Q 9: Photonics I

Time: Monday 14:00–16:00 Location: A 310

Q 9.1 Mon 14:00 A 310

Frequency Down-Conversion of Single Photons — •Andreas Lenhard[1], Sebastian Zaske[1], Christian Kessler[2], Jan Kettler[2], Carsten Arend[1], Christian Hepp[1], Roland Albrecht[1], Wolfgang-Michael Schulz[2], Michael Jetter[2], Peter Michler[2], and Christoph Becher[1] — [1]Universität des Saarlandes, FR 7.2 Experimentalphysik, Campus E2.6, 66123 Saarbrücken — [2]Institut für Halbleiteroptik und funktionelle Grenzflächen and Research Center SCoPE, Universität Stuttgart, 70569 Stuttgart

Establishing a quantum network over existing fiber transmission lines requires photons at low-loss telecommunication wavelengths, serving as flying qubits. To this end, photons generated by a quantum emitter in the red or near-infrared spectral region can be translated to the telecom bands via frequency down-conversion in a nonlinear medium using a strong mixing wave.

We report on the frequency down-conversion of single photons emitted by an InP/GaInP quantum dot at 710 nm to the telecom O-band at 1310 nm via difference frequency generation [1]. The strong pump field is generated by an optical parametric oscillator and mixed with the single photons in a PPLN waveguide. With an over-all conversion efficiency above 30% we were able to measure the second-order correlation function of the photons before and after conversion and prove the conservation of the single photon statistics. Furthermore, the temporal and coherence properties are also shown to be preserved.

1. Zaske et al., Phys. Rev. Lett. **109**, 147404 (2012)

Q 9.2 Mon 14:15 A 310

Coupling of single colour centres to photonic crystal cavities in monocrystalline diamond — •Janine Riedrich-Möller[1], Laura Kipfstuhl[1], Sébastien Pezzagna[2], Jan Meijer[2], Martin Fischer[3], Stefan Gsell[3], Matthias Schreck[3], and Christoph Becher[1] — [1]Experimentalphysik 7.2, Universität des Saarlandes, Germany — [2]Rubion, Ruhr-Universität Bochum, Germany — [3]Experimentalphysik IV, Universität Augsburg, Germany

The deterministic coupling of single quantum emitters to photonic crystal cavities is considered as an important step towards integrated solid-state devices for quantum information processing. As single emitters, colour centres in diamond, e.g. nitrogen- (NV) or silicon-vacancy (SiV) centres have attracted significant interest due to their extraordinary properties like long spin coherence times or narrow bandwidth emission, respectively. For controlled coupling of a single defect centre to photonic crystal cavities several challenges have to overcome, e.g. exact emitter positioning and alignment of the dipole moment with respect to the cavity electric field as well as cavity tuning methods. Here we present two strategies towards deterministic coupling of single colour centres to photonic crystal cavities fabricated in monocrystalline diamond. In the first approach, we locate a single SiV centre in a diamond thin film and etch a photonic structure around the emitter via focused ion beam milling. After the fabrication, the cavity modes are tuned into resonance with the zero phonon line of a single SiV centre. In the second approach, the photonic crystal cavity is fabricated first and NV centres are subsequently implanted at the cavity centre.

Q 9.3 Mon 14:30 A 310

Atomic defects in silicon carbide LEDs as a perspective single photon source — •Franziska Fuchs[1], Victor Soltamov[2], Stefan Väth[1], Pavel Baranov[2], Eugeny Mokhov[2], Georgy Astakhov[1], and Vladimir Dyakonov[1,3] — [1]Experimental Physics VI, Julius Maximilian University of Würzburg, 97074 Würzburg — [2]Ioffe Physical-Technical Institute, St. Petersburg, 194021 Russia — [3]ZAE Bayern, 97074 Würzburg

Single photon sources, reliably emitting on demand, are necessary for e.g. optical quantum computers. For this purpose, several systems seem suitable, including atoms, molecules, quantum dots and color centers in diamond. But all these systems are difficult to implement, since they either only work at low temperatures, or do not emit at typical wavelengths used in existing telecommunication infrastructure. We suggest another system - silicon vacancy defects in silicon carbide, emitting photons in the near infrared [1]. We fabricated light emitting diodes based on intrinsic defects in silicon carbide. The room temperature electroluminescence reveals two strong emission bands in visible and NIR, the latter assigned to silicon vacancy defects. Our approach can be used to realize an electrically driven single photon source for quantum telecommunication.

