Quantum Superluminal Communication

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The implications of quantum nonlocality are briefly reviewed. It is shown that the collapse of the wave function requires the existence of a preferred Lorentz frame. This opens the first door to quantum superluminal communication (QSC). The possibility of the existence of QSC is further analyzed. We demonstrate that the combination of the collapse of the wave function and the consciousness of the observer will permit the observer to distinguish nonorthogonal states under some condition. This provides a principle for realizing QSC. A practical QSC scheme and some optimizing schemes are given based upon the QSC principle. Some evidence of the existence of QSC is also discussed.

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1. The appearance of quantum nonlocality

The property of quantum nonlocality, which is implied by the entanglement state of particles, was first brought to the attention of the physics community by Einstein, who strongly opposed it. In 1935, Einstein and his collaborators, Podolsky and Rosen, published a paper known as the EPR paper[1]. In this paper, they utilized the correlation property of the particles in a two-particle entanglement state (TPES), and demonstrated that quantum mechanics is incomplete with an implicit locality assumption. According to the locality assumption, when two particles in TPES no longer interact, the measurement of any one of the particles will not (immediately) impose any influence on the state of the other particle. In fact, Einstein et al proved that the locality assumption is incompatible within the completeness of the description of quantum mechanics. In other words, if the wave function in quantum mechanics completely describes all the reality elements of a particle, then quantum mechanics must be nonlocal, i.e. there must exist a nonlocal correlation between the particles in the entanglement state [1]. However, it is very difficult or even impossible to determine whether to maintain the locality assumption, or the completeness of the description of quantum mechanics.

In 1964, Bell made a big stride forward in the study of quantum nonlocality[2]. On the basis of the EPR arguments, Bell further analyzed the statistical correlation of the possible measurement results, which are obtained through the different measurements about these two particles in TPES, and presented the famous Bell inequality. This inequality clearly shows the contradiction between locality and quantum mechanics, not only the completeness of the description of quantum mechanics. Thus according to Bell's analysis, if the prediction of quantum mechanics is correct for the above statistical correlation, then it must be nonlocal. This conclusion is called Bell's theorem. Its original expression states that any local hidden variables theory can not be consistent with the predictions of quantum mechanics.

Many experiments have been conducted to confirm Bell's theorem. One of the most convincing experiments was performed by Aspect et al[3]. Although some loopholes exist in these experiments, (for example, the space-like separation condition may not be satisfied) their results basically confirm the predictions of quantum mechanics, and reveal the actual existence of quantum nonlocality.

Physicists have expressed a variety of different opinions about the conclusion that quantum mechanics allow the existence of quantum nonlocality. In Shimony's opinion[4], this simply indicates that the existing quantum theory can be compatible with special relativity. But Alharonov and Albert pointed out a special difficulty in combining quantum mechanics with special relativity when taking the measurement process as one kind of realistic process[5]. In fact, Bell himself also realized the inconsistency of his inequality with special relativity, and thought that there exists a deeper level which is not Lorentz invariant, hidden behind the apparent Lorentz invariance of the phenomena[6]. Thus Bell suggested that there might exist a preferred Lorentz frame or ether, in which actual causal sequences of nonlocally correlating events can be defined. When assuming the existence of a preferred Lorentz frame, the existence of quantum nonlocality can be naturally understood, but Bell didn't provide a further strict demonstration.

2. Real collapse and preferred Lorentz frame

Recently, the incompatibility between quantum nonlocality and special relativity has been demonstrated from different points of view[7-12]. It has been argued that any dynamical theory describing the collapse of the wave function, in which the predictions of the theory agree with those of ordinary quantum theory, must have a preferred Lorentz frame. A general demonstration was given by Percival[9]. His conclusion based upon the realistic assumption of the measurement process was that quantum nonlocal phenomena do not satisfy Lorentz invariance, thus resulting in the existence of a preferred Lorentz frame. In other words, the consistent description of quantum nonlocal phenomena requires a preferred Lorentz frame. Since Percival's demonstration was independent of any causality assumption in the quantum domain, and only depended on the causal relation between the classical input and output, his conclusion is universal.

[1] Later Einstein expressed his firm distrust, calling such nonlocal correlations "ghostlike action at a distance."

It can be seen that the above conclusion is a special case of a general conclusion, which says that only one speed value is permitted to be invariant in any Lorentz frame[12]. If we assume that the collapse process of the wave functions of the particles in TPES is simultaneous in all Lorentz frames, i.e. the simultaneity of the collapse of wave function possesses Lorentz invariance, then there will appear two speed values. In this case light speed and infinite speed are both invariant in any Lorentz frame. Thus one of the speed values must be not invariant in all Lorentz frames. This will naturally result in the existence of a preferred Lorentz frame. The standard convention is to stipulate the constancy of one-way light speed, then the simultaneity of the collapse of wave function will not possess Lorentz invariance[2]. A strict physical definition of the preferred Lorentz frame is that in this frame the collapse of wave function happens simultaneously in different positions in space, and the causal relation between the nonlocally correlating events are actually and exclusively determined. In other Lorentz frames, the quantum nonlocal influences will no longer be simultaneous, and the time order and the simultaneous time order in the preferred Lorentz frame satisfy Lorentz transformation relations. The causal relations between the nonlocally correlating events in these frames will no longer accord with their time orders, but will be determined by their time orders in the preferred Lorentz frame. This guarantees that causes always come before effects in any Lorentz frame, and there will no longer exist any causal loops for the quantum nonlocal influence and the possible QSC based on such influence.

