The mutual energy current interpretation for quantum mechanics

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Quantum physics has the probability interpretation. Traditionally we have believed the particle for example electron looks like the light wave. From the knowledge of light, we know that wave is always spread out, and hence the electron wave should also spread out. That means the electron wave beam should like the light wave beam become diverged from the source. When the electron is received by an atom we thought the wave collapse. The place to collapse is depends on the probability calculated from the square of absolute value of the wave function. The recent new discovery tell us that the light is not just wave, it is a combination of waves, retarded potential and advanced potential. These two potentials together produce the mutual energy current or referred as M-current. Hence light is not a wave and not particles, it is M-current. Light energy current is often described as a surface integral of Poynting vector. This energy current can be referred as P-current. The new discovery found that P-current doesn’t carry any energy for light. The contribution of P-current to energy transfer can be omitted. The light energy is transferred only by M-current. The beam of M-current doesn’t like the beam of P-current which is diverged from the source, instead, the M-current beam first diverges from the source (a electron in an atom) and then converged to the sink (an electron in another atom). Since the M-current at the place to be received is localized at one electron, the concept of wave function collapse is needless. The probability results of light is because that we have use P-current to roughly calculate the M-current. We thought if Schrödinger knew today’s light theory, he would for sure also build his wave theory for quantum mechanics similar to the new light theory with M-current. Hence we claim that the M-current theory is not only suitable to the light but also can be applied to the quantum physics. This means all particles are M-current. The M-current is composed of not only the retarded potential, but also the advanced potential. M-current is a inner product of the retarded potential and the advanced potential. Since there is two waves, the M-current theory can offer a very nature way to the phenomena of spin. The traditional wave energy current which is calculated with only retarded potential, we obtained the P-current. If we still calculate P-current for particles, we have to use the concept of probability, however P-current is only an inaccurate calculation of the energy current. More accurate method should be the M-current method. In this new method, the concept of the wave function collapse is not necessary. We still can use the probability, however the reason of the probability becomes very clear.

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I. INTRODUCTION

In quantum physics, particle for example electron must satisfy the wave function. The wave is a retarded wave. This wave is a diverged wave which spread out from the source to a bigger region. But when electron is absorbed by an atom, we say that the wave function collapses. Hence it seems that the square absolute value of the wave function can offer the probability of the position of wave function collapse. This become the probability interpretation of quantum physics, it is also referred as the Copenhagen interpretation. This interpretation cannot be accepted by many physicists. Einstein said “God does not play at dice.” To which Bohr could only answer: “But still, it cannot be for us to tell God, how he is to run the world”. Schrödinger disagreed also the probability interpretation of the quantum physics. There are other interpretation for example many-worlds interpretation now they become also very popular. The transactional interpretation is interested with more and more physicists. However until now seems still no any other interpretations can replace the probability interpretation.

In light situation, traditionally we know there is light wave which is retarded potential, from this wave we can calculate the Poynting vector, a surface integral of Poynting vector can be seen as energy current, it is referred as P-current. P-current looks like a diverged beam started from the source go to the surrounding environment.

Recently the authors’ study shown that light is not just wave, the retarded potential. Light is mutual energy current. Mutual energy current is referred as M-current. M-current is composed of the retarded potential and advanced potential. M-current is a inner product of the two potentials. Interesting thing is the two different potentials can be synchronized to transfer
II. REVIEW M-CURRENT IN ELECTROMAGNETIC FIELDS

A. Introduction of the M-current in light and electromagnetic field

Maxwell equations have two solutions: the retarded potential and the advanced potential. Many physicists accept the advanced potential, for example the theory of Lawrence M. Stephenson[22]. The absorb theory of D. T. Pegg, Wheeler and Feynman[1][2][5][6][14] also based on the advanced potential. Einstein has joined a talk of Feynman about his absorb theory that need a complete absorber in the future. After the talk, Pauli object the theory and ask Einstein to agree to him. Einstein did not agree that, he support the absorb theory and said, without the absorb theory, it would be very difficult to make a corresponding theory for gravitational interaction. Actually in 1909 Einstein has debated with Ritz about advanced potential. Ritz has a emission theory based on only retarded potential, hence he was against the advanced potential. Einstein applaud the concept of advanced potential. Although there are so many important physicists applaud the concept of the advanced potential, but there is no any selfconsistent theory can apply advanced potential in our electromagnetic field calculation. How advanced potential worked in antenna system, power station system and electronic circuits? No one offers a convinced answer. Hence, antenna and microwave engineers, electronic engineers and most physicists still reject the concept of the advanced potential.

