1) \tag{6}$$

In the right side of the formula, the first item $\boldsymbol{E}_1 \times \boldsymbol{H}_1$ corresponding the self-energy and self-energy flow of the retarded wave. The second item $\boldsymbol{E}_2 \times \boldsymbol{H}_2$ is corresponding to the self-energy and self-energy flow of the advanced wave. The third item $(\boldsymbol{E}_1 \times \boldsymbol{H}_2 + \boldsymbol{E}_2 \times \boldsymbol{H}_1)$ is corresponding to the mutual energy and

mutual energy flow. Hence the mutual energy is corresponding the addition part of energy because the two field is superposed. The mutual energy and mutual energy flow can also be produced if the two fields are all retarded or all advanced.

This author believe that advanced wave and retarded wave can be superposed and interfere with each other. Many other authors even do not believe the advanced wave, hence they will not think about whether or not a advanced wave can superposed with a retarded wave. The two retarded waves or two advanced waves can also produce the mutual energy and also mutual energy flow, but the most important mutual energy flow are the mutual energy flow produced by a retarded wave and an advanced wave. This kind mutual energy flow is responsible for the energy transfer. In this article the author will prove that the self-energy and self-energy flow do not produce or contribute to the energy transfer between the emitter and the absorber.

The self-energy flows will time-reversal return to their sources, either emitter or absorber. time-reversal return is a process in which the sent wave returns back from the whole space to its source satisfying the time-reversal Maxwell equations. The time-reversal Maxwell equations are not a Maxwell equations. In this article the wave function collapse process is that the wave sent form its source to the whole space suddenly go to its target. Hence the retarded wave sent from emitter will collapse to its absorber. The advanced wave sent from the absorber will collapse to its emitter. For the time-reversal-returning process the wave sent from the emitter will time-reversal return to the emitter. The wave sent from the absorber will time-reversal return to the absorber. Hence time-reversal-returning process is a total different process compare to the collapse process. This article will talk more details about the time-reversal-returning process. The author believe the self-energy time-reversal-returning process together with the mutual energy flow transfer the energy from the emitter to the absorber will be equivalent to a collapse process. However the collapse process cannot be described by any equations, a time-reversal-returning process can be described by time-reversal Maxwell equations. Hence a time-reversal-returning process is much more "real" than a collapse process. It should point out the time-reversal Maxwell equations are not Maxwell equations, they only looks like the Maxwell equations. The author believe corresponding to the retarded wave and the advanced wave their are two time-reversal-returning processes which can be described by the time-reversal Maxwell equations. The author believes there exist no the collapse process for photon, there only exist the time-reversal-return processes and a energy transfer process described by the mutual energy flow.

1.7   What will be done in this article

In this article the author will review the whole concept about the mutual energy, mutual energy theorem, and mutual energy flow theorem, mutual energy principle and the self-energy principle. The author will try to to persuade the reader to accept these new theories. Considered the author has overturned many our traditional principles, for example the superposition principle is wrong, the Poynting theorem does not send energy out, the Lorentz reciprocity theorem

is not a wrong physical theorem because it change the advanced wave (which is real) to a retarded wave (which is false), wave function collapse need to be replace by two time-reverse-return process and a mutual energy flow process, Maxwell equations are remedied by adding 4 new equations, these all together are too difficult to be accept by any readers, the author will explain the concepts with extremely more details.

In this article the author also introduced some new concept which are following,

(1) We first introduced the ideal of strong mutual energy theorem. This will distinguish the original mutual energy theorem[?, ?, ?] with the new mutual energy theorem derived from the mutual energy principle. The original mutual energy theorem tell us there is a part of energy sent out by the transmitting antenna which is received by the receiving antenna. This theorem looks trivial. It is clear there are some energy will be sent from the transmitting antenna to the receiving antenna. The new mutual energy theorem tell us all the energy sent from emitter is received by the absorber. There is no any energy has been lost in the empty space. Hence, the new mutual energy is much stronger and meaningful compare to the original mutual energy theorem.

