A Quantum Dot in an Open Microcavity as a High-Rate Source of Polarization Entangled Photon Pairs

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Quantum photonic technologies are a promising platform for quantum information processing, with applications ranging from secure communication to quantum computing and simulation [1]. At the heart of many quantum photonic protocols lies the entangled photon pair. Traditionally, spontaneous parametric down-conversion (SPDC) in nonlinear crystals has been the workhorse for generating such entangled photons. However, SPDC sources face fundamental trade-offs between brightness and fidelity [2]. Semiconductor quantum dots (QDs) present an attractive alternative, promising on-demand generation of highly indistinguishable single photons, and the creation of entangled pairs by interference at a beam-splitter.

Here, we use an InGaAs QDs embedded in a tunable open microcavity [3]. This platform serves as an ultra-bright single photon source with state-of-the-art coherence and purity. We achieve a 2 million-pair per second generation rate of polarization-entangled photon pairs with a fidelity of 96% (Fig. 1a). The photons are mutually indistinguishable, enabling efficient entanglement swapping, a crucial requirement for quantum repeaters. We find that the fidelity is limited mostly by two-photon events in the QD's output. The fidelity increases to 98% on applying a time gate to exclude coincidences from early times (Fig. 1b) [4]. This is consistent with a model in which the two-photon events arise by re-excitation of the QD. In this way, the fidelity can be increased with only a modest reduction in creation rate. We present schemes to increase the generation rate to several hundred million-pairs per second.

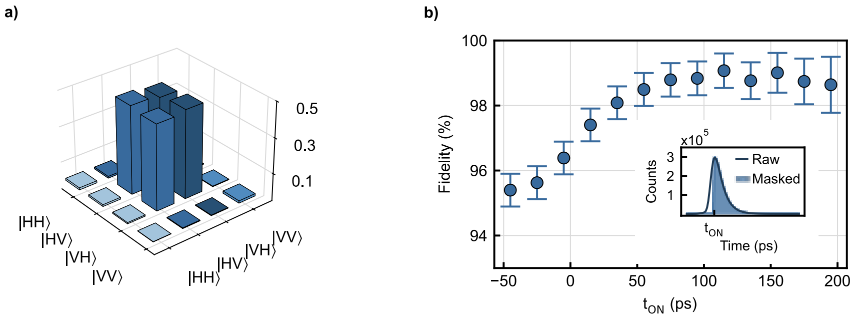

Fig 1. a) Reconstructed density matrix after quantum state tomography. The entanglement fidelity is 96% and mainly limited by the single-photon purity ($g^{(2)}(0) = 1.5\%$). **b)** Temporal filtering to reject photons from early emission increases the entanglement fidelity to 98%. Inset: Example histogram between the data and trigger signals. The dark blue curve corresponds to the raw histogram, while the lighter blue curve shows the histogram after temporal filtering.

References

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