Direction-Correlated Correlated Photons Cannot Self-Interfere: A Prediction

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A corollary to an experimental proposal made by Anton Zeilinger – the famous double-double slit experiment – is suggested to be possible. The double Mach-Zehnder experiment.

Key words: EPR-Experiments; Bell Correlation; Double Mach-Zehnder Experiment.

Zeilinger's "double-double slit" experiment admits a variant. In his well-known book, Zeilinger showed that correlated photons cannot self-interfere in a two-sided (double) double slit experiment. The reason indicated there: The diameter of the source cannot be smaller than the distance between the two slits, hence the geometric preconditions for self-interference are not fulfilled [1].

It is proposed that the idea is of more general significance. Two correlated photons, coming from the same well-defined cross-sectional element of a source of correlated photons, that can be registered as coming from that same area, cannot self-interfere. Specifically, the same region of a source, observed in two opposite directions by two Mach-Zehnder interferometers, can only yield an interference-free (50 : 50) outcome on either side.

The proof for this apparently new prediction goes as follows. Otherwise – if it was not true –, we could learn about both the *path* chosen by such a photon (by our disrupting the two paths in the one Mach-Zehnder through inserting a detector into each path) and the *wave* properties of the same photon (by making an interference measurement on the other side). That is, we could know two noncommuting properties of a photon, in accord with Einstein's ingenious idea to "complete quantum mechanics" by violating the commutator relations using two correlated particles (so that the one measurement could be done on the one and the other on the other) [2]. Einstein was unsuccessful with this proposal as is well known, cf. [1]. Only the relativistic Bell experiment, in which the two measuring stations are mutually receding [3], is still waiting to be performed.

Our prediction of a lack of self-interference of correlated photons in a double Mach-Zehnder experiment, which complements Zeilinger's proposal with two double slit interferometers, is testable. A first version of the experiment was proposed a few years ago [4]. However, at that time the importance of the source diameter, brought to our attention by Zeilinger's book, was not yet recognized by us. The experiment proposed above is, therefore, an improved, possibly more powerful test.

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