(2) the effect of the action-at-a-distance is shown by the strong mutual energy theorem. Especially the recoil force which is the effect of the mutual energy flow. Since the mutual energy flow is consist of the advanced field, it has ability to offer a recoil force to the emitter, this recoil force happens at the current time that the emitter sends a retarded wave out. The emitter sends the retarded wave out, the retarded wave reach the absorber need some time T, but the absorber sends the advanced wave back to the emitter which needs a negative time $-T$, the total time when the action from the emitter to the absorber and the reaction from absorber to the emitter is a time $T + (-T) = 0$.

(3) In this article we begin added a new kind of mutual energy and mutual energy flow, the time-reversal mutual energy flow. This kind mutual energy flow can be used to explain if there is a race situation, hence the two absorber all received only a half photon. In this situation, the half photon needs to be returned. This will guarantee the transactional process of the whole photon energy package can be implemented.

(4) Mechanics law of Newton has been explained. Newton third law is that the force of action and the force of the reaction is equal and in the opposite direction. This law can be expanded as a remote law, the two objects can separated a distance. In this case, there still exist the expanded third law. That is the recoil force (reaction) which is equal to the force (action) to the remote object. The direction of the recoil force is in the opposite direction of the action force.

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 Conclusion

2.1 What have done

This article discuss how to solve the wave-particle duality. The author started from the Maxwell equations and superposition principle. The author thought that the photon should also satisfy these two conditions. Moreover the author adds an additional condition, energy conservation condition. Originally with Maxwell equations, and superposition principle, the electromagnetic field can be solved. When a new condition is added on the top of the two conditions, too many condition will make the system without a solution. This is called conflict. When conflict happens the author has to solve the conflict. This leads the self-condition. The self-condition tells us that the energy items and the self-energy flow must vanish at all. From this the author obtained the mutual energy formula, the author found that the mutual energy formula do not conflict with all the above 3 conditions. Because the above 3 condition conflict with each other, the author call the mutual energy formula as mutual energy principle. It is used as axiom of the author's new electromagnetic field theory. This theory works also with photon.

Maxwell equations can be derived from the mutual energy principle. However, this time the Maxwell equations are not original Maxwell equations, this time there are additional conditions to the Maxwell equations. The Maxwell equations must be a pair, one is applied to the retarded wave and another is applied to the advanced wave. The two groups of Maxwell equations must be synchronized together. The together synchronized two waves produces the mutual energy flow which is a photon's energy flow. This way in the author's theory the advanced wave cannot be avoid.

It noticed that the Maxwell equations are not always correct. For single charge even it is moved with acceleration or deceleration, there is no any field can be sent out if this wave did not find a counterpart wave to match. Hence in this time the Maxwell equations are not correct. Maxwell equations are only partially correct or correct in some probability.

If there are two waves synchronized, one is retarded wave one is for the advanced wave, in this time the two groups of Maxwell equations are satisfied. Even Maxwell equations are only partially correct or correct in some probability, they still need the self-energy flow do not vanish. This is conflict with the self-energy condition. The self-energy condition require that all the self-energy items, the self-energy flow must vanish. This is second time the author meets a conflict. In this time in order to solve the conflict, the author has added 2 time-reversal-return waves, one is corresponding to the retarded wave, one is corresponding to the advanced wave. The time-reversal-return waves bal-

ance out the two self-energy or self-energy flows of the retarded wave and the advanced wave. The self-energy flows and the time-reversal-return self-energy flow together will cancel each other and do not produce any energy flow. The energy flow between emitter and the absorber is produce by the mutual energy flow which is built with the retarded wave of the emitter and the advanced wave of the absorber.

This way a photon can be described. The photon is produce by 4 waves instead of one or two waves, i.e. the retarded wave, the advanced wave and the two corresponding to time-reversal-return waves. There are 6 energy flows. Corresponding to the 4 waves there are 4 energy flows, but the retarded wave and the advanced wave can produce an additional energy flow which is the mutual energy flow. The two time-reversal-return waves also produce a time-reversal-return mutual energy flow. Hence there are two mutual energy flow. The mutual energy flow is responsible to transfer the energy from emitter to the absorber. This energy is the photon's energy. The time-reversal mutual energy flow is applied in case a race condition happened. In case of race, the time-reversal mutual energy flow is responsible to bring the energy of a half photon back to the emitter.