Given that the preferred Lorentz frame exists, another natural question is how the preferred frame is selected from infinitely many Lorentz frames, or where it is. Our guess is that the answer to this question relates to the origin of our universe[12]. Concretely speaking, the fact that the collapse process happens simultaneously in different positions in space in the preferred Lorentz frame means that the time order of the process in space is irrelevant to the spatial direction in this frame. The time order of the collapse process in space is isotropic in the preferred Lorentz frame. On the other hand, according to the Big Bang theory, the creation of our universe naturally results in the existence of an isotropic cosmos frame, in which all natural processes are isotropic [3]. As an example, the microwave background radiation is isotropic in the cosmos frame. The collapse process should be also isotropic in the cosmos frame. This means that the time order of the collapse process in space will be irrelevant to the spatial direction. The collapse process happens simultaneously in different positions in space in the cosmos frame. Thus we find that the preferred Lorentz frame is the cosmos frame, and it is selected by Nature through the Big Bang. This conclusion also demonstrates that the preferred Lorentz frame determined by the collapse process doesn't require the existence of a background field or quantum ether.

It should be mentioned that Einstein, the founder of special relativity, also realized the possible limitation of the principle of relativity. He thought[17], "As long as one was convinced that all natural phenomena were capable of representation with the help of classical mechanics, there was no need to doubt the validity of this principle of relativity. But in view of the more recent development of electrodynamics and optics, it became more and more evident that classical mechanics affords an

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[2] It should be denoted that we can also stipulate that the simultaneity of the collapse of wave function possesses Lorentz invariance, then the one-way light speed will relate to the Lorentz frames, and is isotropic only in the preferred Lorentz frame. This convention will hold the absoluteness of simultaneity, and may have some advantages over the standard convention[13-16]. As we think, the convention may even be physically required in case of the existence of a preferred Lorentz frame[16].

[3] This is actually a natural result of general relativity, and its normal Big Bang solution indeed provides a special Lorentz cosmos frame, in which the photons emitted from the Big Bang, namely the cosmos microwave background radiation is isotropic, and the temperature of radiation provides an absolute measure of the cosmos time.

insufficient foundation for the physical description of all natural phenomena. At this juncture the question of the validity of the principle of relativity became ripe for discussion, and it did not appear impossible that the answer to this question might be in the negative."

Indeed, Einstein's worries become true when considering the quantum nonlocal influence in quantum world. As we have seen, the collapse of the wave function doesn't satisfy Lorentz invariance, and results in the existence of a preferred Lorentz frame. Therefore the principle of relativity is not universal, and it doesn't apply in the domain of quantum nonlocal phenomena. Thus special relativity can't inhibit the use of the quantum nonlocal influence to achieve QSC. On the contrary, special relativity must be revised due to the existence of quantum nonlocal phenomena. For detailed discussions please refer to the book[18].

3 The Existence of QSC

In case of the existence of a preferred Lorentz frame, QSC, which uses the quantum nonlocal influence to transfer information faster than light, will not result in the usual causal loop. This undoubtedly opens the first door for realizing superluminal communication. In this section, we will further analyze the relation between quantum nonlocal influence and QSC. Given that the minimum ontology is valid, it will be shown that the existence of the quantum nonlocal influence may actually result in the availability of QSC.

We have demonstrated the existence of a preferred Lorentz frame among the infinitely many Lorentz frames due to the existence of the quantum nonlocal influence. Can the preferred Lorentz frame be detected? According to one of the most basic of scientific beliefs, namely the minimum ontology, the preferred Lorentz frame should be detectable in principle if it exists[4]. In the following, we will deeply analyze the measurability of the preferred Lorentz frame, and demonstrate that it may result in the availability of QSC.

Since the existence of a preferred Lorentz frame is required by the existence of the quantum nonlocal influence, its detection should relate to this kind of quantum nonlocal influence. For simplicity but without losing generality, we will analyze the quantum nonlocal influence in usual Bell experiment. In order to detect the preferred Lorentz frame or the velocity of the experiment frame relative to it, we must be able to determine the time order of the nonlocally correlating events in the experiment frame. This means that if we measure particle 1, we must be able to determine the instants t_1 and t_2 of the state changes of particle 1 and 2 resulting from the collapse process in the measurement. If $t_2 = t_1$, we can directly find the preferred Lorentz frame. It is just the experiment frame; if $t_2 \neq t_1$, we can calculate the velocity of the preferred Lorentz frame relative to the experiment frame and thus find it. The formula is $u = c^2 \Delta t / \Delta x$, where u is the velocity of preferred Lorentz frame relative to the experiment frame, $\Delta t = t_2 - t_1$, $\Delta x = x_2 - x_1$ is the distance between the measuring devices for particle 1 and 2, c is light speed. From the above formula we can

[4] Recently some possible methods to detect the preferred Lorentz frame have also been presented[16].

see that the instant t_2 may be earlier than t_1 or later than t_1. This is determined by the distance between the nonlocally correlating events and the direction of the velocity of the preferred Lorentz frame relative to the experiment frame. For the usual situations where $u << c$, $\Delta t << \Delta x / c$ is a very short interval.

Once the instant t_2 of the state change of particle 2 (resulting from the collapse process) can be determined, we can actually realize QSC. The method can be stated as follows. In the above Bell experiment, we first prepare a large number of entangled particle pairs. Then the sender of the information measures particle 1 in each entangled pair one after the other, and encodes the information in the time intervals between the adjacent measurements. Accordingly, the receiver of the information determines the instant t_2 of the state change of particle 2 in each pair, and decodes the information from the time intervals. Therefore QSC can be achieved.

We have demonstrated that the measurability of the preferred Lorentz frame will result in the availability of QSC. The above demonstration may also provide some possible means of realizing QSC. The key is to determine the instant of the state change of particle 2 resulting from the collapse process. One way is to directly determine the state change of a single particle. This requires that two given nonorthogonal states can be distinguished. The other way is to determine the state changes of a large number of particles, such as measuring the interference pattern. This requires that the state evolution doesn't maintain the orthogonality between states. In the next section, we will see that these requirements are very important in finding a method of realizing QSC.

