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Peer Review

Review of: "Aristotle, Heisenberg, and the Non-Locality and Non-Temporality of a Single Photon"

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Rather than writing a regular review report, I would like to limit myself to a few comments.

The basic idea of the paper is that the elementary quantum process (emission, propagation, absorption) constitutes an inseparable whole, in the sense that a temporal analysis of it in classical terms is not possible. In my opinion, this is true, and it is a consequence of the fact that any analysis based on dynamic causality understood in the classical sense finds its limit in the quantum of action. Pushing the application of such analysis beyond this limit leads to the appearance of fictitious subquantum elements (hidden variables, "corpuscles", pseudo-events, etc.) among which relations come to exist that violate causality because they are non-local, retrocausal, etc. This is a well-known topic since 1927, when the founding fathers of quantum theory discussed it at the V Solvay Congress in Brussels, and it has been widely explored in the glorious forty years of quantum foundations (1951–1992).

The point, however, is that the previous argument does not prevent the possibility of analyzing the elementary quantum process using properly quantum tools and categories. Of these tools, the best known is probably the wave function. It is perhaps worth remembering that the wave function is not an individual property of a particle, but a collective property attributable to a statistical ensemble of identical preparations of the same particle. When a single particle of the ensemble undergoes a discontinuous variation of the wave function during a quantum jump, it becomes part of a new statistical ensemble in which the preparation is represented by the repetition of that jump. It is only this passage to the new ensemble that represents an individual property of that particle.

Following Fock, we can divide the overall process (emission, propagation, absorption) into two phases: the "initial" experiment (emission, propagation), which includes the preparation and defines the wave function, and the "final" experiment (absorption or detection), which defines the outcome. It is important

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that the different phases of the initial experiment correspond to different CAUSALLY DETERMINED modifications of the wave function, and they together determine the outgoing wave function. By "causally determined," we mean that none of them is the effect of conditions in the future nor of conditions external to the light cone.

To come to the theme of the article, the coherence length is a property of the photon wave function (we use this improper terminology here for simplicity, assuming that photons can be described in this way; the Scully group article in reference 3 goes into this point in more detail). Therefore, it depends on the preparation of the photon understood as a whole: the process of emission and passage in the various optical instruments (spectrometer, interferometer, fiber) arranged in a given succession. Each of these preparation stages is causally determined and therefore independent of conditions on the future, contrary to what the author claims.

In particular, what the author demonstrates with his argument is the indisputable fact that (4) is valid in every single stage of preparation. The fiber argument only demonstrates that transmission along it has modified the coherence properties of the photons. It does not seem to me that this argument proves some form of "pre-established harmony" between the spectrometer and the fiber, as the author suggests.

Points i-ii-iii on page 5 all state the same thing, namely the dependence of the wave function (and hence of the coherence length of the outgoing radiation) on the entire initial experiment. This dependence does not imply some form of pre-science of photons between the successive stages of the initial experiment.

Declarations

Potential competing interests: No potential competing interests to declare.