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Non-local signaling based on noise reduction

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Abstract:

Superluminal communication is considered impossible by most physicists. However this statement must be examined over and over. This paper offers an experiment that can in theory check the validity of this statement.

Introduction:

In 1935 EPR [1] had proposed a gadaneken experiment which purpose was to show quantum mechanics is an incomplete theory. EPR's gadaneken experiment was quantified by JS Bell in 1964 [2] offering the famous Bell's inequality $P(a,c) - P(b,a) - P(b,c) \leq 1$, as P is the correlation between the measurements of the spins of the pair of entangled particles a,b, and c is the 3 arbitrary settings of the two detectors.

Bell's experiment was adapted by CHSH[3] in 1969, and proved experimentally by Alain Aspects and others [4] during 1982 and on.

CHSH's inequality states that:

$$P(a,b) - P(a,b') \leq 2 \pm [P(a',b') + P(a',b)]$$

as P is the expected value of the correlation, a,b,a',b' are alternative settings for the detectors.

Bell's inequality was tested many times, with some experiments violating Bell's inequality by over 100 standard deviations [5].

Local realism:

In order to test superluminality, we must state that in a local realism deterministic world, the world imagined by EPR, a Bell experiment would have result in:
$P(a,c) - P(b,a) - P(b,c) \geq 1$.

If this was the case, then EPR would have been correct, and no non-local connections would have taken place in our universe.

However, if we were able to somehow measure, or at least know the spin (or polarization) of our entangled system before it reaches our detectors, then the superposition between particles of our system would collapse.

If we could have then enabled our particles to reach the detector, we would have received $P(a,c) - P(b,a) - P(b,c) \geq 1$. This is because the measurement (or our knowledge) turned the spin or polarization to be a "pre-determined hidden variable".

To be more specific, if any observer knows in advance the outcome of our experiment, the outcome of our experiment is predetermined, and hidden, as we don't yet have this information.

Bell's inequality was designed to eliminate this exact possibility.

Multiple entanglements:

However, we do have the possibility to know the outcomes of at least some of our particles measurements prior to their measurement in our detectors.

For example, consider a GHZ [6] system$\frac{1}{\sqrt{2}}(|H\rangle_1|H\rangle_2|V\rangle_3 + |V\rangle_1|V\rangle_2|H\rangle_3)$. We can send photon number 1 to a distant observer, conventionally called Bob.

Alice, our experimenter, now holds two entangled photons in an entangled state of $\frac{1}{\sqrt{2}}(|H\rangle_2|V\rangle_3 + |V\rangle_2|H\rangle_3)$.

Alice, instead of measuring her results, can now send her two entangled photons to a standard CHSH test.

If distant Bob chooses to turn off his detector, Alice's measurement will find $P(a,b) - P(a,b') \leq 2 \pm [P(a',b') + P(a',b)]$, compatible with a standard CHSH experiment. This means Bob had transmitted a <0>.

However, if distant Bob chooses to measure his photon's state, then by so Bob knows the results of Alice's experiment before Alice's measurement, causing Alice's outcomes to be pre-determined and by so obeying EPR's statistics, i.e.

$$P(a,b) - P(a,b') \geq 2 \pm [P(a',b') + P(a',b)]$$

Bob has now transmitted <1>. This method of superluminal communication shall be called type 1.

Other multiple entanglements or even other measuring methods may be used as well, as long as Bob's measurement predetermined Alice's CHSH test result.

The altering of Alice's results is a superluminal phenomenon.

Interesting enough, this result is not necessarily caused by the properties of entanglement. If Bob receives a mixed ensemble of GHZ states, Bob's measurements do not pre-determine the expected outcome of Alice's experiment, and no pre-determination had occurred.

It may prove that the GHZ state of the photons is only determined in the moment of measurement, unless pre-determined, for example by a GHZ experiment setup.

It may be Bob's knowledge that causes the collapse of the GHZ state superposition, rather than the technical act of the measurement.

Another method of superluminal communication was mentioned by JG Crammer and Nick Herbert [7], using the "ghost interference" experiment of the Shih group\UMBC [8].

In this experiment [7, fig 3] distant Bob sends Alice messages by passing the o photon from an entangled pair through a single slit or a double slit.

Distant Alice measures her "e photon" and discovers Bob's message.

This method of superluminal communication shall be referred to as type 2.

This method can also be used with GHZ state prepared photons, as the GHZ method can be useful in the reduction of noise.

Noise:

The strongest technical problem standing in front of superluminal communication is the presence of noise.

For example, in JG Crammer and Nick Herbert's proposition [7], entangled photons are sent to a distance, and the measurement of one affects the expected results of the other (appearance of interferometry patterns).

However, in order to know which photons are to be tested, a coincidence counter must be present, as a method of noise decreasing. Otherwise, only a comparison of data between Alice and Bob's measurements that can be made only by sub-luminal methods can reveal which photons are to be referred to.