4 The Realization of QSC

Given that QSC may exist, seeking its realization is very natural and urgent. QSC will undoubtedly bring a new technological revolution to modern communication, and become the main method of communication in the near future.

4.1 Seeking the way

When physicists discovered that quantum nonlocal influences exist between particles in the quantum entanglement state[1-3], it was very natural for them to attempt to use the nonlocal influences to transfer information, i.e. realize QSC. One of the best-known efforts was made by Herbert[19]. He tried to decode the information contained in the quantum nonlocal influences by copying the state of a single particle. Wootters and Zurek[20] soon demonstrated that Herbert's copy method is forbidden by the existing (linear) quantum theory. They concluded that a single quantum couldn't be cloned. In fact, there exists a more general demonstration proving that the existing quantum theory prevents the use of the quantum nonlocal correlation for QSC. Eberhard[21] and Ghirardi[22] had given such demonstrations as early as the 1970s, and others also gave similar general demonstrations such as Busch et al[23]. One common conclusion within the framework of the existing quantum theory is that an unknown quantum state can't be completely determined, and two arbitrarily given nonorthogonal states can't be distinguished.

Since the existing quantum theory does not permit QSC, we need a new complete theory to realize QSC. But which way should we go? A definite revision to the existing linear quantum theory will result in a theory of nonlinear quantum mechanics[24-26]. However no known experiments have revealed any evidence of requiring such a nonlinear revision. A nonlinear theory also has its own internal difficulties[25-26]. For example, a nonlinear theory can't be extended to a relativistic theory. On the other hand, once the existing quantum theory is replaced by nonlinear quantum mechanics where the normal evolution of wave function satisfies the nonlinear evolution equation and there is a real collapse process, the QSC must exist[26]. The reason is that nonlinear evolution doesn't conserve scalar products. States that are initially orthogonal will lose their orthogonality during the evolution. This corresponds to the second method of realizing QSC referred to in the last section.

Secondly, a revised quantum dynamics that describes the instantaneous collapse process as a dynamical process would be more rational and necessary than nonlinear quantum mechanics. It is well known that the most serious problem in the existing quantum theory is the measurement problem. The existing quantum theory doesn't tell us how and when the measurement result appears. The projection postulate is just a makeshift[6]. In this sense, the existing quantum theory is an incomplete description of a realistic process, even if it is a consistent theory through the expression of the projection postulate as a conditional one. On the other hand, mainly due to research in quantum cosmology, physicists have come to realize that the measurement process does not need to be related to the observer (as the orthodox view requires), but must be taken as a self-acting process of the wave function. Therefore it is very natural to combine the normal linear evolution with the instantaneous collapse process to form a unified evolution process, where the normal linear evolution and the instantaneous collapse process are only two ideal approximations of the unified evolution process. The resulting theory is well known as revised quantum dynamics, and has been widely and deeply studied in recent times[12][27-36]. In revised quantum dynamics the linear evolution equation of the wave function is replaced by a stochastic nonlinear equation. The probability prediction about the measurement results is the same as the Born rule in the existing quantum theory, but the instantaneous collapse process is replaced with a describable and dynamical collapse process. At the present time, even if the last complete theory has not been found, there is one thing certain for the revised quantum dynamics: the collapse process of the wave function is one kind of dynamical process, and it will take a finite time interval to finish.

Thirdly, the many-worlds theory is another alternative to a complete quantum theory [37-40]. In the many-worlds theory, the linear Schrodinger equation is taken as the complete description of the evolution of the wave function, and there is no collapse of the wave function. The theory asserts that the appearance of a definite measurement results from an objective environmental decoherence process [39-40]. When the decoherence process is finished, the whole world splits. This split means that there is a world for each possible definite measurement result, and the observer perceives the corresponding result for all practical purposes (FAPP). The role of the decoherence process in the many-worlds theory is similar to that of the dynamical collapse process in the revised quantum dynamics. They both used to solve the measurement problem, and explain how and when the measurement results appear. The existence of such objective dynamical processes is the common characteristic of a complete quantum theory. Our following analysis will only rely on this common characteristic.

Lastly, it should be stressed that the origin of quantum nonlocality doesn't affect the possible realization of QSC based upon it. Even if nonlocal hidden variables and super-determinism exist, it only asserts that the free will of the persons in superluminal communication and the transferred information are pre-determined by the initial condition of the universe. If the receiver doesn't know the transferred information beforehand, super-determinism doesn't affect the validity of superluminal communication at all. This is also true for classical communication.

For simplicity but without losing generality, as a typical example we will primarily analyze the possibility of realizing QSC using the dynamical collapse process in revised quantum dynamics. The conclusion will be also valid for the many-worlds theory.

4.2 Quantum observer

Although no one has strictly demonstrated that revised quantum dynamics does not permit the existence of QSC, physicists generally think that the conclusion should be the same as that of the existing quantum theory. The reason is that these two theories give the same probability prediction about the usual measurement results. However, this conclusion doesn't consider all possible experimental situations. Consider the usual case where physicists argue from the orthodox position of no-QSC for the situation of revised quantum dynamics. This is equivalent to assuming that the observer (and especially his conscious perception) does not intervene before the completion of the dynamical collapse. In other words what the observer identifies is only the definite measurement result, and the observer in a quantum superposition state does not exist. Thus the usual no-QSC demonstration doesn't take into consideration the unusual situation in which the observer directly intervenes in the dynamical collapse process and may in fact exist in a quantum superposition state. Since the dynamical collapse process is an objective process that is not related to the consciousness of the observer, the existence of the special case of superposition of the observer can't be excluded in principle. This means that consciousness is not invoked to produce the dynamical collapse process, and the superposition state of the observer with consciousness may exist. We call an observer in a quantum superposition state a “quantum observer.”