It seems without advanced potential the engineer still can solve all engineering problems by using the reciprocity theorem[3][4][12][19][23][10][11]. The author introduced the concept of mutual energy and the mutual energy theorem[15][16][27][28]. There were very closed earlier publications related to the mutual energy theorem[21][20], but they did not realize it is the energy and still thought it as some kind of reciprocity. The author of ref.[15][27][28] thought it is energy and referred it as “mutual energy” but didn’t continue to work on it for a long time. The reason is that there is another energy current which is based on an surface integral of Poynting vector, it is referred as P-current. The mutual energy current (it is referred as M-current) is only part of P-current. Another reason is theory of the mutual energy is based on the mutual energy theorem which can be used to the calculation of the antenna system with at least one receive antenna. However there is the reciprocity theorem[3][4][12][19][23][10][11]. Which is also can be used to do the same thing and have been widely applied. In the mutual energy theorem advanced potential is involved, that is weird. In the reciprocity theorem, we do not need advanced potential. Only recently the authors have found that the contribution of P-current to light energy transfer can be omitted[17][18]. Hence M-current becomes the only one that can carry energy. It is the only way to transfer energy between two remote
objects. By the way, to transfer energy in wave guides or coaxial-cables, energy transferred by M-current and P-current is half to half. In antenna system the M-current is dominant, but P-current still have some contribution. Recently the authors have also shown that the in the loss media, the reciprocity theorem cannot offer any results which guarantee the energy conservation, but mutual energy theorem can do[17]. After these two breakthroughs, it is clear to the authors that light should be explained as M-current and light is not only the retarded potential, it is a combination of a retarded potential and an advanced potential. It is a inner product of the retarded potential and an advanced potential. The authors found that the duality of the light, photon and wave both can be explained with M-current. M-current diverges in the beginning and then it converges to a point and hence M-current is local which eliminate the concept of the wave function collapse. M-current can also interpret the phenomena of spin in a nature way.

B. The mutual energy theorem

1. Mutual energy theorem in loss media

The theory for the mutual energy theorem includes the following components. Before the full formula of the mutual energy theorem, there are two early version of it, which can be seen in [24][20]. The formula of the mutual energy theorem can be found [15][27][28]. The formula [15][27][28] is in Fourier domain. The corresponding time domain mutual energy theorem can be found in ref.[7].

In Fourier domain the modified mutual energy theorem formula can be written as following[16],

\[ (\xi_1, \rho_2) = \int (E_1 \times J_2^* + H_1 \times K_2^*) dV \]  \hspace{1cm} (5)

The symbol \(\equiv\) means “is defined as”. It is possible that the modified mutual energy theorem is not a physical theorem since the media of the two fields \(\xi_1\) and \(\xi_2\) can be different or at different spaces. If we assume they are the same, i.e., \(\xi_1 = \xi_2\) and \(\mu_1 = \mu_2\), there is

\[ \epsilon^\dagger(\omega) = \epsilon(\omega), \quad \mu^\dagger(\omega) = \mu(\omega) \]  \hspace{1cm} (6)

That is lossless condition. Hence in lossless media the mutual energy theorem (note here, there is no “modified”) is established. Eq.(1) can be written as

\[ (\xi_1, \xi_2) = -(\rho_1, \xi_2) - (\xi_1, \rho_2) \]  \hspace{1cm} (7)

The left side of the formula is the energy current send to outside of the big sphere. The right side are the emission energies from the sources(or sinks) \(\rho_1\) and \(\rho_2\). \((\rho_1, \xi_2)\) can be seen as received energy. \(-(\rho_1, \xi_2)\) can be seen as the emission energy.

If the media has energy loss, It can be proven that the emission energy should equal to the summation of the outgo energy and the energy loss,

\[ (\xi_1, \xi_2) + Q_{loss} = -(\rho_1, \xi_2) - (\xi_1, \rho_2) \]  \hspace{1cm} (8)

Here \(Q_{loss}\) is the energy loss in the media. Hence the above formula is referred as the mutual energy theorem with energy loss.