The probability of creating an entangled pair by using a typical λ = 788nm from a mode-locked Ti-Sapphire laser, which passes through an optically nonlinear crystal (for example a Beta-Barium-Borate, BBO) is 10^{-4}[6].

In other words, the SNR in JG Crammer and Nick Herbert's proposition is 0.01%, which may prove challenging to measure.

However, we can improve the SNR ratio by using a GHZ experiment setup [6].

Consider a GHZ experiment setup [6, fig 1], as Alice holds detector T, and detectors D_3 and D_2. Distant Bob holds detector D_1.

According to the paper mentioned in [6], if all four detectors detected a coincident detection, then we can conclude that a GHZ entanglement was recorded.

Bob's detector D_1 is not connected to Alice's coincidence counter, but to its own separate clock, registering times of detections.

Since, in theory, Bob has the possibility in the future to compare results with Alice, Bob caused Alice's present GHZ state to collapse and the result became pre-determined.

In Alice's system, noise will be considered a case in which all three detectors held by Alice in [6, fig 1] (Trigger detector, D_2, D_3) will register a coincident detection, but Bob's (future) clock comparison (Bob holds detector 1) will show no coincident detection correlated to Alice's.

If this is the case then no definite GHZ state was held by Alice, and Bob's distant (present) measurement had no effect on Alice's system. Alice's photons are entangled however.

The probability of achieving a GHZ state, i.e. a coincident detection of all four detectors divided by the probability of finding noise (only three coincident detections, all of them in Alice's detectors) will be called sound to noise ratio - SNR.

To overcome the noise in type 1 transmitters, Alice performs a CHSH experiment on her entangled photons, those connected to detectors 2 and 3 [6, fig 1].

$P_{(l.r)}$ will be defined as the probability of finding correlations between entangled photons by mere statistics, complying with the rules of a local realism universe.

$P_{(q.m)}$ will be defined as the probability of detecting correlations according to quantum mechanics in a specific setting.

In order to read <1>, the correlations between the photons must follow: $((1 - SNR)(\mathrm{P}(\mathrm{l.r})) + SNR(P(\mathrm{q.m})))(S)$, as S is the total number of coincidences counted in Alice's coincidence monitor. Alice can now calculate SNR as she expects $P_{(q.m)}$ results. If SNR=1, Bob made no measurement and by so broadcasted a <0>. If SNR<1, Bob interfered with Alice's measurements and broadcasted a <1>.

If using type 2 transmitters, Bob can transmit a <1> by the appearance of a double slit interferometry pattern in detector "f2" [7, fig 3] or a <0> by the appearance of a broad diffraction pattern.

Again, using the GHZ setup [6, fig 1], Alice counts only events in which all three detectors detect a coincident detection.

Noise will be defined in the same way as defined by type 1 transmitters.

In case of noise, Alice will receive no interferometry pattern on her screen.

Naming a double slit interferometry pattern "d.s.i" and a broad diffraction pattern "b.d.p" by closing one slit, Alice will receive a pattern correlating with $SNR(dsi)$ or $SNR(bdp)$, but not an SNR pattern.

Conclusion:

In every set of superluminal communication, if we connect only Alice's detectors to a coincidence monitor, by counting entangled photons at Alice's detectors, and by Bob's measuring (or not measuring) all of his photons, we can reduce noise in a manner that might prove sufficient for superluminal communication.

Bob's system may not be connected to Alice's system, yet affects it from afar.

Special relativity's equality of invariant systems:

It has been mentioned by Mauldin [9] that superluminal communication is apparently inconsistent with special relativity. Other than the obvious inconsistency, that is, the superluminality, superluminal communication apparently doesn't comply with S.R's most fundamental postulate, i.e. that laws of physics are invariant in all inertial systems.

Consider two reference frames, S and S', S' being on board a fast traveling train while S is the dock nearby.

Two observers, O and O', are observing the communication between Bob and Alice.

O, boarding the train, reports that Bob's measurement occurred in t_1, Bob's distance from Alice is x, and Alice's measurement occurred in t_2, $t_2>t_1$. As Bob broadcasted a <1>, Bob's measurements caused Alice's superposition to collapse, hence Alice measured SNR<1.

However, O', standing on the dock, may tell a different story. As $t' = ((t - vx) \div c^2)\gamma$, as v is the velocity observer O sees observer O' in, x is position at t ($_0$). From here we can achieve that $t'_1>t'_2$, or in other words, that Alice's measurement came before Bob's measurement.

But if this is the case, what made Alice's q.m measurements collapse in communication type 1?

It couldn't be Bob's measurements, as these yet weren't made according to O'. O' will conclude that q.m rules are sometimes broken prior to the system being measured by another observer (Bob), as O will conclude that only Bob's measurement can alter Alice's measurement. This is inconsistent with the statement of invariance in all inertial systems.

