On-demand generation of indistinguishable polarization-entangled photon pairs

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An on-demand source of indistinguishable and entangled photon pairs is a fundamental component for different quantum information applications such as optical quantum computing, quantum repeaters, quantum teleportation and quantum communication. To date, spontaneous parametric down-conversion (SPDC) and four wave mixing sources have been mostly used for the generation of entangled photon pairs to realize quantum communication protocols and to demonstrate basic quantum logic experiments. However, the photon pair statistic of these sources is described by a Poissonian distribution which implies also the generation of zero and multiple pairs. This leads to errors in the quantum algorithm protocols which effectively limit their usefulness for deterministic quantum technologies. Radiative cascades in single quantum emitters, such as atoms or quantum dots, can in principle emit on demand single pairs of polarization entangled photons with high generation efficiencies.

Here we show simultaneously ultra-high purity ($g^{(2)}(0) < 0.004$), high entanglement fidelity (0.81 ± 0.02), high two-photon interference visibility (0.86 ± 0.03 and 0.71 ± 0.04) and on-demand generation of polarization-entangled photon pairs from a single semiconductor quantum dot. Through a two-photon resonant excitation scheme, the biexciton population is deterministically prepared by π-pulses. Applied on a quantum dot showing no exciton fine structure splitting, this result in the deterministic generation of indistinguishable entangled photon pairs.

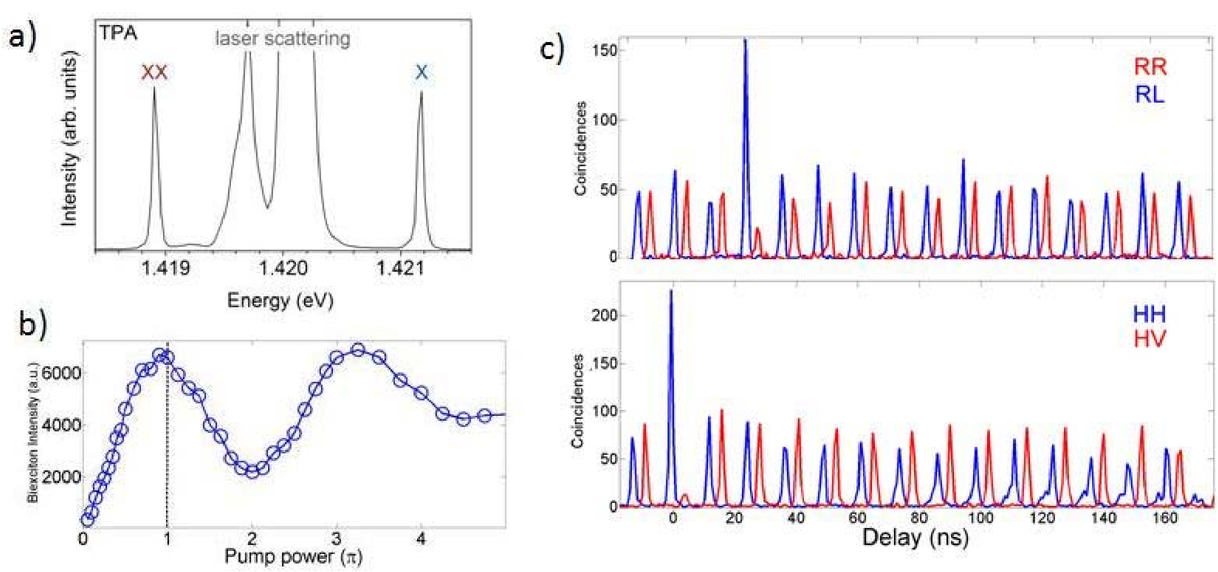

Figure 1: a) Two-photon excitation spectrum of a single quantum dot. b) Rabi oscillation of the biexciton population with resonant pump power. The line indicates the pump power used for the photon correlation experiments. c) Polarization dependent cross correlation histograms in the linear and circular basis.