Since the existence of a “quantum observer” may be very important for the realization of QSC, we will further analyze the physical possibility of the existence of a “quantum observer.” It will be shown that the dynamical collapse process and the conscious perception process are physically independent, and that the condition for the existence of a “quantum observer” is likely to be satisfied by natural selection and evolution.

First, it is important to point out that the dynamical collapse process is an objective process that is independent of the existence of consciousness. In reality, the dynamical collapse process and its law have existed in Nature since before the appearance of conscious beings. The collapse process and its law should be not be influenced by consciousness. This is in accordance with the common scientific point of view of the nature of matter and consciousness.

Secondly, for a conscious being the perception time of for a definite state is mainly determined by the structure of his perception part. On the other hand, the dynamical collapse time for the *observed* superposition state during perception is mainly determined by the energy involved for the perception. Since the structure and energy for perception can’t determine each other completely, the corresponding perception time and dynamical collapse time are relatively independent. It is reasonable to assume that there should exist some conscious beings for whom the perception time for the definite state will be shorter than the dynamical collapse time of the *perceived* superposition state, and the time difference is large enough for the conscious being to identify. We call such a condition the “QSC condition” [5]. Conscious beings satisfying the “QSC condition” are able to become “quantum observers.” There should also exist other conscious beings that do not satisfy the “QSC

[5] As we will see, this condition will permit the realization of QSC.

condition."

Lastly, the structure of the perception part of the conscious being will become more and more complex, and the perception time will become shorter and shorter due to natural selection. At the same time, the energy involved for perception may become less and less, and the dynamical collapse time may become longer and longer. Therefore more conscious beings satisfying the "QSC condition" may appear as a result of natural selection. Besides, as it will be shown below, the "QSC condition" will result in the availability of superluminal communication, which will be undoubtedly helpful for the existence and evolution of conscious beings. Thus the conscious beings satisfying "QSC condition." will be also more likely to survive during the ruthless natural selection.

We conclude that some kinds of conscious beings may be able to become "quantum observers" by satisfying the "QSC condition". This means that the perception time for a definite state is shorter than the dynamical collapse time of the *perceived* superposition state, and that the time difference is great enough for a conscious being to identify. Even if a human being can not satisfy the "QSC condition", other conscious beings may exist that can. In fact, there is some evidence that indicate that some human beings may satisfy the "QSC condition."[41-43]

4.3 The principle

In this section, we will show that the "QSC condition" permits a conscious to distinguish nonorthogonal states, and further achieve QSC. This provides the principle of realizing QSC.

The states to be distinguished are the following nonorthogonal states ψ_1 and $\psi_1+\psi_2$, where ψ_1 and ψ_2 can trigger the definite perception state χ_1 and χ_2 of the observer, and are the preferred bases during the perception-induced collapse process. We assume that the initial perception state of the observer is χ_0, then after interaction the corresponding entangled state of the whole system is respectively $\psi_1\ \chi_1$ and $\psi_1\ \chi_1+\psi_2\ \chi_2$ [6]. We assume that the observer satisfies the "QSC condition." This means that the perception time of the observer for the definite state $\psi_1\ \chi_1$, which is denoted by t_P, is shorter than the dynamical collapse time for the superposition state $\psi_1\ \chi_1+\psi_2\ \chi_2$, which is denoted by t_C, and that the time difference $\Delta t = t_C - t_P$ is large enough for the observer to identify [7]. The observer can perceive the measured definite state ψ_1 or his own state χ_1 after the perception time t_P, whereas for the measured superposition state $\psi_1+\psi_2$, only after the collapse time t_C can the observer perceive the collapse state ψ_1 or ψ_2, or his own

[6] For example, the entangled state can be obtained by inputting the photon in the superposition state to the eyes of the observer.

[7] In real experiments, conscious perception can be more accurately recorded by the EEG recording of the observer, and the "QSC condition" can also be stated using the corresponding EEG recordings.

corresponding state χ_1 or χ_2. Since the observer can also be conscious of the time difference between t_P and t_C, he can distinguish the measured nonorthogonal states ψ_1 and $\psi_1 + \psi_2$. This will directly result in the availability of QSC as denoted in Section 3 [8].

It should be stressed that, since the collapse time of a single superposition state is an essentially stochastic variable, which average value is t_C, the "QSC condition" can be in principle satisfied in some collapse events with non-zero probability. For these stochastic collapse processes, the collapse time of the single superposition state is much longer than the (average) collapse time t_C and the perception time t_P. This provides an essential availability of QSC.

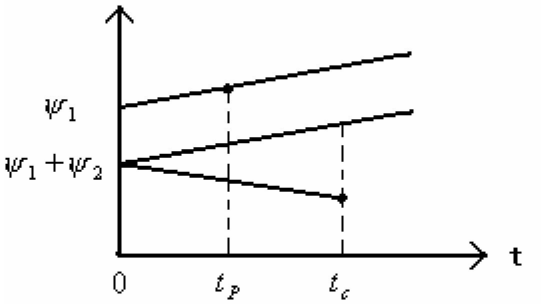

Fig 1. A scheme of QSC principle

In order to understand the unusual QSC principle, we will further analyze the above demonstrations. As we know, it is still unclear what the perception of the observer in the entangled state $\psi_1\ \chi_1 + \psi_2\ \chi_2$ is. Albert analyzed a similar situation in detail[44]. He called such a "quantum observer" John. He concluded that John's perception is not the same as χ_1 and χ_2, and noted that the perception may be very strange. In the following we further demonstrate that the QSC principle is irrelevant to the concrete perception of the "quantum observer" in a superposed state of definite perceptions.