In order to sustain consistency between superluminal communication and special relativity, we must add a new symmetry to quantum mechanics, which is a future/pass symmetry. In this symmetry, *if an event has a 100% probability to occur, it will be considered as if the event had already occurred.*

For example, in O's system, in superluminal communication devices of type 2, the fact that Bob *will* open both slits in his system in the future causes Alice's experiment in the past to behave as if the systems have *already* gone through a double slit, thus being consistent with the invariance of all inertial systems.

Both O and O' will report a double slit interferometry pattern in Alice's screen. O will report that this happened due to Bob's past measurement, and O' will report that this happened due to Bob's 100% probability future measurement.

However, if Bob will open only one slit in the future, Alice's experiment in the present will show a broad diffraction pattern.

In other words, according to O's view, future Bob had sent a signal to present Alice.

A weaker version of this symmetry was mentioned by John Wheeler [10], but in Wheeler's version, present results "shed different light" on past occurrence. In this example, future results alter present results.

This can be validated by an experiment:

Consider the experiment mentioned by the Shih group [8 fig. 1]. In this experiment the detectors are placed in a similar distance from one another. We can place a small "delay" between the beam splitter and detector f1.

In this case, photons will reach detector f2 before photons reaching detector f1 will pass through a single slit or through a double slit.

However, if the delay is small enough, (yet large enough to be considered macroscopic, several hundred µm's to several mm's, depending on the efficiency of the system), there is a 100% probability that the photons will pass through the single or double slit, and therefore the result had already occurred.

Bob is now unable in any way to change the results of the experiment between the time that Alice made her measurement and the arrival of Bob's photons to Bob's slits.

Also, the results of the experiment are very much unlikely to change due to loss of data at these short distances.

Alice will receive a double slit interferometry pattern if Bob's two slits are open or a broad diffraction pattern if only one slit is open. This, despite the fact that photons clearly haven't yet reached Bob's slits.

This however, sounds inconsistent with quantum delayed choice experiments [11]. In these experiments if the "which way" information exists, no interferometry pattern will be shown on screen unless the information had been erased by a quantum eraser [11].

In quantum delayed choice experiments the existence of the information causes no pattern to appear. We expect the same result in our experiment, *no* interferometry pattern should be apparent, neither a broad diffraction pattern nor a double slit interferometry pattern on Alice's screen.

This inconsistency is caused by the fact that in quantum delayed choice experiments, the information *can* be measured and therefor there is a probability of a paradox to occur. The experiment described above was conditioned by the fact that Bob cannot change the result of the measurement after Alice made her measurement.

If the "delay" leading to "f1" detector is large enough, however, Bob can close or open one slit between Alice's measurement and the arrival of the photons to Bob's slits.

This means future Bob can interfere with Alice's present measurements.

Moreover, information maybe lost due to system failures.

If this is the case, there is no 100% probability for Bob to measure neither a double slit interferometry pattern nor a single slit broad diffraction pattern.

In this case, Alice will receive no interferometry pattern, not a double slit nor a single slit pattern. This result is consistent with quantum delayed choice experiments.

However, in the case mentioned above with O and O', O' seemingly will report that after Alice made a measurement and found a "half double slit interferometry pattern", the photons arrived at Bob's detectors.

According to O', nothing now denies Bob from closing one slit. According to O', Bob will *decide* whether he wants to open one slit or two, and he will decide to open both slits, and therefore a double slit interferometry pattern already appeared on Alice's screen.

In O's experiment Alice's measurement came before Bob's measurement and Bob had a choice whether to open one slit or both, and therefore no 100% probability of any event occurred, and therefore Alice should have received no interferometry pattern at all.

The answer to this seeming paradox lies within the ability of Bob to choose if he wants to measure the information or not.

In the experiment held on a fast traveling train according to O' Bob didn't have freedom of choice whether he wishes to open one slit or both. This is because according to O Bob *already* opened both slits. Therefore in O's system Bob had no freedom of choice and Alice's screen showed a measurement that was already pre-determined.

Bob had only a mere illusion of freedom of choice according to O'.

The fact that in quantum delayed choice experiments and in the experiments mentioned above, the mere existence of the information causes no interferometry pattern to appear unless the information was erased or had 100% of not being altered, is explained by the freedom of choice possessed by Bob – Bob's ability to alter Alice's past caused the entanglement to collapse, and by the probability of system failures to alter future results.

Special relativity's light barrier:

However, an apparent stronger inconsistency lies between superluminal communication and special relativity. The light speed barrier, imposed by the last, seems to prove that superluminal communication is impossible.

To date, every experiment made backed this claim of special relativity, and no experiment was able to prove otherwise.

Superluminal communication would prove that signaling faster than light is possible. In this case, is this an inconsistency with special relativity?

We must point out that all superluminal transmitters offered in this paper work in condition that the superluminal signaling occurred prior to our measurements. However, no experiment has ever ruled out a possibility that before our measurement superluminal velocity was achieved, and that the measurement itself caused the result to appear sub-luminal.