2. M-current is inner product

The surface integral in the mutual energy formula \((\xi_1, \xi_2)\) is a inner product [15]. Here we assume that that the two fields \(\xi_1, \xi_2\) are two retarded potentials, the surface integral satisfies following 3 inner product laws,

I. conjugate symmetry,

\[ (\xi_1, \xi_2) = (\xi_2, \xi_1)^* \]  \hspace{1cm} (9)

II linear,

\[ (\xi_1 + \xi_2, \xi_3) = (\xi_1, \xi_3) + (\xi_2, \xi_3) \]  \hspace{1cm} (10)

III Positive-definiteness

\[ (\xi, \xi) \geq 0 \]  \hspace{1cm} (12)

\[ (\xi, \xi) = 0 \iff x = 0 \]  \hspace{1cm} (13)

Here \(\iff\) means if and only if. If the two fields are all advanced potentials, the most above results can also be obtained except,
\[(\xi, \xi)_{r} \leq 0 \quad (14)\]

In the mixture situation, if we \(\xi = \xi_{1} + \xi_{2}\), and \(\xi_{1}\) one is retarded potential and \(\xi_{2}\) is advanced potential, the above most inner product laws are still satisfied, except the formula Eq. (12,13) does not satisfy. Even so, this still means the above surface integral is a good inner product. The above inner product formulas guarantee that we can use the inner product expression \((\xi_{1}, \xi_{2})_{r}\). Mutual energy current is referred as M-current. In optics vector field become scale field. M-current is a inner product, that means, we can image \(\xi_{1}\) and \(\xi_{2}\) as two scale value, and hence \((\xi_{1}, \xi_{2})_{r} \rightarrow \xi_{1}\xi_{2}^{*}\) in optics and quantum mchanics.

Assume \(\xi_{1}\) is retarded potential and \(\xi_{2}\) is advanced potential we can prove that in the free space (where the media is \(\epsilon_{0}\) and \(\mu_{0}\)), it can be proven that the surface integral of the mutual energy theorem will vanish at infinite big sphere \(\Gamma\)

\[
\lim_{r \rightarrow \infty} (\xi_{1}, \xi_{2})_{r} = 0 \quad (15)
\]

where \(r\) is the radio of the surface \(\Gamma\).

C. The system with transmit antenna and receive antenna

We have proven that in the mutual energy theorem, if \(\xi_{1}\) and \(\xi_{2}\) one is retarded potential and another is advanced potential, the surface integral vanishes, i.e., \((\xi_{1}, \xi_{2})_{\Gamma} = 0\). Here \(\Gamma\) is infinite big sphere. \(\hat{n}\) is the outward unit vector of surface \(\Gamma\). This means no mutual energy can go out of the big sphere \(\Gamma\). The mutual energy can only go from \(\rho_{1}\) to \(\rho_{2}\). Assume, the media \((\epsilon, \mu)\) are loss less, in that situation there is \(Q_{\text{loss}} = 0\), we have

\[
(\xi_{1}, \rho_{2})_{V_{1}} = -(\rho_{1}, \xi_{2})_{V_{1}} \quad (16)
\]

Here \(-(\rho_{1}, \xi_{2})_{V_{1}}\) is the emitted energy of \(\rho_{1}\), \((\xi_{1}, \rho_{2})_{V_{2}}\) is the received energy of \(\rho_{2}\). If we choose a surface \(\Gamma_{1}\) in which, there is only \(\rho_{1}\) inside and \(\rho_{2}\) is at outside, the mutual energy theorem can be written as

\[
(\xi_{1}, \xi_{2})_{\Gamma_{1}} = -(\rho_{1}, \xi_{2})_{V_{1}} \quad (17)
\]

\((\xi_{1}, \xi_{2})_{\Gamma_{1}}\) is the mutual energy current or M-current between the source \(\rho_{1}\) and the sink \(\rho_{2}\). \(\Gamma_{1}\) can be any surface between the two current \(\rho_{1}\) and \(\rho_{2}\). M-current is equal to the emitted energy \(-(\rho_{1}, \xi_{2})_{V_{1}}\) and the received energy \((\xi_{1}, \rho_{2})_{V_{2}}\).