First, we assume that a definite perception of the input superposition state $\psi_1 + \psi_2$ can appear only after a dynamical collapse. This is well-accepted as it is in accordance with one of our basic scientific beliefs, i.e. that our inner perception reflects the objective world correctly. As we have shown, under this assumption the observer can have a definite perception about the measured state ψ_1 after the perception time t_P, but only after the collapse time t_C can the observer have a definite perception about the measured superposition state $\psi_1 + \psi_2$. When the observer satisfies the "QSC

[8] It should be denoted that Squires also noticed the relationship between the explicit collapse and superluminal signaling from a slightly different point of view[8].

condition", the observer is able to distinguish the nonorthogonal states $\psi_1 + \psi_2$ and ψ_1 or ψ_2. Thus the QSC principle holds.

Secondly, we assume that the above well-accepted assumption is *not true*, i.e. that the observer can have a definite perception of the measured superposition state *before* the dynamical collapse has completed. We will demonstrate that the observer is also able to distinguish the nonorthogonal states $\psi_1 + \psi_2$ and ψ_1 or ψ_2 with non-zero probability, and the above QSC principle still holds for this situation.

(1). If the definite perception of the observer in the superposed state $\psi_1\ \chi_1 + \psi_2\ \chi_2$ is neither χ_1 nor χ_2, then the observer can directly distinguish the nonorthogonal states $\psi_1 + \psi_2$ and ψ_1 or ψ_2. For the measured state ψ_1 or ψ_2, the definite perception of the observer is χ_1 or χ_2, but for the measured superposition state $\psi_1 + \psi_2$, the definite perception of the observer is neither χ_1 nor χ_2.

(2). If the definite perception of the observer in the superposed state $\psi_1\ \chi_1 + \psi_2\ \chi_2$ is χ_1, then the observer can directly distinguish the nonorthogonal states $\psi_1 + \psi_2$ and ψ_2. For the measured state ψ_2, the definite perception of the observer is χ_2, but for the measured superposition state $\psi_1 + \psi_2$, the definite perception of the observer is χ_1 before the collapse process finishes. Besides, the superposition state $\psi_1\ \chi_1 + \psi_2\ \chi_2$ will become $\psi_2\ \chi_2$ with probability ½ after the collapse process finishes. Then the definite perception of the observer will also change from χ_1 to χ_2 accordingly. For the measured state ψ_1 or ψ_2, the definite perception of the observer has no such change. Thus the observer is also able to distinguish the nonorthogonal states $\psi_1 + \psi_2$ and ψ_1 with probability ½.

(3). If the definite perception of the observer in the superposed state $\psi_1\ \chi_1 + \psi_2\ \chi_2$ is χ_2, the demonstration is similar to that of (2).

(4). If the definite perception of the observer in the superposed state $\psi_1\ \chi_1 + \psi_2\ \chi_2$ is random[9], i.e. one time it is χ_1, another time it is χ_2, then the observer can still distinguish the nonorthogonal

[9] It is our opinion that this presumption is impossible.

states $\psi_1+\psi_2$ and ψ_1 or ψ_2 with non-zero probability. For the measured state ψ_1 or ψ_2, the perception of the observer does not change during the measurement process. For the measured superposition state $\psi_1+\psi_2$, the perception of the observer will change from χ_1 to χ_2 or from χ_2 to χ_1 with non-zero probability during the collapse process with independent randomness. For example, if the definite perception of the observer in the superposed state $\psi_1\ \chi_1+\psi_2\ \chi_2$ is χ_1 before the collapse process finishes, but the superposition state becomes $\psi_2\ \chi_2$ after the collapse process finishes, then the perception of the observer will change from χ_1 to χ_2. If the definite perception of the observer in the superposed state $\psi_1\ \chi_1+\psi_2\ \chi_2$ assumes χ_1 or χ_2 with the same probability ½, then the above non-zero distinguishing probability will be ½.

We have demonstrated that if the observer satisfies the "QSC condition" he is able to distinguish the nonorthogonal states $\psi_1+\psi_2$ and ψ_1 or ψ_2 with non-zero probability, thus superluminal communication can be realized in principle. This conclusion is irrelevant to the concrete perception of the "quantum observer" in the superposed state of definite perceptions.

4.4 A practical scheme

In this section, we will give a practical scheme of achieving QSC based upon the above principle. It includes two parts. The first part is how to distinguish the nonorthogonal states. We design a device implementing this function, which is called NSID (Nonorthogonal States Identifying Device). The second part is how to achieve QSC using the hardcore device NSID.

The implementation scheme of NSID is as follows. The particles to be identified are photons, and the conscious being in the device can perceive a single photon[10]. Let the input states of the device be the nonorthogonal states $\psi_A+\psi_B$ or $\psi_A-\psi_B$ and ψ_A or ψ_B. ψ_A is the definite state of photon entering into the perception part of the conscious being from the direction A, which can trigger a definite perception of the conscious being who perceives that the photon arrives from the direction A. ψ_B is the definite state of the photon entering into the perception part of the conscious being from the direction B, which can trigger a definite perception of the conscious being who perceives that the photon arrives from the direction B. $\psi_A+\psi_B$ and $\psi_A-\psi_B$ are the space superposition states of the definite states ψ_A and ψ_B of photon. The conscious being satisfies the "QSC condition", i.e. his perception time t_p for the definite state ψ_A and ψ_B is shorter than the

[10] In practical situation, a few photons may be needed.

dynamical collapse time t_C of the perceived superposition state $\psi_A + \psi_B$ and $\psi_A - \psi_B$, and the conscious being can be aware of the time difference. When the input state is ψ_A or ψ_B, the conscious being will perceive that the photon arrives from the direction A or B after the perception time t_p, and he assigns '1' as the output of the device[11]. When the input state is $\psi_A + \psi_B$ or $\psi_A - \psi_B$, the conscious being will perceive that the photon arrives from the direction A or B after the collapse time t_C, and he assigns '0' as the output of the device. Thus the device NSID can distinguish the nonorthogonal states $\psi_A + \psi_B$ or $\psi_A - \psi_B$ and ψ_A or ψ_B. NSID can be implemented through the direct use of a conscious being or by an advanced consciousness simulation device in the future.

