Comments to “Asking Photons Where They Have Been” [A. Danan, D. Farfurnik, S. Bar-Ad and L. Vaidman, Phys.Rev.Letters 111, 240402 (2013)]

The letter by Danan et al [1] describes an interesting experiment using nested Mach-Zehnder interferometers (MZI) with vibrating mirrors to “tag” the photons. Here, I question some of the theoretical interpretations in [1].

The experiment in [1] is analyzed using arguments based on weak values in the two-state vector formalism [3]; this formalism is completely equivalent to a formalism simply using (adequately time-evolved) pre- and post-selected states. The pre- and post-selected states used in [1] are given in its eq. (1). But the choice of the backward-evolving state $<\Phi|$ is not correct. In fact, the prescription in [3] for the backward-evolving state is to use the post-selected state and then evolve it backwards in time with (the inverse of) the actual time-evolution operator. This time-evolution process may be read off from figure 2(b) in [1], where there is no transition towards the nested MZI in the lowermost beam-splitter. The correct choice for $<\Phi|$ must therefore be the (backward-evolving) state in the C-arm, completely invalidating the conclusions of eq. (3) in [1]. Expressed in the two-state vector description of fig. 3 in [1], there should be no green, dashed line from the lower-most beam-splitter to the mirror F.

In sum, statements in [1] like “(t)he photons do not always follow continuous trajectories“ and “… they never left the nested interferometer…” are not corroborated by a closer analysis of the experiment of Danan et al.

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References
[1] A. Danan, D. Farfurnik, S. Bar-Ad and L. Vaidman, Phys.Rev.Letters 111, 240402 (2013)
[2] L. Vaidman, Past of a quantum particle, Phys.Rev. A 87, 052104 (2013)
[3] Y. Aharonov and L. Vaidman, Phys.Rev. A 41, 11 (1990)