D. The beam shape of the M-current.

Assume \(\xi_{1}\) is retarded potential, \(\xi_{2}\) is advanced potential,

\[
(\xi_{1}, \xi_{1})_{\Gamma_{1}} = \iint_{\Gamma_{1}} (E_{1} \times H_{1}^{*} + E_{1}^{*} \times H_{1}) \cdot \hat{n} d\Gamma \quad (18)
\]

where \(\hat{n} d\Gamma\) means take the real values. \(\Gamma_{1}\) is any surface between \(\rho_{1}\) and \(\rho_{2}\). \(S_{1} = E_{1} \times H_{1}^{*}\) is Poynting vector, hence \((\xi_{1}, \xi_{1})_{\Gamma_{1}}\) is P-current. The beam shape of P-current is similar to the that of retarded potential \(\xi_{1}\), which is diverged from the source \(\rho_{1}\). Similarly that \((\xi_{2}, \xi_{2})_{\Gamma_{2}}\) is also P-current the beam shape of it is diverged from the sink \(\rho_{2}\).

\[
\lim_{\Gamma_{2} \rightarrow \infty} (\xi_{2}, \xi_{2})_{\Gamma_{2}} = \iint_{\Gamma_{2}} (E_{2} \times H_{2}^{*} + E_{2}^{*} \times H_{2}) \cdot \hat{n} d\Gamma \quad (19)
\]

\(\Gamma_{2}\) is any surface between \(\rho_{2}\) and \(\rho_{1}\). The beam shape of the \((\xi_{1}, \xi_{2})_{\Gamma_{2}}\) mutual energy current can be obtained largely according to

\[
\text{beam} \{(\xi_{1}, \xi_{2})_{\Gamma_{2}}\} = \text{beam} \{(\xi_{1}, \xi_{1})_{\Gamma_{1}}\} \cap \text{beam} \{(\xi_{2}, \xi_{2})_{\Gamma_{2}}\} \quad (20)
\]

where \(\text{beam} \{\bullet\}\) shows the beam shape of the energy current. The symbol \(\cap\) means the intersection sets. Hence the beam shape of M-current in the beginning diverges from the source \(\rho_{1}\) and then converges to the sink \(\rho_{2}\). The beam shape of M-current can be seen in Figure 1.

E. Retarded potential and advanced potential can be synchronized

We often think the retarded potential and advanced potential are totally different things, but actually they...
looks similar even can be synchronized. For example in the wave guide, assume in the two ends there is a transmitter and a receiver, the wave between the two ends can be seen as retarded potential to the transmitter and also can be seen as advanced potential to the receiver. In the transactional interpretation\cite{5, 6}, they think the advanced potential can not be tested in laboratory and it is impossible to be falsified. We do not agree with them. We believe advanced potential can be tested we will discuss this a future article. Here we can see the advanced potential sent by the receiver indeed is synchronized with the retarded potential sent by the transmitter.

We assume in the wave guide, the transmitter contributed half retarded potential the receiver contributed another half. But even the two half are retarded potential and advanced potential they are completely synchronized, hence, there is,

$$\xi_1(t, x) = \xi_2(t, x) = \frac{1}{2} \xi(t, x)$$

where $t, x$ are time and position in the wave guide. Traditionally we assume in the wave guide there is only retarded potential, even this is wrong, but all results are still correct.

In other situation, for example two antennas one is the transmitter and another is the receiver. The beam shape of the retarded potential and advanced potential are different, one is diverged from the source, the other is diverged from the sink, but the value inside the M-current beam is still very good synchronized with time and position. This is also the reason why the M-current can transfer energy.

\section*{III. REVIEW M-CURRENT FOR LIGHT}

\subsection*{A. Photo}

If we assume the energy emitted from source $\rho_1$ is discrete and the sink $\rho_2$ receive energy also discrete. All electrons in an atom in the environment can be seen as sinks which can absorb the energy. Assume the every electron can randomly jump from low energy to the high energy and also can randomly jump from low energy to high energy. The probability of the jump is very low. Assume in the environment there is a absorber electron from lower energy jump to high energy, hence sends advanced potential to the transmitter. In the same time in the emitter there is a electron jump from high energy down to lower energy. If the time just match each other, the retarded potential of the emitter and the advanced potential of the absorber build a M-current, which send the energy from the emitter to the absorber. In this case of the mutual energy current, the electron in the absorber stayed at higher energy. The electron in the emitter kept at the lower energy. The electron in the absorber keep in the higher energy. If in the above the two time windows does not match, the mutual energy current does not build. If there has not built the mutual energy current, the electron at absorber will return to its original energy lever and the electron at the emitter will also return to its original energy.