Prior measurement and post measurement:

This option wasn't examined thoroughly, as this thesis sounds counter-intuitive. This interpretation means that prior to our measurement the system behaved with certain rules, and after our measurement the system behaved with a different set of rules.

Einstein once ridiculed this option by saying: "I like to think that the **moon** is there even if I am not looking at it"[12]. Schrödinger ridiculed this idea by using the famous "Schrödinger's cat" thought experiment. And so asked Schrödinger- Prior to our measurement, what is the state of the cat? [13].

Let's now examine seriously the option that prior to our measurement the system behaves in a very different manner than after our measurements.

The presence of superluminal transmitters will force us to assume that at least one rule applies on our pre-measured system, that doesn't apply to our post measured system, and this is superluminal velocity. Since the superluminal communicator can communicate in 0 time between any two distances, we may have to conclude that infinite velocity is achievable prior to our measurement.

Philosophic discussion:

With fidelity to the ideas mentioned above by Einstein and Schrödinger, we would like to minimize the controversy between prior measurement and post measurement physical rules.

However, superluminal communication forces us to make the assumption that if a particle or a photon is a particle or a photon *before* being measured, then it must have at least one rank of freedom of superluminal velocity.

Let's think of a particle traveling with infinite speed. If it travels in a certain direction, it will reach the end of the universe and disappear in 0 time.

Therefore, we must be discussing an oscillator of some type.

But how will an infinite speed particle oscillator behave?

First of all, it will have no specific place in space. Rather, it will be simultaneously in the entire space that it occupies.

This property is similar to the property of a wave that occupies simultaneously all space that it is present in.

It may prove to be a wave by any definition waves can be defined by, including complying with Huygens' Principle.

Second, after its measurement, it will be forced to comply with special relativity's light speed barrier. However, once traveling in luminal or sub-luminal speed, it is not anymore present in the entire space that it occupies.

Rather, it again becomes a particle occupying space relative to its size.

This property is similar to the wave function collapse. The collapse of the wave function is the process in which a wave becomes a particle. It happens only (to the best of our knowledge up to date) in case of measurements.

In this description – an infinite velocity moving particle (which is actually a wave) turns into a subluminal velocity moving particle after our measurement, as our measurement forced it to comply with special relativity's rules.

The fact that the particle's velocity became subluminal caused the "wave function" to collapse. This description is very much similar to our description of "wave function collapse".

Another interesting property of this infinite velocity particle oscillator is that when we measure its location, for example, we don't know what results we shall expect.

Since its velocity is infinite, and it is present in the same time in all space that it occupies, no determinate measurement can state where it will be found.

We can however state that if its oscillation is between two points A and B, it has an equal probability of being found anywhere between A and B.

This is similar to the probabilistic interpretation of quantum mechanics.

However, mathematics should be applied in order to phrase the exact properties of such an oscillator (oscillating in infinite velocity).

In conclusion, superluminality and special relativity not only don't contradict one another, but combined together they can explain fundamental properties of quantum mechanics, that today are considered mysteries.

However, in order for these two theories to live in harmony, we must forfeit our realistic view and accept that physics laws before measurement are different than those after.

Prior measurement/ Post measurement

The conclusion of this philosophic discussion is that wave functions, and the collapse of the wave function, are physical entities, and not only ways for us to describe our systems.

Prior to our measurement, the wave function represents a wave. After our measurement, the measured matter becomes a particle.

Before our measurement, the examined particle behaves in a non-deterministic probabilistic manner, described well by quantum mechanics equations.

After our measurement, the particle behaves in a deterministic manner described well by classical mechanics.

This can be shown by several thought experiments.

Consider a pair of entangled electrons A and B, as described by Kumar to be the original EPR paradox [14]. According to Kumar, it is possible to measure the exact position of particle A and by calculation finding the exact position of particle B. Now, we can place a potential barrier in front of electron A. If position of electron B is unmeasured, due to the tunneling effect, electron A has a certain probability to overcome this potential barrier even if the potential V_0 is greater than the energy E of the electron.

Textbook formulas state that the transmission coefficient for a rectangular potential barrier is $T = 1\backslash(1 + \frac{V_0^2 sinh^2(k_1 a)}{4E(V_0 - E)})$, as a is the width of the barrier, and $k1 = \sqrt{2m(V0 - E)/\hbar^2}$.

It is easy to set for example T to be equal 0.1, which means 10% of all electrons will pass through the potential barrier.

However, the tunneling effect is a result of the wave-like nature of the pre-measured substance.

If position of electron B is measured before electron A reaches the potential barrier, then the wave function of electron A will collapse.

Same as in the double slit interferometry experiment, no wave function will now be apparent. Therefore, electron A will comply with classical mechanics, which state that if $V_0>E$, no electrons will pass through the potential barrier.

Now, in theory, we can place an energy detector C after the potential barrier, which is connected to a coincidence counter.

This measurement will show that if electrons A and B were entangled, and electron B's position was measured, electron A which passed through the potential barrier had $E>V_0$.

