<u>Faster Than Light Communication</u>

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1. Introduction

Communication is essential to life as we know it. Over the course of time, humanity has developed ways of communicating information over progressively greater distances and at progressively greater speeds. It is widely believed that there is a fundamental limit to the speed at which information can be transferred from one place to another: the speed of light. As humanity can now transfer information at this speed, it is thought that there is no more progress to be made in this regard.

At one point, some scientists were led to believe that this information transfer "speed limit" might be overcome by means of the manipulation of entangled composite quantum systems. Unfortunately, it was eventually demonstrated that entanglement cannot be used to communicate information faster than the speed of light, a result known as the "no signaling theorem". However, among the assumptions upon which no signaling theorem relies is the postulate that there is no way to control, direct, or in any way influence the process of measurement collapse. Experimental findings of the Princeton Engineering Anomaly Research (PEAR) laboratory challenge this assumption, and therefore undermine the validity of the no-signaling theorem. In fact, some of the experimental findings of the PEAR lab immediately suggest that it might be possible to transmit information faster than the speed of light. Below, I will describe one way in which information could be transferred faster than the speed of light given the assumption that the PEAR findings are genuine.

2. Discussion of the Relevant Findings

The findings of the PEAR lab imply that human agents are able to influence the process of measurement collapse of a quantum state, albeit in a way that is not fully understood. In particular, PEAR gathered evidence that, in a given trial of measurements of a particular fiducial quantum state |PSI> which is a superposition of multiple eigenstates of a given classical observable O, a human agent can willfully increase the number of measurement collapses of |PSI> to a chosen eigenstates of O in statistical excess (or deficit) of that predicted by standard quantum theory. To illustrate the idea, say we have a system that is in the state $|PSI> \ = (|0>+ |1>)/(\sqrt{2})$. According to standard quantum theory, 50% of the measurements of this system should result in the state collapsing to |0> and 50% should result in the state collapsing to |1>. However, PEAR presented evidence that, under certain conditions, a human agent can willfully cause the statistical distribution to deviate from 50%-50% to another distribution, say 53%-47% (or 47%-53%), and to do so consistently enough to reasonably rule out the effect as amounting to random statistical aberration.

3. Implications for Information Transfer

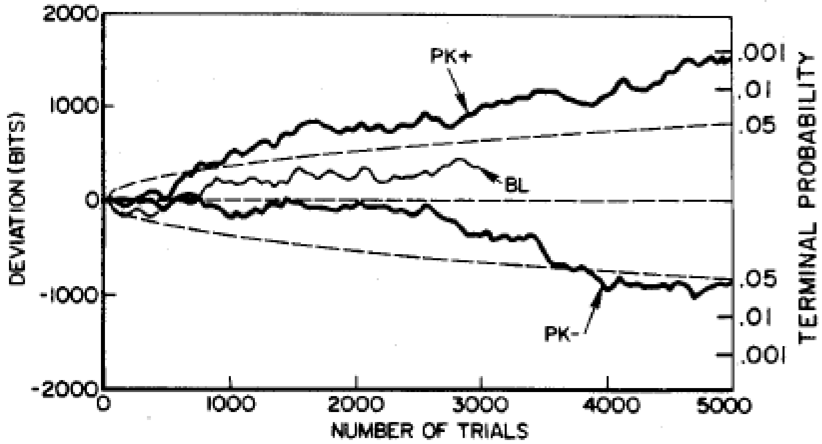
If some persons do indeed have the ability to alter the statistical distribution of measurement collapses in a series of measurements of a certain fiducial quantum state, then the no-signaling theorem no longer holds. Further, it is relatively easy to see, if this is the case, how information could be transferred faster than the speed of light. I will describe a simple scenario for faster than light communication which assumes that the above described phenomenon is genuine, and which seems amenable to relatively easy experimental verification.