In another situation, we have assumed that for the electron in absorber there is only a very short time windows which can absorb the retarded potential. There will be randomly some electron react to the retarded potential emitted from $\rho_1$. The M-current can be built between the source and the sinks. Since this M-current is localized in the place it is absorbed, it looks a particle when it is received and emitted. In place between the source and a sink, the beam of M-current is much wider, and looks very like waves. This is why when light go through the double slit will looks like wave, but in the absorb place it becomes many points and looks like particles, which can be seen as photons. Figure 2 shows the tree absorbers reacted with the emitter, hence there are 3 M-currents transferred from the emitter to the absorbers, these can be seen as 3 photons. The figure shows that the shape of M-currents are focused at absorbers, there is no so called wave collapse in the absorbers.

\subsection*{B. Double slits}

For light we must explain the experiment of double slits. The mutual energy current method offers a accurate method to calculate the energy go through the slits. The retarded potential and advanced potential can all be calculated through the Huygens principle. There is the version modified version of Huygens principle\cite{27}. The second step is calculate the mutual energy which is the inner product of the advanced potential and retarded potential. The mutual energy theorem should help us exactly calculate...
the intensity of the electromagnetic fields. However we can easy to find out the beam shape of the mutual energy current which can be seen in Figure 3.

We can see the light energy which is M-current goes through double slits, in the end the light line combined together to the place of the absorber. It is clear there is no need of wave function collapse. Compare to the transactional interpretation[1, 2, 5, 6], since the both retarded potential and advanced potential are still separated, hence the wave function double collapses are needed for both retarded and advanced potential in the absorber and emitter. Transactional interpretation can not offer energy current calculation. M-current method not only offer a interpretation but also offer a very accurate method to calculate the energy current in any time and surface.

It is clear that when light go through the double slits, it looks like light will produce the interference pattern. In the place light is absorbed, like looks light particle, because all M-current energy has focused to a point.

C. Delay choice

The above M-current model is also very easy to explain the delay choice experiment[13, 25]. Because the advanced potential is send out from absorber, even the photon (light or M-current) has go through the double slits, if the absorber configuration is changed it is still can change the beam shape of the M-current. For example if at the time we know the photon (light or M-current) has go through the double slits, if a calibrator is quickly added to the front of the absorber which direct to one of slit, the beam shape of M-current is changed, only one side of M-current up or down left, and hence the light is go only from one slit. The photon looks as particle.

From the view of M-current, the concept of photon, is not complete correct. In the space light can be as M-current go through the double slit. It is focused to a point only when it is emitted or absorbed. However since this energy is still discrete, we can still call it as photon. If we know the photon is just M-current, it is very easy to understand the behave when it go through the double slits.

Delayed choice experiment tell us the observer can change the results of experiment. This actually is very easy to understand. In the early time, the people think the principle of eye is like today’s ultrasound machine or radar system which sends wave to the object and receive the return wave. In the M-current interpretation, the eye actually just looks very like the the radar system or ultrasound system, the only difference is the eye sends advanced potential instead of retarded potential.

D. Spin

The phenomena of spin can also be explained easily. When we thought the light is only composed of only one potential, when we found it has the property of circle polarization, it becomes very confuse. How can only one field produce a circle polarization? The circle polarization needs two wave superposed together with 90 degree phase difference. We can only say that there is a spin which is the light’s intrinsic property.

Now according to the above theory of M-current, it just have two potentials and they are nearly synchronized. If we assume that there is 90 degree difference between the two potentials. The light will become circle polarized. When the receiver receives the retarded potential, its current in the sink changes, that causes it to send an advanced potential. In the light situation, the advanced potential has a 90 degree delay. This 90 degree delay also can happen at the position of source. If the sink first send an advanced potential the source reacted by send a retarded potential a 90 degree delay. This two situations corresponding to the two kinds of circle polarization: left and right circle polarization. This kind of interpretation is much nature than speak about photon spins.

E. Quantum entanglement

The photon entanglement happens when an spin photon go through a nonlinear media, two lower frequency photon will produced with one is left spin and the other is right spin. We know that the angle momentum must conserved. Hence one photon is left the other must right spin, otherwise the angle momentum doesn’t conserved.

The quantum entanglement can also be explained with M-current. Assume a emitter send two entanglement photons. One of the photon is received by an absorber. This absorber will send advanced wave to the emitter. If we receive a left/right spin photon that means the advanced potential have a +/- 90 degree phase difference to the retarded potential. When this event happens, the emitter will know this a time before, since the absorber sends advanced wave. The emitter will send a right/left photon spin photon, that means the retarded potential
will have +/− 90 degree phase difference to the advanced potential.

The problem is the two photon has been sent out a time, when we seen the first one is left the second immediately (1000 time fast then light speed) become right.