Since in the author's theory the energy can flow from absorber back to the emitter, the energy can vibrate back and forth, this guarantees that the energy can flow on the detector screen. This looks like a wave function collapse process. Hence the wave function collapse process is also solved with the 2 mutual energy flows and the 4 self-energy flows together.

2.2   The self-energy and the mutual energy principles

This article describe 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 vanish, 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 charge is the emitter and another charge is the absorber. From 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 are 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 condition. This conflict in turn leads this author to introduce a time-reversal-return wave, which is a time reversal process. The time-reversal-return waves, hence, should satisfy the time reversal Maxwell equations. This time-reversal-return wave balance out all self-energy flow and self-energy items. This also avoids a wave function collapse process. After this two principles are introduced, 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 and the self-energy principles. The probability phenomenon of the 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 a higher energy 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 items and self-energy flows are time-reversal 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. The field can be superposed only at the charge. In the space where without a charge, if all field are superposed, the energy will have a overestimation. In the place of a charge, the field is also defined by all other charge do not include the charge itself. It lucky that the theory of the self-energy principle and the mutual energy principle do not dependent to the superposition principle.

Maxwell equations are also not used as axioms, since the relationship of the two solutions retarded wave and advanced wave cannot be clearly obtained from them, which can only be obtained by the mutual energy principle. If Maxwell equations are used as starting point, the people always will ask, there are two solution one is retarded wave and another is advanced wave, are them all physical solutions? Another reason Maxwell equations are not applied as axioms is that the superimposition principle is problematic, even Maxwell equations for single charge is correct we cannot from them to deduce that the Maxwell equation still correct for N charges. This reduce the usefulness of Maxwell equations. Started form Maxwell equations can also very difficult to obtained the time-reversal-return waves.

Instead the Maxwell equation, the self-energy and the mutual energy principles 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. In author's theory Maxwell equations are only correct, in case there are at least two group equations, one is for the emitter and another one is for the absorber. Any waves sent by single charge has no effect to other world since there is a time-reversal-return wave just balance out or canceled it. In this case we can think the Maxwell equation is wrong, or we can think it is correct, but since there is a time-reverse-return wave which has balance out all energy flow send out. Hence the wave described by the Maxwell equations does not transfer any energy.

2.3 New results for electromagnetic field theory and photon theory

(1) photon is system which consists of 4 waves and 6 energy flow instead of 1 wave and 1 energy flow.

(2) Maxwell equations are only partially correct or correct with some probability. This explained the reason why in quantum mechanics the wave is probability wave. The author have added two time-reversal Maxwell equations to the original Maxwell equations, hence now a photon is consist of 4 waves. These 4 wave will created 4 energy flow. There are two additional energy flow, the mutual energy flow and the time-reversal energy flow.

(3) The superposition principle are wrong. The field can only be superposed at the position where there is a charge. In the place of charge, this charge cannot be included in the calculation of the field. In any other place where there is no charge, the energy and energy flow can be calculated through the mutual energy principle where summation is $\sum_{i=1}^{N} \sum_{j=1,j \neq i}^{N}$, instead of $\sum_{i=1}^{N} \sum_{j=1}^{N}$.

(4) The Poynting theory for N charges are wrong. Poynting theory for N charges tell us that there are energy flow from this N charge go outside the infinite big sphere, which lead the energy lose to the outside of our universe. That is wrong. The correct results are take out all the self-energy items. After take out all self-energy items, the mutual energy principle is obtained. The mutual energy principle is correct. Which can be see as updated version of energy law compare to the Poynting theorem.

(5) We have obtained the mutual energy theorem. This new mutual energy flow theorem is a much stronger results compare to old mutual energy theorems[?],[?],[?, ?, ?] and [?]. The old mutual energy theorem tell us that there is part of energy sent from transmitting antenna will be received by the receiving antenna. That means the most energy sent from the transmitting antenna has sent to other place instead of the receiving antenna. The new mutual energy theorem tell us that all the energy sent out from the emitter is received by the absorber. There is no any energy sent from the emitter is lost to the empty space. This energy sent by emitter is received all by an absorber. This energy just describes the photon. We also introduced the mutual energy flow theorem, which tells that the energy transferred in any complete surface between the emitter and the absorber are equal to the the energy of the photon. The mutual energy flow is a inner product between the retarded wave and the advanced wave.

