A 22: Photon Sources for Quantum Networks SYQR 4 (with Q)

Time: Tuesday 14:00–15:45 Location: Kinosaal

A 22.1 Tue 14:00 Kinosaal

High efficient generation of single mode narrow-band photon pairs — •Michael Förtsch[1,2], Gerhard Schunk[1,2], Josef U. Fürst[1,2], Dmitry Strekalov[1,2], Florian Sedlmeir[1,2], Harald G. L. Schwefel[1,2], Thomas Gerrits[3], Martin J. Stevens[3], Sae Woo Nam[3], Gerd Leuchs[1,2], and Christoph Marquardt[1,2] — [1]Max Planck Institut für die Physik des Lichts, Günther-Scharowsky-Str. 1, Bau 24, 91058, Erlangen, Deutschland — [2]Institut für Optik, Information und Photonik, Universität Erlangen-Nürnberg, Staudtstraße 7/B2, 91058, Erlangen, Deutschland — [3]National Institute of Standards and Technology, 325 Broadway, Boulder, CO, 80305, USA

Over the past ten years the interest in resonator assisted spontaneous parametric down-conversion (RA-SPDC) has increased significantly since it offers the possibility to efficiently generate narrow-band heralded single photons, which are directly compatible with atomic transitions. One still remaining challenge with RA-SPDC based systems is the efficient photon generation in exactly one spatiotemporal mode, which up to now is often accompanied with additional lossy filtering. Here we experimentally demonstrate a narrow-band RA-SPDC source based on a crystalline whispering gallery mode resonator, which emits photons in exactly one mode. The unique phase-matching conditions make additional filter cavities unnecessary and results to the best of our knowledge in the highest reported single mode pair-production rate. In combination with the unique wavelength and bandwidth tuning possibilities, our setup is ready to serve as the heralded single photon source in a large variety of proposed quantum-repeater networks.

A 22.2 Tue 14:15 Kinosaal

Electro-mechanical engineering of Non-classical Photon Emissions from Single Quantum Dots — •Bianca Höfer[1], Eugenio Zallo[1], Jiaxiang Zhang[1], Rinaldo Trotta[2], Armando Rastelli[2], Fei Ding[1], and Oliver G. Schmidt[1] — [1]Institute for Integrative Nanosciences, IFW-Dresden, Helmholtzstrasse 20, D-01069 Dresden, Germany — [2]Institute of Semiconductor and Solid State Physics, Johannes Kepler University Linz, Altenbergerstrasse 69, A-4040 Linz, Austria

Indistinguishable photons and entangled photon pairs are the key elements for quantum information applications, for example, building a quantum repeater. Self-assembled semiconductor quantum dots (QDs) are promising candidates for the creation of such non-classical photon emissions, and offer the possibility to be integrated into solid state devices. However, due to the random nature of the self-assembled growth process, post-growth treatments are required to engineer the exciton state in the QDs (e.g. energies, exciton lifetimes, and fine structure splittings). In this work, we study the electro-mechanical engineering of the exciton lifetime, emission energy in the QDs, with the aim to produce single photons with higher indistinguishability. Also we present a recent experimental study on the statistical properties of fine structure splittings in the QD ensemble, in order to gain a deeper understanding of how to generate entangled photon pairs using semiconductor QDs.

A 22.3 Tue 14:30 Kinosaal

Two Photon Interference from Remote Quantum Dots with Inhomogeneously Broadened Linewidths — •Peter Gold[1], Alexander Thoma[1], Sebastian Maier[1], Stephan Reitzenstein[1,2], Sven Höfling[1,3], Christian Schneider[1], and Martin Kamp[1] — [1]Technische Physik, Universität Würzburg, Am Hubland, D-97074, Würzburg, Germany — [2]present address: Institut für Festkörperphysik, Technische Universität Berlin, Hardenbergstraße 36, D-10623 Berlin, Germany — [3]present address: SUPA, School of Physics and Astronomy, University of St Andrews, St Andrews, KY16 9SS, United Kingdom

The interference of single, indistinguishable photons is at the heart of long distance quantum repeaters. Here, we investigate the influence of non-resonant and quasi-resonant excitation on the interference properties of single photons emitted from semiconductor quantum dots (QDs). For the quasi-resonant excitation scheme, we observe an increase of interference visibility for consecutively emitted photons from the same QD of 69% compared to 12% for non-resonant excitation. In addition, we demonstrate quantum interference of photons emitted from separate QDs simultaneously excited into their p-shell. We can extract a two photon interference visibility as high as $(39\pm2)\%$ for non-postselected coincidences. This value exceeds the predicted value based on coherence and radiative decay times of the quantum dot emission ($\approx 25\%$). We account for this by treating the emission of both quantum dots as inhomogeneously broadened ensembles of Fourier limited photons and observe good congruence between experiment and model.