According to M-current theory, the left/right spin of photon is not decided by emitter, it is decided by both emitter and absorber. The phase difference of the retarded potential of the emitter and the advanced potential of the absorber decides the spin rotation direction. If the absorber received a left spin photon the emitter will know that when it send out the retarded wave. Since the second of photon is sent also by same emitter, this emitter is a high frequency photon in the nonlinear device with non angle momentum. When this photon be come two low frequency photon, the angle momentum must conserved. Hence the second low frequency photon sent by the emitter must with different spin direction to the first low frequency photon. If we receive the second photon we find it has different angle momentum with the first photon. The only strange thing is the time from the first we observer the first to the second photon, it is

where \( \tau = \tau_1 + \tau_2 \)  

Where \( \tau \) is the time from observer the first photon, \( \tau_1 \) is the advanced wave send from first absorber to the emitter. This time has negative value, since the wave is advanced wave. \( \tau_2 \) is the time from emitter to the second absorber, this time has positive value. In case \( |\tau_1| \approx |\tau_2| \), \( \tau \approx 0 \). In this case the events from first photon is absorbed to the second photon is absorber can have zero time. Hence this two events are not local.

\[ \tau \approx 0 \]  

\[ \text{speed} = \frac{L}{\tau} \gg 0 \]

IV. OTHER PARTICLES

In the time de Broglie and Schrödinger built their wave theory for the particles, they do not knew the above new discoveries for light. Hence they built their particle theory only including the retarded wave. Now we have known for light it is M-current composed with retarded wave and advanced wave, for us it is easy to think all particles perhaps also have the same structure as light. The particles also transfer energy by M-current instead of P-current. The particle’s M-current also is composed of retarded wave and advanced wave.

A. Electron

Assume electron is the M-current, which is composed of two waves, retarded wave and advanced wave. The atom emits the electron is referred as emitter, the atom receives the electron is referred as absorber. The electron’s mutual energy beam should similar to the mutual energy of the light beam, it is very narrow in both emitter point and at the absorber point and it becomes wide in the place between the emitter and the absorber.

Electron has fixed energy, that can be explained as the time window of the emitter and absorber. This time window is very narrow, only allowing sending and receiving an amount of energy equal to a electron. Hence there is only one or a few absorbers to randomly react the retarded wave and send back the advanced waves. Between this particular emitter atom and the particular absorber atom, the mutual energy is produced which is composed with the retarded wave and the advanced wave. The electron is just this M-current. Electron looks more like a particle at the place it is emitted and absorbed and it look more like wave at the place between the emitter and absorber. However electrons actually are M-current in all the time.

B. Wave function

In the quantum physics, assume \( \psi \) is the wave function, then \( |\psi|^2 \) is explained as probability. However the authors thought that is because the lack of the knowledge of M-current for light. If 90 years ago Schrödinger and Dirac knew the above theory about light they will build their quantum theory looks like light. Here the author means the theory which explain light as M-current. The M-current is composed of retarded wave and an advanced wave.

After we have the new understanding about light, we know that, the situation of quantum physics should be similar to electromagnetic wave or light wave. If we accept the advanced wave in electromagnetic field and light, if we accept the light is just the mutual energy current of the two waves, one is retarded wave, another is advanced wave, we can immediately thought that in the quantum physics perhaps there is also the advanced wave. Assume \( \psi_1, \psi_2 \) are two waves, we can define the M-current (mutual energy current) of quantum physics as

\[ Q_{12} = (\psi_1, \psi_2)_\Gamma = \iint_\Gamma \psi_1 \psi_2^* d\Gamma \]  

Where \( \Gamma \) is a surface between the emitter and absorber. It is possible that \( \psi_1, \psi_2 \) are vectors like in the electromagnetic field situation, in that situation \( (\psi_1, \psi_2) \) will define the mutual energy current. In quantum physics \( \psi_1, \psi_2 \) are scales (the scale is possible only a simplified version of vector field, just like in optics we can use scale value
to describe the electromagnetic field, which actually is a vector field).

