Abstract:

Here we describe an experiment that demonstrates how messages might be sent using entangled photons. While super-luminal signaling is considered impossible due to the statistical nature of quantum processes, we suggest a possible loophole has been found. Provided the reasoning here is correct, we have an open conflict between quantum mechanics and special relativity. If we can send messages, we can time them. Quantum mechanics predicts instantaneous action-at-a-distance. Special relativity tells us that no information can be transmitted faster than the speed of light. Hence, whether the timing turns out to be super-luminal or not, we have an apparent contradiction between the results and one of these two theories. We hypothesize that a timing test will demonstrate super-luminal signaling.

<table>
<thead>
<tr>
<th>Distribution of photons at the detectors when:</th>
<th>A-1</th>
<th>A-2</th>
<th>A-3</th>
<th>A-4</th>
<th>B-0</th>
<th>B-1</th>
<th>B-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bob raises mirror M-1 to direct photons to mirror M-0</td>
<td>50%</td>
<td>0%</td>
<td>0%</td>
<td>50%</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Bob lowers mirror M-1 to direct photons to BS-2</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>0%</td>
<td>50%</td>
<td>50%</td>
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</tbody>
</table>

1. Introduction:

There are just two principles from quantum mechanics used for the test.
First, we know that if we measure the polarization of an entangled photon along some axis, then we change the state of the partner photon.

Second, we know that if we measure the polarization state of a photon, and it is found to be vertically polarized, then a subsequent measurement along the vertical axis will produce identical results with probability one. However, if we can manipulate the polarization state of the photon between the two measurements, we can change this probability. Our idea is to measure the partner photon along a 45° axis when the original photon is between measurements.

For clarity, the only message we contemplate at the moment is a simple yes/no message.

2. Experimental Setup:

Referring to the diagram, our procedure is as follows:

1. Charlie is situated midway between Alice and Bob. He generates a continuous stream of entangled photons using a Type 2 SPDC EPR source. Charlie measures the polarization of Alice’s photon along a vertical axis using a polarizing beam splitter at BS-1.

2. Let us suppose that Alice and Bob want pizza for lunch. They agree that Bob will set his mirror M-1 to direct the photons to mirror M-0, then order the pizza. When the pizza arrives, Bob will lower mirror M-1 so that the photons are directed to his beam splitter BS-2. The sole purpose of BS-2 is to manipulate the state of Alice’s photon.

3. Alice expects to find all her photons at detectors A-1 and A-4 until Bob signals her. When Alice sees a statistically significant number of photons at detectors A-2 and A-3, she knows the pizza has arrived.

The placement of the beam splitters and detectors is crucial. They must be placed at distances specifically designed to ensure the photons arrive at the beam splitters and detectors in the correct order.

Referring to the photons shown in the diagram, we see that when Bob measures his photon at BS-2, Alice’s partner photon needs to be between BS-1 and BS-3v/BS-3h. Ideally, Alice’s partner photon will be just arriving at one of her beam splitters as soon as Bob’s photon clears his beam splitter.

Additionally, Bob’s photons must not reach his detectors until Alice’s partner photons have been recorded. We do not want uncontrolled changes to the state of Bob’s photons that might affect the probability distribution of Alice’s photons.

Note that Alice and Bob may be located at significant distances from each other. The specific equipment configuration and distances needed to measure the speed of the yes/no signal would need to be determined by experimentalists. A speed estimate would be based on the time difference between when Alice’s photons start arriving at A-2/A-3, versus when Bob’s photons shift from B-0 to B-1/B-2.