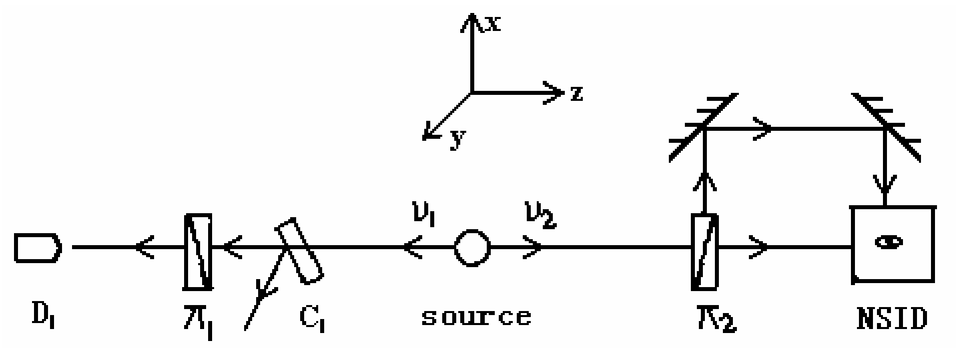

Fig 2. A Practical Scheme of QSC

Now we will give the scheme of achieving QSC using the device NSID. In reality, once the nonorthogonal single photon states can be distinguished, achieving QSC will be an easy task, and it may be implemented by means of existing technology. Here we use the EPR polarization correlation pairs of photons as the carriers of information. We encode the outgoing information by operating the polarizer, and decode the incoming information using the device NSID. The experimental setting is shown in the above figure. Pairs of photons, whose frequencies are ν_1 and ν_2, are emitted in the -z direction and +z direction from a source, are then analyzed by a one-channel polarizer π_1 and a two-channel polarizer π_2 respectively. The optical switch C_1 in the left side can be controlled to determine whether or not the photon ν_1 will pass to π_1. The transmission axes of the polarizers are both set in the direction x. The one-channel polarizer π_1 allows only the polarization components of

[11] In view of accuracy, a EEG device may be used to record the perception time and produce the output of the device.

the photon parallel to the transmission axis of the polarizer to be passed, and the two-channel polarizer π_2 allows the polarization components of the photon both parallel to and perpendicular to the transmission axis of the polarizer to be passed. The photon passed and analyzed by the polarizer π_1 is detected by D_1, and the photon analyzed by the two-channel polarizers π_2 is divided into two paths in space, and respectively input to NSID from different directions.

We now explain how QSC can be achieved by means of the above setting. Let the sender operate the optical switch C_1, and have the receiver observe the output of NSID. Suppose the communication rules are stated as follows. The encoding rule for the sender is that not measuring the photon represents sending the code '0', and measuring the photon represents sending the code '1'[12]. The decoding rule for the receiver is that the output of NSID being ‘0’ represents having received the code '0', and the output of NSID being ‘1’ represents having received the code '1'.

The communication process can be stated as follows. When the sender wants to send a code '0', he controls the optical switch C_1 to let the photon ν_1 move freely and not be analyzed by the polarizer π_1. Then the state of the photon ν_2 is a superposition state like $\psi_A+\psi_B$ or ψ_A-ψ_B after it passes the polarizer π_2, and the output of NSID is ‘0’. The receiver can decode the sent code as '0'. When the sender wants to send a code '1', he controls the optical switch C_1 to allow the photon ν_1 to be analyzed by the polarizer π_1 and detected by D_1 *before* the photon ν_2 arrives at NSID. Then the state of the photon ν_2 collapses to a definite state like ψ_A or ψ_B, and the output of NSID is ‘1’. The receiver can decode the sent code as '1'. Thus the sender and receiver can achieve QSC using the above setting and communication rules.

4.5 Some optimizing methods

Since it may be very difficult for the conscious being to perceive a single photon, the superposition state of a small number of photons such as $|\varphi_1\varphi_2...\varphi_n>_{\nu_1}|\phi_1\phi_2...\phi_n>_{\nu_2}+|\phi_1\phi_2...\phi_n>_{\nu_1}|\varphi_1\varphi_2...\varphi_n>_{\nu_2}$ is needed to achieve QSC in a practical situation. Unfortunately it is also very difficult to achieve such a superposition state of many photons using existing technology. Here we will present an optimizing scheme. The method is to use a large number of entanglement states of pair photons[13]. We assume pair photons, which state is $|\varphi_i>_{\nu_1}|\phi_i>_{\nu_2}+|\phi_i>_{\nu_1}|\varphi_i>_{\nu_2}$, where *i* denotes the *i*-th pair photons, are independently emitted

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[12] In a practical situation, in view of the stochastic property of the collapse time and other possible errors, redundancy coding is required. A single information code should be encoded through the same operation on a small number of photons, not a single photon.

