Comment on “Subjective nature of path information in quantum mechanics”

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Abstract

In a recent preprint [1] (arXiv:2505.05930), Jiang et al. presented impressive high-quality results of an experimental study of the so-called which-path information problem for the case of a three-crystal interference setup. We believe that the results obtained represent one of the numerous manifestations of the nonequivalence of forward and reversed processes in quantum physics. It is probably, this nonequivalence is the physical basis for the widely discussed principle (rule) of relation between path distinguishability and interference visibility.

Keywords: visibility, distinguishability, which-way information, time reversal non-invariance. nonlocal memory.

In quantum mechanics, the concept of the relation between path distinguishability and interference visibility has long been established [2–5]. This rule is artificial, empirical. We do not know what physical principle it is based on. Where are the limits of its application?

The paper [1] presents high-quality results of an experimental study of the so-called frustrated down-conversion for the case of a three-crystal interference setup. Here the authors found that the relation between path distinguishability and interference visibility rule does not work. They demonstrated the simultaneous observation of zero interference visibility and the complete absence of which-path information. There is a limit to the application of this rule somewhere here.

Is it possible to find a physical explanation for the results obtained? We believe that such a physical explanation exists. In each nonlinear crystal, there is a forward process of splitting a photon into signal and idler photons. The reversed process of regeneration of the original photon also takes place here. Moreover, the reversed process is extremely efficient (it has an extremely large differential cross-section) [6]. In addition, this reversed process (unlike the forward process) has a strong phase dependence [6, 7]. This phase dependence is manifested in the experiments discussed [1]. And yet, there is the so-called non-local memory of the quantum system (as a whole) about its initial state [8].

In general, all this makes it possible to understand the physical nature of the results obtained. For a detailed description, it is necessary to know the differential cross sections of forward and reversed processes and the basic properties of the nonlocal memory of a quantum

system. To obtain such information, not very complicated experiments are needed [8, 9]. Unfortunately, our experimenters are not ready to begin such work without the approval of theorists. But, theorists can't get away from their mathematics and at last recognize the experimental fact of the non-invariance of time reversal in quantum physics [10].

Conclusion

The nonequivalence of forward and reversed processes in quantum physics and the associated nonlocal memory of a quantum system about its initial state is obviously the physical foundation of the widely discussed rule of complementarity between complete path information and the occurrence of interference.

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