Comment on "Single Photon Experiments and Quantum Complementarity" by D. Georgiev

William G. Unruh

CIAR Cosmology and Gravity Program, Dept. of Physics, University of B. C., Vancouver V6T 1Z1, Canada

E-mail: unruh@physics.ubc.ca

The paper "Single Photon Experiments and Quantum Complementarity" by Georgiev misrepresents my position on the Afshar "which path/interference" debate.

D. Georgiev has recently published a paper [1] in which he argues that my interpretation [2] of a "complementarity" experiment based on Afshar's original suggestion [3] is incoherent and wrong. Unfortunately his interpretation of my model distorted what I say.

The Afshar experiment is one in which it is claimed one can both determine both which path a photon has followed and that the photon self interfered in one and same experiment, violating Bohr's complementarity principle, that complementary aspects of a system cannot simultaneously be measured. I have suggested a more stark experiment than Afshar's which throws the issues into greater relief, one whose setup Georgiev describes well in his paper.

However, he then implies that I hold certain positions about the interpretation of the experiment, interpretations which I neither hold not are contained in my description.

Referring to Georgiev's diagram, I demonstrate that **if** the photon is known to have traveled down arm 1 of the interferometer (for example by blocking arm 2, or by any other means, then the detector D1 will always register the photon. If the photon is known to have gone down arm 2, then detector D2 always clicks. The crucial question is what happens if the photon is in an arbitrary state. This raises a variety of questions, including the question as to whether one can ever infer anything about a system being measured from the outcomes reported on the measuring instrument. One could of course take the position of no. That the readings on measurement instruments tell one only about that measuring instrument and cannot be used to infer anything about the system being measured. While a defensible position, it is also one which would make experimental physics impossible. My position follows that of von Neuman, that one can make inferences from the reading on the measurement instruments to the system being measured. IF there is a 100% correlation between the apparatus outcome and the system when the system is known to be in a certain state, and if orthogonal states for the system lead to different outcomes in the apparatus, then one can make inferences from the outcome of the apparatus to the attribute of the system. In this case, the 100% correlation between which detector registers the photon to the known path the photon followed (1 or 2) allows one to infer that IF the detector D1 registers the photon, then that photon has the property that it followed path 1. This is true no matter what the state of the photon was — pure or mixed or something else. Readings on apparatus, if properly designed DO allow one to infer values for attributes of the system at earlier time.

Note the key point I made in my paper was that **if** one places an absorber into path 5 or 6, then even if those absorbers do not ever actually absorb any photons, they do destroy that correlation between the reading on the detectors and the the path, 1 or 2, the photon follows. Because in this case, if we know that the photon was on path 1, either detector D1 or D2 will register, with 50% probability or if the photon was detected by detector D1, the photon could have come from either path 1 or 2. One cannot any longer infer from the apparatus (the detectors) which path of the photon took, precisely because one was also trying to determine in the two paths interfered. The change in the experimental situation destroys the critical correlation required to make those inferences.

Georgiev then claims to prove that such an interpretation is incoherent and disagrees with the mathematics. He bases this on his equations 7 and 8 in which he ascribes a state to the photon both passing along arm 1 or 2 and arm 5 or 6. In no conventional quantum formalism do such states exist. Certainly amplitudes for the particle traveling along both path 1 and 5, say, exist, but amplitudes are just complex numbers. They are not states. And complex numbers can be added and subtracted no matter where they came from.

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