[13] This method may also help to overcome the limitation resulting from the inefficiency of the photon detector to some extent. Here we only need to collapse the superposition state using the photon detector, and concrete detection

from the source one after the other in the above experiment, and the other settings are the same. Now the state of many such independent pair photons will be $\prod_{i=1}^{n}(|\varphi_i>_{\nu_1}|\phi_i>_{\nu_2}+|\phi_i>_{\nu_1}|\varphi_i>_{\nu_2})$. Since the observer satisfies the "QSC condition", he can still distinguish the nonorthogonal states $\prod_{i=1}^{n}(|\varphi_i>_{\nu_1}|\phi_i>_{\nu_2}+|\phi_i>_{\nu_1}|\varphi_i>_{\nu_2})$ and one of its sub-states, say $|\phi_1>_{\nu_2}|\varphi_2>_{\nu_2}\ldots|\varphi_n>_{\nu_2}$. If the sender wants to send a code '1', he can still control the optical switch C_1 to let the photons ν_1 be analyzed by the polarizer π_1 and detected by D_1 before the photons ν_2 arrives at NSID. The receiver will identify the input state of the photons ν_2 as a randomly collapsed definite state such as $|x_1y_2...y_n>_{\nu_2}$, and decode the sent code as '0'. Similarly, if the sender wants to send a code '0', he can still control the optical switch C_1 to let the photons ν_1 move freely and not be analyzed by the polarizer π_1. Then the observer will identify the input state of the photons ν_2 as a superposition state $\prod_{i=1}^{n}(|x_i>_{\nu_1}|y_i>_{\nu_2}+|y_i>_{\nu_1}|x_i>_{\nu_2})$, and decode the sent code as '0'. Thus QSC can also be achieved using the above method. Evidently this experiment could more easily be conducted using existing technology, and may be completed in the near future.

On the other hand, the communication rate of QSC will be limited by the perception time of the conscious being[14], and this may prevent QSC from being widely applied. One optimizing scheme would be to combine QSC and quantum teleportation. QSC would be used to replace the classical communication required by quantum teleportation. Since the information transferred through this channel is very little, and the majority of information is transferred through the quantum channel in quantum teleportation, this combination will largely increase the communication rate of QSC. It is anticipated that advanced perception simulation technology may be available in the near future, and thus the communication rate of QSC would be largely increased.

There are several practical means for achieving QSC in terms of the position of the particle's source. They are middle type, one-end type and two-end type. The middle type and one-end type both require that the carriers of information be transferred between the sender and receiver, and can be implemented more easily. These types are suitable for research. The two-end type does not require that the carriers of information are transferred, and they are stored in the sender and receiver. This type would be more suitable for practical applications.

QSC will undoubtedly have advantages over conventional communication. First, the transfer delay of QSC is irrelevant to the communication distance, and can be zero in principle. Thus QSC is the fastest communication method. Secondly, the carriers of information may not pass through the space between the sender and the receiver for QSC, thus the communication process is not influenced by the environment between them. Thus QSC is a kind of complete anti-jamming communication

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recording is not needed.

[14] The perception time of human being is of the orders of 0.1s, thus the corresponding communication rate of QSC will be of the orders of 10bps.

method. Thirdly, since the carriers of information can be stored only in the sender and receiver for QSC, a third party can not eavesdrop in on the transferred information. Thus QSC is the most secret and secure communication method. Lastly, as there is no electro-magnetic radiation involved in QSC, it is a “green” communication method.

5 Further Analysis

In order to further understand the above QSC principle, we will give an analysis about the relation between quantum collapse and consciousness.

Bohr first stressed the special role of measurement in quantum theory with his complementarity principle[45]. Later von Neumann rigorously formulated the measurement process mathematically by means of the projection postulate[46], but the inherent vagueness in the definition of a measurement or projection still exists. In order to explain how a definite result is generated by the measurement of an indefinite quantum superposition state, the consciousness of the observer was invoked by von Neumann[46]. This theory was further advocated by Wigner[47], according to which consciousness can break the linear superposition law of quantum mechanics. This may be the first statement made about the relationship between consciousness and collapse. It implies that consciousness results in the collapse of wave function.

However as this relationship between the quantum and consciousness needs to be greatly revised when faced with the problem of quantum cosmology[48-49]. For the state of the whole universe, no outside measuring device or observer exists. Thus the special role of measurement or observation is essentially deprived, and the collapse process, if it exists, must be added to the wave function. The recent dynamical collapse theory further revised the above relationship[12][27-36]. In the dynamical collapse theory the normal linear evolution and collapse process of the wave function are unified in a stochastic nonlinear Schrödinger equation, and the collapse process is a natural result of such evolution. Thus the new relationship between consciousness and collapse is that collapse of wave function must happen independent of consciousness.

Although the collapse of the wave function does not need to resort to the consciousness of an observer, and is an objective process in the dynamical collapse theory, most physicists hold an implicit prejudice. The implicit prejudice is that the collapse process of the observed superposition state of classical definite states must have finished *after* the conscious observer can identify the classical definite states. It would therefore appear that consciousness is essentially connected with collapse again. But this can't be accounted for by the dynamical collapse theory, and no known theories and experiments have confirmed it. It is our opinion that this prejudice may result from a misunderstanding that when a conscious observer can identify the definite measurement result of the superposition state, collapse must happen. In fact, as we have demonstrated, consciousness and collapse are relatively independent in the framework of a dynamical collapse theory. Although consciousness rejects superposition, it needs not result in collapse, and their combination can also permit the availability of QSC.

As the seeds of QSC, consciousness and collapse are both indispensable. Collapse provides the basis, and consciousness provides the means. Even if consciousness doesn't intervene, collapse itself can also display quantum nonlocality, and thus result in the existence of a preferred Lorentz frame. This may further imply the existence of QSC when combined with the minimum ontology. However, collapse alone can't provide the means of realizing QSC, and its inherent randomicity ruthlessly block the way. Here consciousness becomes a delicate bridge to QSC. The direct intervention of consciousness can help to obtain more information about the measured quantum state, which is enough to distinguish nonorthogonal states, and decode the veiled information nonlocally transferred by collapse. Then QSC is no longer a dream.

