The influence of polarization and phase shift on the average photon trajectories behind two slits

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The work of Kocsis et al. [1] was rightly selected by the IOP Physics World as the top breakthrough [2] for the year 2011. In [1] the average trajectories of single photons in a two-slit interferometer were observed using weak measurements on the photon momentum and strong measurements of photon position in a series of planes. The authors claim that single-particle trajectories measured in this way reproduce those predicted by the Bohm - de Broglie interpretation of quantum mechanics, namely the pilot wave interpretation [3]. However Bohm's theory, being based on Schrödinger's equation, is only applicable to massive particles (matter waves). In the case of photons and, in general, electromagnetic radiation, different trajectory based approaches have been developed in the literature. These works do not deal with Bohmian trajectories, but specifically with the concept itself of photon trajectory, also guided by the corresponding associated (photon) wave function[4]. While for massive particles the equation of the trajectory is associated with the quantum probability current density, for photons it is associated with the Poynting vector for the electromagnetic field. Such an approach was used in [5], where the trajectories were calculated for the same polarization of incident wave at both slits and for mutually orthogonal polarizations. In these cases EME-flow lines starting from the left/right slit end up on the left/right hand side of the screen. However, the distribution of EME flow lines is different in two cases, in full agreement with the Arago-Fresnel laws. For the same orientation of the polarizers, the distribution shows interference fringes, while for orthogonal orientations fringes are absent. In the present paper we vary the angle between the polarization axis of two polarizers put behind both slits and show how the avarage photon trajectories change. As seen from Fig. 1 some EME flow lines cross the symmetry axis of the slit sistem. We also study how the phase shift induced at one slit influnce the shape of trajectories. By generalizing the experiment of Kocis at al., as proposed in [6], it would be possible to check these predictions.

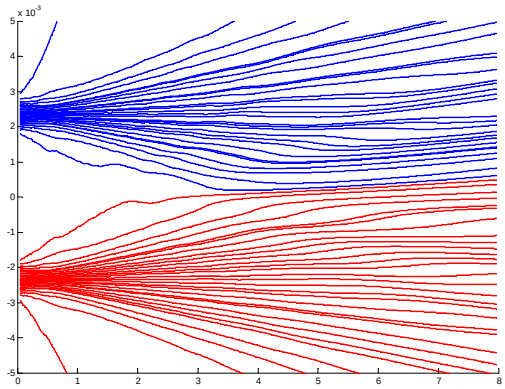

FIG. 1. Photon paths behind two slits for the polarization angles $\theta_1 = 0$ and $\theta_2 = \frac{7\pi}{10}$.

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[1] S. Kocsis, B. Braverman, S. Ravets, M. J. Stevens, R. P. Mirin, L. K. Shalm and A. M. Steinberg, Science **332**, 1170 (2011).
[2] http://physicsworld.com/cws/article/news/2011/dec/16/physics-world-reveals-its-top-10-breakthroughs-for-2011
[3] D. Bohm and B.J Hiley, *The undivided universe*, (Rautlege, 1993), London.
[4] P. Ghose, A.S. Majumdar, S. Guha and J. Sau, Phys. Lett. A **290**, 205 (2001).
[5] A. S. Sanz, M. Davidović, M. Božić and S. Miret Artés, Ann. Phys. **325**, 763 (2010).
[6] M. Davidović, A. S. Sanz, M. Božić, D. Arsenović and D. Dimić, Phys. Scr. **153**, 014015 (2013).