Assume in quantum physics, $\psi_1$ is retarded wave which send out from a emitter atom, $\psi_2$ is advanced wave which is send out from an absorber atom. When the electron is inside the orbit of the atom, we assume there are also advanced wave and retarded wave. This situation, is similar to electromagnetic wave in a waveguide, the advanced wave can be completely synchronized with the retarded wave. Traditionally we though there is only retarded wave in this situation, but now we assume $\psi_2 = \psi_1$, assume the field of electron can be superposed, hence the field in the electron orbit will be

$$\psi = \psi_1 + \psi_2$$  \hspace{1cm} (25)

$\psi$ is the electron field inside the orbit. Hence

$$\psi_1 = \psi_2 = \frac{1}{2} \psi$$  \hspace{1cm} (26)

$$(\psi, \psi) = (\psi_1 + \psi_2)(\psi_1 + \psi_2)^*$$

$$= \psi_1 \psi_1^* + \psi_2 \psi_2^* + \psi_1 \psi_2^* + \psi_2 \psi_1^*$$  \hspace{1cm} (27)

$\psi_1 \psi_1^*$ is corresponding to the retarded wave’s self-energy current. $\psi_2 \psi_2^*$ is corresponding to the advanced wave’s self-energy current. $\psi_1 \psi_2^* + \psi_2 \psi_1^*$ is corresponding the M-current. $\psi_1 \psi_1^*$ and $\psi_2 \psi_2^*$ is P-current. P-current is not important, even we can calculate it to obtain some values, but since it has no contribution to exchange energy with others, hence it can be omitted.

In this situation since $\psi_1 = \psi_2$, the calculation only with retarded wave, i.e., assume there is only $\psi$ which is retarded wave, will obtain the same result compare the new quantum theory with both retarded wave and advanced wave. This is the reason why if we do not introduce the concept of advanced wave and the M-current, quantum physics still obtains very good results in the situation where the electron is inside an atom or inside a potential well. This is so called static wave situation, in the static wave the time $t$ will explicitly appear. Even in this situation only retarded wave can also obtain good calculation results, actually the advanced wave still exists.

**C. Election in the free space**

The self-energy current $\psi_1 \psi_1^*$, $\psi_2 \psi_2^*$ have no contribution to the emitter atom and the absorber atom, this is similar to the situation of light. $\psi_1 \psi_1^*$ is a beam diverged from the emitter, when it reach the absorber, since the section area of the absorber atom is too small, the energy received by absorber from the $\psi_1 \psi_1^*$ can be omitted. $\psi_2 \psi_2^*$ is diverged from receiver, when it reached to the emitter atom, since the section area of the emitter is too small, this part of transferred energy can be omitted. In this situation only the mutual energy current is important, which is

$$\iint_{\Gamma} (\psi_1 \psi_2^* + \psi_2 \psi_1^*) \, d\Gamma = 2 \Re \{ \iint_{\Gamma} \psi_1 \psi_2^* \, d\Gamma \}$$  \hspace{1cm} (28)

Where $\Re \{ \cdot \}$ means to take the real value. For simplification, we will call $Q_{12} = \iint_{\Gamma} \psi_1 \psi_2^* \, d\Gamma$ as M-current. Keep in mind that the real energy between the emitter and absorb is $2\Re Q_{12}$.

The mutual energy current similar to the situation of light the beam is that the electron beam first diverged from the emitter and then converged to the absorber. Here the emitter and the absorber are two atoms which can send or absorb the electrons. Here since the beam of M-current can focus to a small point, it does not need the concept of wave function collapse.

The wave function collapse is because we do not know there is also the advanced wave. So we calculate $\psi_1 \psi_1^*$ which is a diverged beam. At the place of the wave is received, the beam of the energy current $\psi_1 \psi_1^*$ become very widely spread out. When we use $\psi_1 \psi_1^*$ as the result of quantum physics, we have to face the wave function suddenly collapsed to a point. After we have explained actually the electron is M-current, the property of M-current which first diverges and then converges can thoroughly avoid the wave function collapse.

The probability interpretation for the wave function is because of we only calculated from the retarded wave, $\psi_1 \psi_1^*$, which is inaccurate to the electron.

The authors don't clear why this particular emitter atom connected to another particular absorber atom. We have said it is perhaps because just in that time, the retarded wave reached the absorber, their time window matched together. But this is only one possibility, that is also possible the transmitter send retarded wave includes a special cryptographic code, which can be understand only some absorber atom. It is also has some positive feedback between the transmitter and the receiver that makes the connection of one pairs of atoms become strong than others. Finally they become connected together. An electron is sent out from the emitter atom to the absorber atom.

