Review of: "What connects entangled photons?"

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Review of the manuscript entitled "What connects entangled photons?" by Eugen Muchowski for Qeios journal.

In this manuscript, the author discusses the important issue of non-locality in entangled quantum states, with a specific emphasis on polarization-entangled photons. While the actual dominant belief among many physicists is that this question has been definitively settled, as highlighted by Nobel laureate Alain Aspect in his article [Physics 8, 123 (2015)], the author challenges this viewpoint and raises doubts regarding its validity.

As I understand it (please correct any misunderstanding), the author proposes a realistic local model based on non-shared hidden variables that, in principle, allows the reproduction of results obtained from one- or two-photon quantum measurements. This model is introduced by a set of four assumptions, where the reproduction of the results of one-photon quantum measurements is provided by two of these assumptions (MA1 and MA4). To reproduce the results of two-photon quantum measurements, the two additional assumptions (MA2 and MA3), in combination with MA1 and MA2, are required. The author applies this model to several examples, demonstrating its effectiveness in reproducing all quantum results. After thoroughly examining the manuscript, I would like to share my review and critique.

1- With regard to the structure and language of the manuscript, the ideas are well organized and coherently presented. However, the language used in the article can be somewhat difficult to comprehend, and there are instances of punctuation errors and improper usage that require a great deal of attention.

2- In MA1, the author assume the presence of a hidden variable λ which determines "a priori" the polarization of a photon and thus controlling the polariser output through which the photon will pass. As explained in section 2.3, in the framework proposed by the author, this assumption makes it possible to predict the probability of detection of a photon, that has passed through a polariser, at any output of the polariser. However, I do not see how this assumption can predict the interference patterns of a photon when the polariser is replaced by a beam splitter, which also gives the same probabilities, followed by a second beam splitter. I am curious how your model can be extended to encompass this scenario.

3- In MA3, it is assumed that an entangled state, such as a Bell state, is a mixture of indistinguishable constituent photon pairs in equal shares whose components have the same polarization θ or $\theta + \pi/2$. Due to their indistinguishability, MA2 states that the polarization of a selection of photons from this entangled state remains undefined until they pass through an α-oriented polarizer, at which point they acquire a shared polarization angle of α or $-\alpha$. When considered together, MA2 and MA3 explain the correlations observed between the polarizations of photons in A and B. First, with regard to

MA3, how can you distinguish between an entangled state and a non-polarised state, such as a thermal state? Second, you claim that "photons in a selection cannot be distinguished by their polarization". If so, how do you explain the polarization-dependent potentials that allow photons to be coherently separated according to their polarization?

Based on my review, I do not recommend publication of the current version of the manuscript in Qeios. I suggest that the author concentrate on improving the clarity and language of the manuscript to make it more understandable to readers.

Best regards,

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