If however electron B was unmeasured then the passing electron A could have had $E<V_0$, as it possessed wave-like properties until measured by detector C.

In this case detector C can detect electrons which possess $E<V_0$.

The difficulty of conducting such an experiment is that the measurement of electron B's position may have altered electron's A's momentum, and therefore electron A's momentum must be measured precisely after the barrier.

However, optical analogues can be measured using the Elitzur Weidman [15] Mach Zender interferometer.

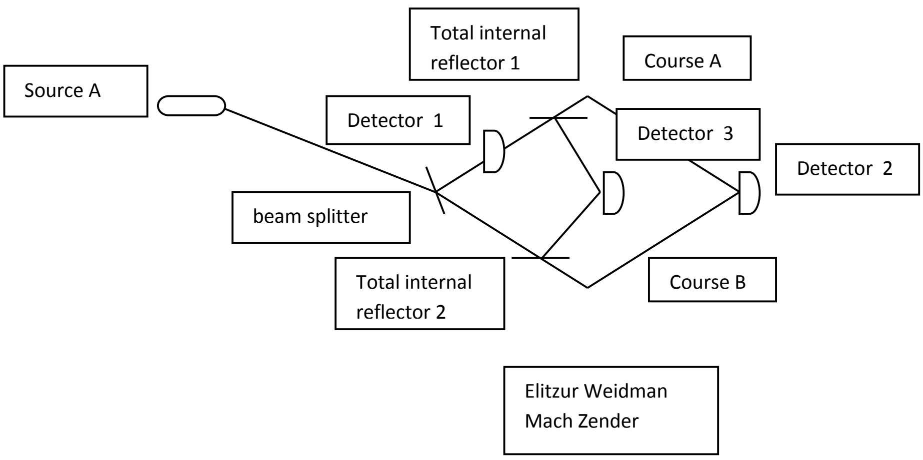

Fig 1-

Light from source A reaches the beam splitter. If detector 1 is closed, light reaches a total internal reflector with $\theta > \theta_c$ and most of the light will be detected by detector 4. The probability of photons passing through the reflector due to their wavelike attributes is inversely proportional to the reflector's width, however it can be set to be different from zero. If detector 1 is open, we now have which way information about the photons course. The photon passed through course B, and therefore the wave function collapsed. The lights behavior is now particle like, and therefore light cannot continue to detector 3 unless its wavelength results in $\theta < \theta_c$.

In the experiment described above wave like properties of light such as the optical tunneling analogue are shown to exist only before the measurement had occurred.

We can find θ_c by using the Snell law: $\frac{n\lambda 1}{n\lambda 2} = sin\theta_c$.

If detector 1 is closed, detector 2 may detect wavelengths that will show that photons passed through the reflector despite $\theta > \theta_c$ for chosen λ. However, if detector 1 is open, detector 3 will detect only wavelengths that comply $\theta < \theta_c$.

The opening of the detector is considered as a measurement, and therefor in order to sustain uncertainty principle, the momentum of the photons may increase. This is the reason that new wavelengths will appear in the experiment, and those are the ones that will be measured by detector 2.

As we open detector 1, we will always find that λ detected by detector 2 is smaller than if detector 1 is closed.

Another thought experiment that can be used to prove the classical nature of the post measured system, is by using two entangled electrons A and B, confining electron A into a potential well, and sending electron B to a momentum detector.

If electron B is left unmeasured, electron A's energy levels will turn out discrete, as text book formulas give energy levels for an infinite well potential $\mathrm{E}n = \frac{\hbar^2\pi^2 n^2}{2md^2}$, $n = 1,2,3$ ...

However, by measurement of electron B's momentum *before* the confinement of electron A, we can derive electron A's energy before it reaches the potential well.

In this case, electron A's energy is predetermined and can be calculated using classical mechanics rules. A's energy measurements can now be continuous and not discrete.

These experiments however demand energy measurements of single photons, which may prove difficult.

An experiment that may be easier to conduct that demonstrates the classical behavior of post measured wave functions can be shown in the collision between two photons.

As post measured wave functions behave like classical particles, we expect that a measured photon interacting with another photon will demonstrate a Compton affect, and its behavior will comply with collision equations.

Consider photons A, B and C, A and B photons are correlated to one another, and the C photon is in a collision course with photon A. If photon B's position is measured before the collision, then photon A's position can now be calculated.

From energy conservation we can derive $hf_{\mathrm{A}} + hf_{\mathrm{C}} = hf'_{\mathrm{A}'} + hf'_{\mathrm{C}'}$.

From momentum conservation we can derive $\frac{h}{\lambda}_{\mathrm{A}} + \frac{h}{\lambda}_{\mathrm{C}} = \frac{h}{\lambda'}_{\mathrm{A}'} + \frac{h}{\lambda'}_{\mathrm{C}'}$.

If θ is the angle between the photons course before the collision, and θ' is the angle between its course after the collision, in some cases we can measure $\theta \neq \theta'$.