Finally, it should be denoted that the above QSC principle also provides a physical method of testing the existence of consciousness[50-52]. We can test whether the conner possesses consciousness through its identification of nonorthogonal states. The conner with consciousness can distinguish the nonorthogonal states, whereas the conner without consciousness can not. This provides a physical way to distinguish between man and machine, and will partially solve one of the hard problems about consciousness, namely 'Who can be said to be a conscious being?'[15]. Certainly, the method can only apply to the conners satisfying the "QSC condition."

6 Some Evidence

In the last section, we will seek the evidence of the existence of QSC in our world. Undoubtedly we are taking a risk by exploring these superphysical phenomena. Long ignored by mainstream science, we will demonstrate that telepathy or perception at a distance has revealed that our human brain may indeed have some kind of QSC ability.

Even though a very large number of superphysical phenomena may be not real, telepathy does appear to exist. Its usual appearance occurs between familiar people, such as twins, relatives or friends. In these special situations one party can perceive the other's experience, such as being sick or injured etc, at a distance. Many people have reported this kind of experience. In recent times telepathy phenomena have been confirmed by some strict scientific experiments[41-43], and are being studied by more scientists[12][53-54]. One of the most convincing experiments was done in 1994 by Grinberg-Zylberbaum et al[42], which has recently been successfully replicated by L. J. Standish et al [43]. In this experiment, pairs of subjects were first allowed to meditate together, and then moved into two semisilent Faraday chambers 14.5m apart. An independent EEG machine registered each subject's EEG activities. 100 flashes stimulated one subject of each pair at random intervals, and each photostimulation resulted in an evoked potential for the stimulated subject. It was observed that when the stimulated subject registered a distinct evoked potential, the non-stimulated subject also registered a "transferred potential" similar to the evoked potential in the stimulated subject. Subjectively both subjects felt that their interaction had been successfully completed. Since soundproof faraday chambers separated the subjects, this experiment guarantees that neither sensory signals nor electromagnetic signals could be the means of communication. This strictly demonstrates the existence of nonlocal correlations or perhaps even QSC between human brains.

In the following, we will analyze the above experiment in terms of our QSC principle. It will be shown that the QSC principle can explain the experimental results. This indicates that QSC may exist between human beings.

[15] It is generally accepted that the hard problems about consciousness mainly include four W problems and one H problems, they are stated as follows:
1. What are the media and mechanisms of consciousness?
2. Where, if anywhere, is the locus of consciousness?
3. Who can be said to be a conscious being？
4. Why is there consciousness at all?
5. How does consciousness arise in, or emerge from, its underlying substance, structure, and mechanism, in the way it does?

For a conscious being the “QSC condition” requires that his perception time for the definite state be shorter than the dynamical collapse time of the perceived superposition state, and that the time difference be large enough for the conscious being to identify. In the above experiment this condition is indeed satisfied as implied by the experiment results. On the one hand, the quantum entanglement state between the subjects A and B in the experiment, which is formed by meditative interaction and can be written as $\chi_1(A)\chi_2(B)+\chi_2(A)\chi_1(B)$, can hold for a long time until the experiment is completed. Thus appears the observed similarity between the evoked and transferred potential. This indicates that the dynamical collapse time of the quantum entanglement state is also very long, say several ten’s of minutes[16]. On the other hand, the perception time of the subjects for a definite state is generally of the orders of 0.1s. We conclude that in the experiment the collapse time of the entanglement state or superposition state is much longer than the perception time of the subject for the definite state, and that the time difference is also large enough for the subject to identify. This means that the “QSC condition” is naturally satisfied in the experiment.

Once the required “QSC condition” is satisfied, QSC can be realized. As we have demonstrated, a subject satisfying this condition can distinguish nonorthogonal states, and he will have different perception processes for a superposition state and a definite state. As revealed in the experiment, when subject A is not stimulated and the quantum entanglement state still holds, subject B will be in the superposition state, and have no distinct feeling related to the state. When subject A is stimulated and the quantum entanglement state collapses, subject B will be in a definite state, and will experience a distinct feeling that their interaction has been successfully completed. Then QSC can be realized if we encode the different stimulating operations on subject A, and correspondingly decode the information using the different perceived feelings of subject B.

Lastly, we will summarize three basic steps to achieve QSC using the quantum entanglement state of brains.

Step 1. Form the entanglement state of the brains

During this step, the quantum states of the brains are entangled. Here we give a possible way to entangle the quantum states of the brains. Suppose two photons are in the entanglement state $\psi_1\varphi_2+\varphi_1\psi_2$, and they respectively enter the eyes of two subjects A and B whose initial states are respectively $\chi_0(A)$ and $\chi_0(B)$. After interaction the entanglement state of these two brains will be formed, which can be written as $\chi_1(A)\chi_2(B)+\chi_2(A)\chi_1(B)$. Here we assume that the photons are absorbed in the process. In the above experiment, this step is realized by the meditative interaction between the subjects.

Step 2. Hold the entanglement state of the brains

The formed entanglement state of the brains may be some kind of microscopic quantum state, and it can be held for a long enough until a measurement results in the collapse process. We assume this condition may be satisfied in some areas of the brains. In the above experiment, this step is realized by the subjects' perception of feeling each other's presence at a distance.

Step 3. Collapse the entanglement state of brains

[16] It should be denoted that some theories may support the possibility of the existence of a much longer collapse time[55-56].

When we want to use the entanglement state of brains to achieve QSC, we measure it by a certain means. The measurement collapses the entanglement state, and the states of both brains become definite. Here the brains may perceive the change. When in the entanglement state or superposition state, no definite perception exists. When the superposition state collapses to a definite state, a definite perception can appear. In the above experiment, this step is realized by stimulating subject A with 100 flashes, and when the entanglement state is collapsed by the stimulation, the subjects perceive a feeling that their interaction has been successfully completed.

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