Imagine that there is a stream of photon pairs, perhaps created through Type-0 or Type-I spontaneous parametric down conversion (SPDC), such that each of the photon pairs occupies the fiduciary polarization state $|PSI> \quad = (|HH>+ \ |VV>)/(\sqrt{2})$. Let one of the photons in each pair be sent to Alice, and another be sent to Bob. Imagine that the distance between Alice and Bob is great enough that light takes an appreciable amount of time to get from Alice to Bob, say 1 year. Further, imagine that Bob is an individual who is able to consistently alter the probability distribution of measurement collapse results of a quantum system. Finally, imagine that Bob receives and measures the polarization of each photon of his (from each photon pair) before Alice receives and measures each corresponding photon belonging to her.

Imagine, further, that Bob has a video monitor set up that displays to him the aggregate value of the measurements he makes on his photon, just as was done in the PEAR experiments. (See Figure 1[1].)

[1] Image credit: Robert Jahn, Brenda Dunne

Figure 1.



In this case, +1 could be the value ascribed to a polarization measurement result of V, while -1 could be the value ascribed to a polarization measurement result of H. According to standard quantum theory, the sum aggregate value of all of Bob's polarization measurements should remain close to 0. But, if Bob can influence the measurement collapse process, the aggregate value should deviate in statistically meaningful ways as shown in this figure.

Of course, whenever Bob measures an H (V) of his photon, the total quantum state is to be understood as collapsed to the state |HH> (|VV>). Everytime Bob measures his photon to be an H (V), he knows that Alice also measures her photon to be an H (V), no matter how far away she is. So, if Bob wishes to send Alice a message faster than the speed of light, all he needs to do is administer the unknown influence to the effect of altering the probability distribution of the measurement collapse results of the system in a way previously agreed upon with Alice. For instance, Alice and Bob could agree that a collapsed system distribution skewing towards |HH> encodes 0, while a distribution skewing towards |VV> encodes 1: Whenever Alice finds that the measurement distribution of her photons is skewing towards |H> or |V>, she knows that Bob intends for her to register a 0 or 1 respectively. (It would be best that Alice does not have a video monitor of her own by which she could look at the results of her measurements in real time, she might inadvertently influence the collapse process herself. Despite that she is performing her measurement after Bob has collapsed the system, there are various considerations which suggest that this possibility should be taken seriously).

In this way, information could be transmitted faster than the speed of light.

4. Some Technical Considerations (non essential)

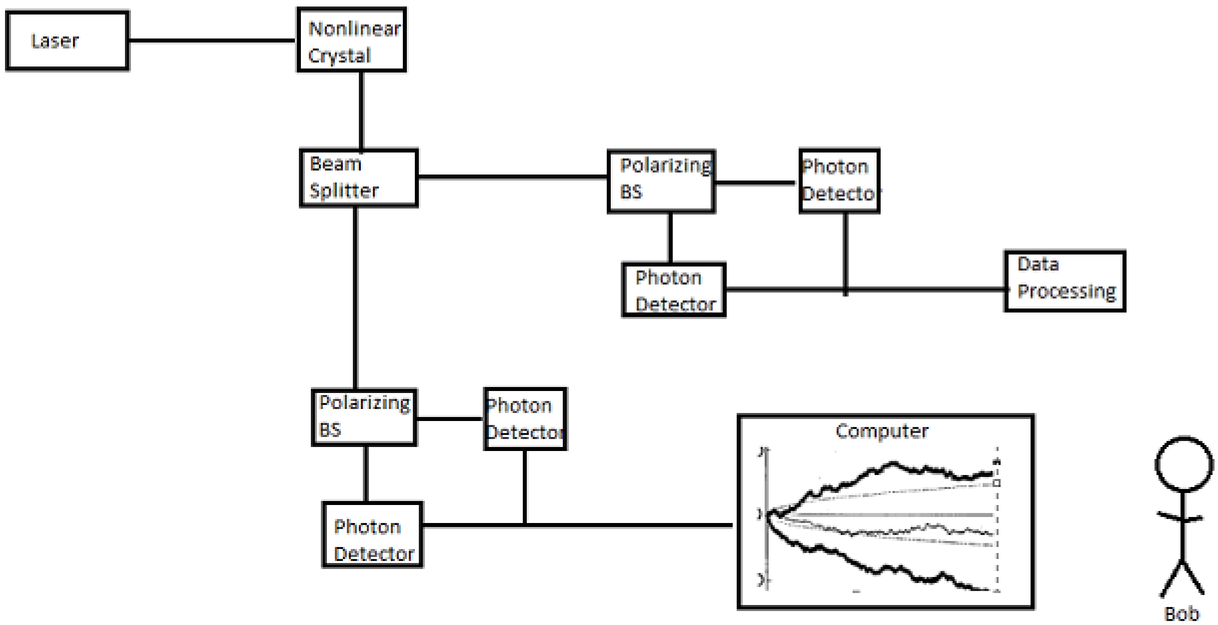
To handle the problem of signal confidence given the potential inconsistency of Bob's ability to elicit the critical effect, the following protocol could be followed:

Bob's measurement data collection and display system is automated such that Bob's video monitor is reset to the original visual settings each time the system detects that he has skewed the results past a threshold value, providing him with a "clean visual slate" with which to work for the next one-bit run of data transmission. Similarly, Alice's measurement system is programmed to collect, aggregate, and interpret the measurement results of her photons in the same way: when Alice's system detects that the aggregate value of measurement results has deviated past the threshold value agreed upon with Bob, the system records the intended message form Bob (0 or 1) and resets its data aggregation process. In this way, Alice and Bob's machines reset at the same time (in the reference frame at which they are both at rest).

5. Practical Experimental Implementation.

While it may be difficult to perform this experiment over the large distances that would be required to definitively demonstrate faster than light communication, what is arguably the most important question to be settled in establishing the possibility for faster than light communication (namely, the possibility that a human agent may be able to influence the collapse process of a system in the fiduciary Bell state described above) can be settled with a relatively simple experimental setup: Create a stream of photon pairs in the fiducial state $|PSI> \;\; = (|HH>+ \; |VV>)/(\surd 2)$ through Type-0 or Type-I spontaneous parametric down conversion. This can be done by applying a laser to an appropriate nonlinear crystal. Some of the photons emerging from this crystal will be entangled pairs in the fiducial state. These photons can be directed into optical fibers (each photon in each pair into its own fiber) via a beam splitter. Each of these fibers can then be directed to a H/V polarizing beam splitter, the output arms of which are each connected to a single photon detector. The two detectors for one of the photons ("Bob's photon") can then be connected to a computer which collects data from the detection events, and displays a line on a monitor representing the aggregate value of the photon detection events as described above. A human subject, Bob, is then tasked with trying to influence the growth of this line in some direction with respect to the zero reference line, particularly to an extent that the line passes another static line representing a threshold of chosen statistical relevance. (See Figure 2.)

Figure 2.



In this way, it can be determined if the human subject can modify the collapse process of the fiducial state of interest to statistically favor an outcome of choice. Verification of such a capability would immediately demonstrate the theoretical possibility of faster than light communication.

6. Implications for Theoretical Physics

An experimental proof of the reality of faster than light information transfer would be, of course, of great practical importance. But, of far greater importance would be the implications with regard to our understanding of reality generally. It is already well understood that faster than light communication would completely "break" all of physics as we know it. It would immediately force upon us a number of profound logical paradoxes respecting the nature of time, space, human agency, consciousness and many other central issues. The full implications of a proven violation of the no signaling theorem may take centuries or longer to fully appreciate and unravel. I suspect that it will require a full reconstruction of the entire edifice of scientific theory, especially at the deepest level of the philosophical foundations of physics, and even deeper.