(6) The mutual energy flow is thin in two ends close to the emitter and the absorber, and the mutual energy flow is thick in the middle between the emitter and the absorber. Hence it is the so called particle wave. It allows this wave to look like a particle at two ends and to look like a wave in the middle between to ends. If the mutual energy flow go through a double slits in a separation board, it is clear the interference patterns will be created. In the place the wave is sent by the emitter and the place the energy is received by absorber the energy will be concentrated to a very small region which looks like a particle.

(7) Self-energy flows do not transfer any energy from emitter to the absorber.

4 self-energy flows all cancel or balance out. The energy is transferred only by the mutual energy flow. The time-reversal mutual energy flow is responsible to return the half photon from the absorber to the emitter in case of race or half photon situation happens.

(8) The author obtained the energy conservation for the wave of the photon. The retarded wave of Maxwell equations cannot make the energy conservation. The energy sends out from a emitter go all different directions and do not run to the absorber, it need a wave function collapse process to make energy conserved. But wave function collapse does not have any formula to describe and hence is a very rough theory. Our mutual energy flow theorem guarantee the energy is flow from emitter to absorber, the mutual energy flow theorem tell us in any surface between the emitter and the absorber the energy flow are all equal. This guarantees the energy is conserved.

(9) The momentum is also conserved. We know even the wave collapse can make energy conserved for the retarded wave of Maxwell equations, it still cannot make the momentum conserved. The retarded wave sent from the emitter to all directions and hence the total momentum is 0. But when the absorber received the momentum, the momentum is not zero (the direction is from the emitter to the absorber). We have the mutual energy flow theorem which also guarantees the momentum is sent from the emitter to the absorber and hence the momentum is also conserved.

(10) The macroscopic theory of the electromagnetic field theory can be obtained from the particle wave of the photon which is the mutual energy principle and self-energy principle. Hence, the infinite particle wave can build a macroscopic wave. The macroscopic Maxwell theory is still correct, if there are infinite absorbers which are distributed on the infinite big sphere. The superposition principle for the macroscopic wave is still correct approximately.

(11) In this theory shows it is clear that the mutual energy theorem and the mutual energy flow theorem is a correct energy theorem and physical theorem. Then it is also clear that the Lorentz reciprocity theorem is only a mathematical transform of the the mutual energy theorem. The Lorentz reciprocity theorem can be obtained from the mutual energy theorem with a conjugate transform. The conjugate transform modified the advanced wave to a retarded wave. Hence in the Lorentz reciprocity theorem the advanced field will not appear. Many people do not accept the advanced wave, hence they like the Lorentz theorem. However Lorentz theorem is only an artificial theorem which hidden the advanced wave and the mutual energy theorem. However this article also shows the advanced wave exist. The receiving antenna should send the advanced wave instead the retarded wave or do not send any wave.

(12) The author has introduced a new interpretation for quantum mechanics. It can be referred as the mutual energy flow interpretation of quantum mechanics. This interpretation is similar to the transactional interpretation of John Crammer, because the retarded wave and advanced wave are all applied.

In the new interpretation the probability wave is because the Maxwell equations are only correct partially. Actually the retarded wave is sent by the emitter randomly and the advanced wave is sent by the absorber randomly. Only when

they are synchronized, the photon energy can transfer from emitter to the absorber. The Maxwell equations are correct this time. Otherwise the energy flow of the corresponding Maxwell equations are time-reversal-returned to the emitter or absorber and hence doesn't have any effect.

The collapse process can be seen as the together with the mutual energy flow transferring the energy and the time-reversal-return of all self-energy. In the author's theory the race situation is also no problem, half photon is allowed to be returned to the emitter through a time-reversal mutual energy flow. Comparing to the transactional interpretation of John Crammer, the author's theory is not only a interpretation, it is a whole theory with details and formulation. Especially 4 additional time-reversal Maxwell equations are added to the original Maxwell equations which remedy the original Maxwell theory.

(13) Compare to the theory of action-at-a-distance, originally the Maxwell's field theory is only mathematically simpler than the action-at-a-distance theory, but it contains conflicts. Now with the self-energy and mutual energy principle the field theory is remedied, the conflict is eliminated. It is not only simpler but also correct compare to the theory of the action-at-a-distance.