A 22.4 Tue 14:45 Kinosaal

Interfacing telecommunication and UV wavelengths — •Helge Rütz, Kai-Hong Luo, Hubertus Suche, and Christine Silberhorn — Universität Paderborn, Integrierte Quantenoptik, Warburger Str. 100, D-33098 Paderborn

Changing the color of a photonic quantum state by means of coherent frequency conversion allows to interface short-wavelength stationary qubit systems and low-loss photonic channels at telecommunication wavelengths.

Here, we report on such an interface for quantum states of light between trapped ions at 369.5 nm and telecommunication wavelengths around 1310 nm. More specifically, we employ a single-pass quasi-phasematched second-order nonlinear interaction in a periodically poled Potassium Titanyl Phosphate- (KTP-) waveguide in conjunction with a strong cw-pump field at 515 nm.

We present experimental details of our interface, showing bright-light conversion efficiencies of up to 10%. Non-phasematched spontaneous parametric downconversion of pump photons is identified as the major limitation in the achievable signal-to-noise-ratio on the single-photon-level.

Finally, the potential use of our frequency conversion interface in quantum information technology is discussed.

A 22.5 Tue 15:00 Kinosaal

Frequency Conversion of Single Photons from a SPDC Source — •Andreas Lenhard, Stephan Kucera, José Brito, Jürgen Eschner, and Christoph Becher — Universität des Saarlandes, FR 7.2 Experimentalphysik, Campus E2.6, 66123 Saarbrücken

Many quantum repeater schemes rely on the transfer of single photons or entangled states. Thus, long-range transmission in fibers requires photons at low-loss telecommunication wavelengths. We have recently demonstrated the frequency conversion of photons generated by a single quantum emitter in the near-infrared spectral region to the telecom bands via frequency down-conversion in a nonlinear medium [1]. The frequency conversion of an entangled photon is another basic building block to establish quantum networks.

Here we report on the frequency down-conversion of single photons from a photon pair source, resonant with an atomic transition of a quantum repeater node. The pairs are generated by a type-II spontaneous parametric downconversion process in a bulk KTP crystal. One photon of the pair is spectrally filtered to fit a transition of $^{40}Ca^+$-ions at 854 nm and used as a herald [2]. By mixing with a pump field at 2.5 μm in a nonlinear waveguide the partner photon is converted to the telecom O-band at 1313 nm with an over-all efficiency around 10 %. We show that the temporal correlation between the photon pairs is preserved in the conversion process by measuring the photon correlation functions.

1. S. Zaske et al., Phys. Rev. Lett. **109** (2012), 147404
2. N. Piro et al., Nat. Phys. **7** (2011), 17-20

A 22.6 Tue 15:15 Kinosaal

Quantum teleportation and entanglement swapping of matter qubits with multiphoton signals — •Juan Mauricio Torres[1,2], József Zsolt Bernád[1], and Gernot Alber[1] — [1]Institut für Angewandte Physik, Technische Universität Darmstadt, D-64289 Germany — [2]Departamento de Investigación en Física, Universidad de Sonora, Hermosillo, México

We introduce a probabilistic Bell measurement of atomic qubits based on two consecutive photonic field measurements of two single mode cavities with which the atoms interact in two separate stages. To this end, we solve the two-atoms Tavis-Cummings model and exploit the property that the antisymmetric Bell state is insensitive to the interaction with the field. We consider implementations for quantum teleportation and for entanglement swapping protocols both of which can be achieved with 25% success probability and with unit fidelity. We emphasize possible applications for hybrid quantum repeaters where the aforementioned quantum protocols play an essential role.

A 22.7 Tue 15:30 Kinosaal

Rydberg gases at room temperature - pulsed four-wave-mixing down to volumes of a few cubic micrometers — •Andreas Kölle, Bernhard Huber, Fabian Ripka, Robert Löw, and Tilman Pfau — 5. Physikalisches Institut, Uni Stuttgart

The van-der-Waals interaction between Rydberg-excited atoms provides an interaction range on the micrometer scale. Various experiments in cold atomic clouds demonstrated the feasibility of using Rydberg states for quantum devices like single photon sources. In our experiments, we want to transfer these results to thermal vapor cells of the size of the Rydberg-Rydberg interaction length scale, which are more favorable in terms of scalability and handling. In comparison to an ultra-cold atomic cloud, thermal cells have the disadvantage of thermal atomic motion and the resulting Doppler shift. To overcome this effect we perform our excitation to the Rydberg state on the nanosecond timescale. We present our results of a pulsed four-wave-mixing scheme via a Rydberg state. We observe four-wave-mixed light emission on a nanosecond time scale with a non-trivial temporal evolution which can be described by a coherent interference within the Doppler ensemble. Furthermore we discuss our experimental effort to reduce the excitation volume to a sub micrometer length scale in all 3 dimensions.