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Entangled photon triplets: a new quantum light source and a test of nonlocality

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Entanglement is required for most applications in quantum information science. In optics, the most widespread source of entangled photon pairs is the nonlinear optical process of parametric down-conversion. Through this process, single high energy pump photons are converted into pairs of lower energy photons. In the first part of my talk I will describe our realization of cascaded parametric down-conversion, a sequence of two downconversion that can produce photon triplets, a longstanding goal of the quantum optics community. I will describe our experiments to detect the novel form of genuine three-photon energy-time entanglement produced through this process and the direct production of polarization Greenberger-Horne-Zeilinger states. In addition to their importance in quantum technologies, entangled photons can be used to perform fundamental tests of nature, such as ruling out local hidden variable descriptions. In the second part of my talk, I will discuss our experimental test of Mermin's inequality: a bound on the strength of correlations between three particles imposed by such models. We have for the first time closed the locality loophole in such a test by distributing three-photon entanglement over long distances using free-space optical links to causally disconnected locations. These results demonstrate the experimental requirements for implementing practical three-party quantum communication protocols (joint work with Thomas Jennewein).

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