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PLENARY: Shaping frequency entangled photon pairs

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Abstract content
 (Max 300 words)

Entanglement is one of the most intriguing features of quantum theory and is a fundamental resource for quantum information processing. It was experimentally revealed by the observation of correlations with no classical origins. Through Bell inequalities, the non-locality of nature was tested by numerous experiments using entangled two-dimensional states (qubits). Both, fundamental tests of quantum theory and applications would benefit greatly from entanglement in higher dimensions. Entangling d -dimensional states denoted as qudits allows to formulate generalized Bell inequalities, which are more resistant to noise than their two-dimensional predecessors. In loophole free Bell experiments the detection efficiency threshold can be lowered. Finally, both the effective bit rate of quantum key distribution and the robustness to errors can be increased. These examples, among others, stimulated research towards different schemes to generate and manipulate photonic qudits in high dimensions. One of the most promising schemes is entanglement in transverse modes. Here, we demonstrate an alternative approach which has the potential to reach even higher dimensions. Specifically, we demonstrate the creation, characterization, and manipulation of frequency entangled qudits by shaping the energy spectrum of entangled photons, a technique that has its origin in ultrafast optics. We show different shaping schemes and applications thereof. We verify the generation of maximally entangled qudit states up to $d=4$ through tomographic quantum state reconstruction. Subsequently, we measure Bell parameters for entangled qubits and qutrits as a function of their degree of entanglement.

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