**D. Spin**

In the traditional quantum physics, there is only one wave function, the retarded wave, when we measured some thing rotated, it is difficult to give an explanation, hence we call it spin. However in the authors' new quantum explanation, there are two wave functions, one $\psi_1$ is retarded and the other $\psi_2$ is advanced. The two waves are nearly synchronized. But there is the possibility they have small phase difference. The spin is also similar to the situation of light. If we assume $\psi_2$ has 90 degree phase difference compare to $\psi_1$, there is a circle polarization. Here we can assume $\psi_1$ and $\psi_2$ are transverse field
one is directed $x$ axis direction and the other is at $y$ axis direction. The wave is transfers in $z$ axis direction. This circle polarization is the phenomena of spin.

In the explanation of the mutual energy current, the spin just two waves have a 90 degree phase difference. This phase difference is caused by the absorber atom or the emitter atom, there is a reaction delay to their wave re-sending process. The delay happens at absorber or at emitter will cause the phase difference as positive 90 degree or negative 90 degree and hence there is left or right polarization. This is phenomena is spin.

E. The Schrödinger equation considered the advanced wave

The original Schrödinger equation which is corresponding to the retarded wave

$$\frac{i}{\hbar}\partial_\psi(x,t) = \left[ -\frac{\hbar^2}{2\mu} \nabla + V(x,t) \right]\psi(x,t) \quad (29)$$

Corresponding to the advanced wave, there is

$$-\frac{i}{\hbar}\partial_\psi(x,t) = \left[ -\frac{\hbar^2}{2\mu} \nabla + V(x,t) \right]\psi(x,t) \quad (30)$$

The above is only one example to create the advanced wave, we also can created the advanced wave using Klein-Gordon equation or Dirac equation, or any other equation still not found, but that is beyond the discussion of here. The point is there must have a advanced wave.

F. Summary

For a free electron, we should calculate M-current which is $\vec{f}_\Gamma \psi_1^* \psi_2^2 d\Gamma$. M-current is a beam first diverge and then converge, for this kind wave beam, the concept of wave function collapse is needless.

When the electron is inside orbit, the two wave can be synchronized completely, and hence the retarded wave and advanced wave are equal to each other. In this situation, the calculation of $\psi_1^\ast \psi_2^2$, the P-current (we can referred it as P-current similar to the light situation) is the same as M-current $\psi_1^\ast \psi_2$. Even though there still exists the advanced wave, but the result is same when we only use retarded wave to calculate, $\psi_1^\ast \psi_2^2 = \psi_1 \psi_2^\ast$. It is same to the wave guide, in the orbit, the energy transferred half by P-current $\psi_1^\ast \psi_2^2$ and half by M-current $\psi_1^\ast \psi_2 + \psi_2^\ast \psi_1$.

In the free space the contribution of P-current can be omitted completely. Only M-current is left. Hence electron is also M-current, which is composed of two waves retarded wave and advanced wave.

Even though the above new interpretation has not changed the calculation of the quantum field. However because it abandons the concept of the wave function collapse, the probability, thing become easy to understand. Electron in the free space is nothing else, it is just M-current. The M-current is composed of two waves one is retarded the other is advanced. The two waves are nearly synchronized. There is 90 degree phase difference which can be seen as the behind scene of spin.

In the authors new interpretation the square absolute value of wave function $|\psi|^2 = \psi_1^\ast \psi_1$ is the P-current, which is only a approximation to the M-current $\psi_1^\ast \psi_2$. Since $\psi_2$ is difficult to obtain, there is hundreds and thousands $\psi_2$ in the environment corresponding to each atom which can receive the electron, we still only calculate $\psi_1^\ast \psi_1$. In this situation, $\psi_1^\ast \psi_1$ offers the probability about $\psi_1 \psi_2^\ast$.

All these can be summarized as electron is not only retarded wave, it combines with two wave retarded and advanced. The two waves build as M-current which is energy current instead probability. The reason of the probability is because if we only calculated P-current of retarded wave which can only offers the probability where the M-current can happen. The probability is because of the inaccurate calculation. The probability is not an intrinsic property of electron.

We also believe the calculation of $\psi_1 \psi_2^\ast$ in some situation can replace the calculation of $\psi_1 \psi_1^\ast$ and offer more accurate results for the understanding of the electron and all other particles.

V. CONCLUSION

Similar to the light, other particles for example electron should also be composed with two waves, retarded wave and advanced wave. The two waves build up the M-current. Since M-current of electron is a beam that in the beginning diverges and in the end it converges, hence for M-current the wave function collapse is not needed. The reason of the probability is re-explained.

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