If A's momentum P_A equals C's momentum P_C, but both photons are sent in opposite directions, photon A may bounce back to its starting point.

A and B could be entangled in a superposition between horizontal and vertical polarization, as C's polarization can be set to a different direction.

If we assume that the collision between A and C can occur in the middle of the distance between them, the distance that A must travel in order to reach C's starting point equals the distance A must travel to reach the collision point and turn back.

We can set the coincidence counter to detect coincidences as if A was to reach C's starting point c.

Now we can place detectors h and v near A's starting point, and a vertical polarizer in front of detector v and a horizontal polarizer in front of detector h.

By measuring photon B's polarization in detector b we know photon A's polarization. If for example a coincident detection was made by detectors v and b, and A's polarization was measured to be vertical, the probability that the origin of a's detection is photon A is very high.

The probability that the origin of detector a's detection is photon C is very low as C photon should be blocked by the polarizer, and we can conclude that a collision had occurred.

However, photons from source A could have only reached detector a by recoil, i.e. if the a photon returned backwards from its original course.

This however requires that polarization will be preserved after the collision, as in the case of a mirror.

If polarization is not preserved, we can detect collisions between photons A and C by setting $P_C \ll P_A$, and by so the problem becomes close to the Compton scattering problem.

Now, we can use the Elitzur Weidman [15] Mach Zender set to show photon photon Compton scattering effect.

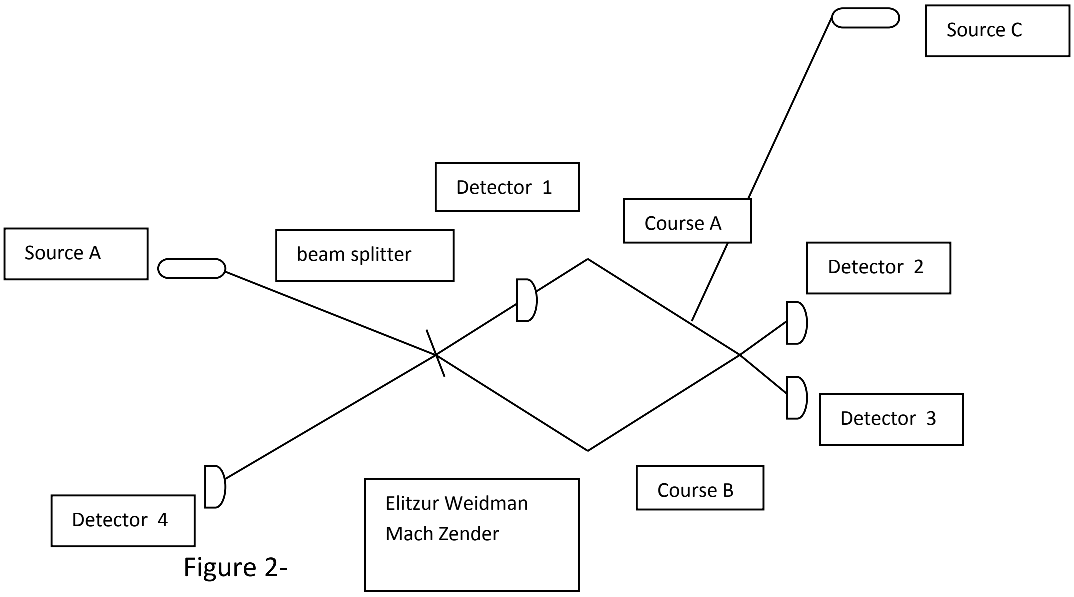

Figure 2-

Photons from source A are sent to a beam splitter. If detector 1 is left closed, we have no which way information about the course of photon A. We can set the Elitzur Weidman interferometer so that only detector 3 will receive light, and not detector 2. Light from Light source C will pass through course B, reach the beam splitter, and have a 50% chance of being detected by detector 4. If $P_C << P_A$, light source C has negligible effects on detectors 2 and 3 in case detector 1 is closed. If detector 1 is open, light from source A could have only come from course B, and by so can reach either detector 2 or 3 as no wave cancelation occurs. Light from source C can reach detector detector 4, but due to the photon Compton scattering effect, it may reach detectors 2 and 3 as well. The probability of light reaching detector 4 is now less than 50 %, and probability of light arriving at detectors 2 and 3 is now higher than if detector 1 is closed.

As shown above, seemingly, the opening or closing of detector 1 should have no apparent effect on the probability of light reaching detector 4. Probability changes in detector 4 prove that light from source C was affected by light from source A. Probability changes in Detectors 3 and 2 when light source C is open, in comparison to probability detections when light source C is closed, proves that light from light source C was measured by detectors 2 and 3.

However, this consequence could have only come from a photon photon scattering Compton effect.

It must be left in mind that the probability of a photon photon collision may be small due to the size of the photon. Using the Elitzur Weidman Mach Zender interferometer may prove as an effective option for detecting this effect.

