Semiconductor photon sources for quantum communication

Gregor Weihs

[1] Institut für Experimentalphysik, Universität Innsbruck,
Technikerstr. 25, 6020 Innsbruck, Austria

[2] Institute for Quantum Computing, University of Waterloo,
200 University Ave W, Waterloo, ON N2L 3G1, Canada

For fundamental tests of quantum physics as well as for quantum communications non-classical states of light are an important tool. In our research we focus on developing semiconductor-based and integrated sources of single photons and entangled photon pairs. In this talk we will present our work on coherent control of InAs/GaAs quantum dots, parametric down-conversion in AlGaAs Bragg-reflection waveguides, and on polariton-polariton scattering in AlGaAs quantum well micro-cavities.

In our quantum dot work, for the highest degree of quantum control we use resonant two-photon excitation to deterministically trigger a biexciton-exciton cascade. We demonstrate Rabi oscillations, Ramsey interference and all-optical coherent control of the quantum dot resulting in single and paired photons with a high degree of indistinguishability leading to high-quality single photons and time-bin entangled photon pairs.

Most III-V semiconductors exhibit a large second-order optical nonlinearity. Phase matching the nonlinear interaction is, however, notoriously difficult. Bragg-reflection waveguides have been shown to allow efficient creation of photon pairs through spontaneous parametric down-conversion. They have the potential to be integrated with a pump laser on the chip for a miniaturized room-temperature entangled photon pair source.

Finally using a planar microcavity with narrow linewidths we are able to demonstrate the bunching of exciton-polaritons through their spontaneous parametric scattering. Taking care to eliminate all the possible background processes as well as possible, we find a strong correlation signal and some first indications of a resulting nonclassical correlation. This is the first step towards the entanglement of exciton-polaritons.

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