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Colloquium

Which-source information for three indistinguishable sources: A weak path-marking analysis

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Abstract :
An experiment with three coherently pumped nonlinear crystals [Jiang et al., Nat. Commun. 17, 2433 (2026)] reported that treating two of three indistinguishable photon-pair sources as one, in two different ways, leads to mutually exclusive conclusions about which source emitted a detected pair. We take the view that a statement about which source a particle came from is meaningful only together with the measurement that supports it. To make this precise, we study an equivalent linear-optical three-path interferometer and ask, for each possible choice of what to distinguish (the three sources individually, or one of the three ways of grouping two of them), what a well-defined measurement can tell about the source of a detected particle. Following the operational approach of Englert et al. [Phys. Rev. A 96, 022126 (2017)], we attach weak path markers to the sources and read them out with optimal unambiguous quantum-state discrimination, which assigns to each configuration an explicit probability of identifying the source without error. These configurations are mutually exclusive, and only one of them can be realized at a time. The analysis shows how the grouping-dependent conclusions arise within standard quantum measurement theory, and why they cannot be obtained in a single experiment.