If polarization is sustained after the collision, we can add polarizers in front of detectors 2 and 3 in figure 4, and set photon C's polarization so it can pass through the polarizers.

In this case, without the photon photon collision effect, no photons should be detected by detectors 2 and 3, as the polarizers should block photons from source A, and photons from source C should arrive at detector 4 or at source A, where they should be destroyed.

If detectors 2 or 3 detect photons from source C, even with low probabilities, this will prove that photon collision effect had occurred.

One of the most distinct features of quantum mechanics is the uncertainty principle. If particles behave quantum like prior to our measurement, and classically after our measurement, the uncertainty principle should not be applied on measured systems.

In order to justify this statement, consider a multiple entangled system with three entangled particles in it, particles 1, 2 and 3.

Consider the system to be in an initial state $P_{0,}$ in which we know exactly the momentum of each particle but we don't know it's location at all.

In this case, we cannot predict in any manner the position, X, of both of the particles, and the result of position measurement of both particles should result in random outcomes.

Now, if we measure precisely the location of the first particle, the wave function collapses, and we can measure the momentum of the second particle precisely.

In a classical system, no "affects from afar" can occur, and no uncertainty relations between momentum and position take place, as these are quantum attributes.

Particle 3, which became a classical particle after the position measurement of particle 1, and possess similar momentum as particle 2, can now be measured.

According to classical mechanics we can chose whether to measure its momentum or its position, and we can give predictions to either measurement.

According to quantum mechanics, since we now know particle 3's position or momentum, one of these properties is unpredictable.

Since particle 3 was measured and therefor behaves classically, we can determine both its position and its location.

For example, if these particles are photons, we can measure in half the cases location and half the cases momentum, and find compatibility between our predictions and our measurements.

We can compare these results to results that are given if location of particle 1 is not measured.

The results may prove that the uncertainty principle doesn't apply to post measured systems, only to pre-measured systems.

In conclusion, small objects such as photons and electrons may behave classically after measurement.

The measurement dictates a deterministic behavior, but however, systems with deterministic behaviors are no longer quantum systems but classical systems.

The pre-determination alone may be the reason of quantum behavior changing into classic, and not necessarily the technical act of measuring.

Non local signaling based on quantum eraser:

In order to eliminate noise, we can build a quantum communication system based on the Mach Zender interferometer and the quantum eraser [11].

Consider a Mach Zender interferometer with two courses A and B, a clock wise circular polarizer on the A course and a counter clock wise circular polarizer on the B course, similar to a standard quantum eraser experiment.

We can set two detectors A_1 and B_1 on the two exits of the Mach Zehnder interferometer, so that regularly light from course A and from course B will reach the A_1 detector in a destructive interference, and detector B_1 in a constructive interference [16 box 1].

If A_1 and B_1 detectors can detect circular polarization, then which way information is apparent, and photons behave particle like. No interference pattern should be seen on both detectors A_1 and B_1.

In this case, the photons will behave particle like and photons have a probability of reaching detector A_1, as shown in the Elitzur Weidman interferometer experiment [15].

Now, we can send entangled photons to the system. The o photon may be sent to the double-slit with the circular polarizers, and the e photon may be sent to the single course, similar to a standard quantum eraser experiment.

Now, Bob, who receives the e photon, can erase the which way information by passing the e photons through a linear polarizer like in a standard quantum eraser. In this case no which way information can be obtained, the photons behave wave-like and Alice, who receives the o photon, will detect an interference pattern in her detectors.

However, Bob can remove the linear polarizer and by so which way information is preserved. The photons behave particle like and distant Alice detects no interference pattern in her detectors. Bob had now transmitted a <1>.

Bob must leave a clock on his system or which way information may be lost, and wave function collapse may not occur.

Encryption

Obviously, if we are certain that only two entangled photons were involved in the process, such communication will be encrypted as an eavesdropper cannot know whether Bob measured his photons or erased them. If he tries intercepting the cypher message he could only alter it by measurement, however, he cannot read the message.

If Alice adds a coincidence counter to the Mach Zender interferometer, if no coincident detections are present, Alice can be sure that only two photons had were present in the message.

Pre-measured and post measured energy states

As this paper describes methods of superluminal communication, one must ask what the energy source that enables this communication is.

One interesting optional answer is that the source is the measurement itself. Measuring the state of the particle requires energy, and this energy enables superluminal communication.

However, this option seems false, as even if 100% of energy invested in measurement will be used for the measurement, superluminal communication is still possible.

However, all energy invested in measurement was used for measurement purpose, and therefore this energy cannot be the source of the energy used for communication.

According to the philosophic discussion above, if a photon passes through two courses A and B, it is present, simultaneously, in both courses, A and B.

That means that it's energy state is twice larger than in its post measured state, which limits the photon to either course A or B.

However, the probability of measuring the photon as it remains in both courses is half of the probability of measuring it when it remains in only one course.

In order to prove this statement, we must first define a measurement, in order to prove that prior to our measurement the total energy of the system is higher.

