

Peer Review

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

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Review of "Aristotle, Heisenberg, and the Non- Locality and Non-Temporality of a Single Photon" by Alfred Driessen

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With the numerous unresolved philosophical and ontological questions that quantum theory poses, the topic is certainly interesting. The idea that a philosophical position of Aristotle might still offer useful perspectives may be useful, even if several ideas in Aristotle's physics have to be dismissed given their contradictions with experimental observations.

In the article, Aristotle's position that the trajectory of movement has to be considered as a **whole** is taken as background to argue for changes in the view of time and locality. As a starting point, the author argues that, in contrast to standard interpretations of quantum theory, the notion of the trajectory of a photon has to be taken seriously even if no trajectory is measured. Photons are viewed as the transfer of energy from one place to another, and without a trajectory, the author would see a strange vanishing of energy during travel time (p. 5). His underlying view, as shown in Fig. 1, however, works against the space-time structure as it is normally depicted in special relativity, but he considers the reversal of the arrow of time and faster-than-light effects (p. 3). His ideas are developed based on an unchanging coherence length of a photon $l_c = c \cdot dt$. From this, the nontemporal character of a single photon is derived. This ontological perspective is brought together with the notion of *potentia* and the remark that the solutions of the Greek atomists are not appropriate for quantum theory.

The article does offer some interesting and unconventional perspectives but lacks clarity and rigor; also, it does not take very bold or radical steps to do away with the classical notion of time. While it concludes

that “in the quantum world, this information is outside space and time” (p. 13), the trajectory seems to be fully regarded as an object inside space and time. The article thus lacks a clear distinction between hidden (i.e., principally unobservable) variables and data accessible from within space and time. The experimentally observed violations of Bell inequalities, which are usually the basis of notions of non-locality, can be explained causally by allowing influences against the normal direction of time that go exclusively to hidden variables (see Blasiak, P. und Gallus, C., Phil. Trans. R. Soc. A, 2024; also <https://arxiv.org/abs/2408.12740>). Taking into account this distinction, improving clarity, and possibly also expanding on the idea of Feynman path integrals to discuss the “occurrence of the natural minimum” (p. 10) via the least action principle could substantially improve the article and broaden the perspective.

Comments on specific points:

- Heisenberg uncertainty (HUP) is discussed for energy and time, but there is no consideration of the question of whether time can even be an operator in QM. Also, it remains unconnected to the actual axioms of QM. The wording “the principle is accepted as a law of nature” (p. 2) is confusing.
- On p.7, it is said that “one has to give up HUP for the individual photon”. Against this background and the generally controversial nature of the time-energy uncertainty relation, the author might want to rethink the role of HUP for his arguments.
- “non-temporality” and “causality” need to be stated more formally; Fig 1 is confusing as it does not distinguish between elements of accessible reality and hidden elements.
- The statement “Eq (3) can be rewritten” is confusing (p. 5): While Equation (4) is not in contradiction to Eq (3), it is certainly not a rewriting.
- References to the discussed experiments should be strengthened. Presentation should be more rigorous.
- The philosophical section could benefit from discussing the “emergence of time”. Causality should be distinguished regarding observable elements of reality and “other”. While concepts that could be described as “hylomorphism” were still popular in medieval philosophy (notably Aquinas et al.) and may be revisited in contemporary philosophy, a detailed elaboration of the concept would be needed for an audience in physics (e.g., Simpson, William M. R. *Hylomorphism*. Cambridge, UK: Cambridge University Press, 2023). Finally, the notion of “natural minimum” needs a clear formal definition.

Declarations

Potential competing interests: No potential competing interests to declare.