However defining measurement is very difficult, therefore, it is easier to define what a measurement is not.

Consider a system in rest with no forces applied to it.

If the mass is large enough we can measure its position and neglect radiation pressure, and the result received will be that the system is in rest with bounds of uncertainty principle.

Now consider an external force is applied to the system. However, the force is relatively to standard quantum limitation very small, and the probability of detecting the force is low.

In other words, any advancement of the object can be attributed to measurement uncertainty alone, with no external force present.

In time, however the object will advance and gain velocity, despite the fact that we couldn't have measured any force applied to it due to uncertainty effect.

This is similar to the ancient Zenon paradox.

In this case, no single measurement was made that proved advancement of the object, yet after time we can see that the object had advanced.

However, since no measurement was made, and wave functions collapse through measurements, and possibly *only* through measurements, it is possible that the wave function in this case did not collapse.

Another way of phrasing this statement is: If the effect of a force is un-measurable, it is as if the force is not present.

For example, if a photon hit a system and changed its location but the change of location was smaller than measureable by standard quantum limitation, it is as if the photon hadn't hit the system, and the photon may go on and hit other systems as it would have in case the photon missed the measured system.

This means that if the power source of the moving object is, for example, very low radiation pressure, and this radiation was emitted through a double slit, and the experiment was set so there are two objects, one after each slit, both photons had a 50% probability of reaching the object and causing it to advance.

As long as the measurement remains below standard quantum limitation, we cannot know if the advancement was caused by an uncertainty fluctuation of the system or by the radiation pressure, and therefore no measurement has been made.

Now, we can measure the advancement of the two objects, each object lays after a double slit, and search for statistic correlations between the two objects.

If two photons in two courses have 50% probability of hitting the object, and a single photon in one course has a 100% probability of hitting the target, then in 25% of cases both photons will reach the target.

This means that in 25% of cases it is impossible for both objects to measure advancement compatible with the lower limit of standard quantum limitation.

However, if the photons are somehow measured before reaching the object, and therefore took only one course, it is always possible that at least one of the two objects advancement will be compatible with the lower limit f standard quantum limitation.

This may be interesting as in the microscopic scale, energy seems to be preserved: If a system has a probability of 50% of colliding with two photons with E energy, or a 100% of colliding with one photon with E energy, the number of collisions remains the same, and the system receives the same amount of energy in both cases.

However, in macroscopic systems the case may be different: Even if the probability of collision is 50% with a particle of the system, since there are many particles present, eventually a collision will occur. One photon transferred energy to two particles.

This may seem contradictive to energy preservation, but this is not true. Similar to the tunneling effect, where a particle can tunnel under a potential barrier, but we cannot measure this effect or predict which particle will tunnel, and moreover, our measurements ruin the possibility of tunneling as shown above. In this case we cannot make a measurement or even know for certain if a certain photon hit two (or more) particles in the system, or is the advancement a result of a random fluctuation caused by the uncertainty principle.

When discussing the tunneling effect, only after looking at the system we can conclude that certain particles tunneled under the potential barrier.

Similarly, in this case, only if we look at a macroscopic system which receives radiation pressure that should result in momentum and position change smaller than the standard quantum limit, we could see that every single photon from this radiation gave momentum and position change to more than one atom in the system.

This effect may explain some of the missing energy, or as called popularly the "Dark Energy".

If we can make statistic measurements under the standard quantum limit and prove that if radiation pressure changes momentum and position of system in a manner less than measurable by the quantum limit, its energy can be doubled with a tradeoff of the probability of measuring it, then we must begin searching this weak energy source in space.

In conclusion- When unmeasured, and moreover when the possibility of measurement does not exist, a single photon with energy E can transfer E amount of energy to two or more distant particles, (apparently breaking energy conservation law but this inconsistency is only apparent, similar to the inconsistency of the tunneling effect and the energy preservation law) if it has a probability of hitting these two (or more) particles.

In microscopic scales energy seems to be preserved, however when more particles are present, more energy seems to be transferred to the system than the energy of the single photon. This may in theory explain some of the missing energy known as the dark energy.

Also, in several cases, this energy may transform into mass as energy can be converted to mass by $E = mc^2$.

The interesting thing about this mass is that this mass is "probability mass".

When examining the total effect of this mass, it may seem rather large, and it may seem that it is caused by many particles.

However, when the location of this mass is measured, only one particle is measured and the rest of the particles "collapse", similar to the collapse of the wave function.

This may explain some of what is called "dark mass". However finding this mass and proving its existence may be extremely difficult.

But proving the existence of "dark energy" below the standard quantum limit may be an important step in this direction.

Summary

As we discuss the pre-measured world, we can find evidence that it is very much different than the post measured one. The pre-measured world behaves quantum-like, the post measured world behaves classically.

However, the pre- measured world must be studied, as even without measurement, we can know about it enough for making use of it, and more than that, we can know enough to find it interesting.

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