[1]Riedel et al.: Resonant Addressing and Manipulation of Silicon Vacancy Qubits in Silicon Carbide, Phys. Rev. Lett.109,226402(2012)

Q 9.4 Mon 14:45 A 310

Three dimensional mapping of the local density of states using a single quantum emitter — •Philip Engel, Andreas W. Schell, and Oliver Benson — Nano-Optics, Institute of Physics, Humboldt-Universität zu Berlin, Newtonstraße 15, D-12489 Berlin

Understanding light matter interaction plays an important role in tailoring and engineering complex environments on the nanoscale. A fundamental requirement for this is knowledge of the local density of optical states (LDOS). We present a method which allows to map the LDOS in all three dimensions with sub-nanometer resolution. Due to Fermi's golden rule the LDOS can be directly measured via lifetime changes of an emitter. We use the nitrogen vacancy defect in nanodiamond as point-like probe glued onto the tip of an atomic force microscopy. This gives us the capability to measure the topography, the lifetime, and therefore the LDOS simultaneously.

Q 9.5 Mon 15:00 A 310

NV-centers as single-photon emitters integrated into three-dimensional laser-written micro-structures — •Andreas W. Schell[1], Johannes Kaschke[2], Joachim Fischer[2], Janik Wolters[1], Rico Henze[1], Martin Wegener[2], and Oliver Benson[1] — [1]AG Nanooptik, Humboldt-Universität zu Berlin, Germany — [2]Institut für Angewandte Physik, Karlsruhe Institute of Technology (KIT), Germany

Future quantum-optical experiments and applications will likely require on-chip integration of micro-optical structures and single-photon emitters. Here, we show the direct integration of nitrogen-vacancy centers (NV centers) in nanodiamonds into various three-dimensional photonic structures by means of two-photon direct laser writing [1]. This technique enables manufacturing micro-optical structures of nearly arbitrary shape. The nanodiamonds are integrated by mixing them into the photoresist prior to its exposure. To exemplify the strength of this approach, we demonstrate efficient coupling of NV centers serving as single-photon sources to waveguides and whispering-gallery-mode optical micro-resonators.

[1] A.W. Schell et al. arXiv:1209.2036 (2012)

Q 9.6 Mon 15:15 A 310

A molecular – atomic hybrid system — •Petr Siyushev[1], Guilherme Stein[1], Jörg Wrachtrup[1,2], and Ilja Gerhardt[1,2] — [1]3. Physics Institute and Research Center SCoPE, University of Stuttgart, 70569 Stuttgart, Germany — [2]Max Planck Institute for Solid State Research, 70569 Stuttgart, Germany

Single photon sources (SPSs) are a key element for quantum information processing (QIP). Among other systems, single molecules are one of the promising candidates due to their high brightness and the possibility to generate single photons on demand [1]. Another crucial point for realization QIP is a quantum memory and atoms constitute a good media for its realization [2]. Here we present recent results in combining single molecule spectroscopy with the spectroscopy on the atomic vapor. A high-brightness molecule based SPS at the Sodium D-line is shown as well as slowed down photons in a Na-vapor cell. In addition, atomic vapor, serving as a very narrow notch filter, allows for an increased detection efficiency in comparison with commercial interference filters.

[1] B. Lounis and W. E. Moerner, Nature **407**, 491 (2000) [2] D. F. Phillips, A. Fleischhauer, A. Mair R. L. Walsworth, and M. D. Lukin, Phys. Rev. Lett. **86**, 783 (2001)

Q 9.7 Mon 15:30 A 310

Coupling color centers in diamond to fiber based Fabry-Pérot microcavities — •Hanno Kaupp[1,2], Christian Deutsch[1,2], Roland Albrecht[3], Elke Neu[4], Christoph Becher[3], Jakob Reichel[5], Theodor W. Hänsch[1,2], and David Hunger[1,2] — [1]Ludwigs-Maximilians-Universität München — [2]Max-Planck Institut für Quantenoptik, Garching — [3]Universität des Saarlandes — [4]Universität Basel — [5]Laboratoire Kastler Brossel, E.N.S, Paris

Optical fibers with machined and coated end facets can serve as high reflectivity mirrors to build low loss optical resonators with free space access. Such microcavities feature a very small mode volume on the order of a few tens of cubic wavelengths and a very large Finesse of up to 10^5, corresponding to quality factors of several millions. The resulting Purcell factor can ideally be as high as 10^4. This can involve a dramatic increase of the emission rate of an emitter inside the cavity.

We use the microcavities to couple color centers in diamond to the cavity. First results of coupling nitrogen-vacancy center (NV) ensembles to the cavity will be discussed. We demonstrate cavity enhanced emission and quantify the effective Purcell factor by analyzing optical spectra. The observed enhancement can be modeled with an effective Purcell factor taking the fast dephasing of the NV center into account.

In contrast to the broad spectral emission characteristics of NV centers, the silicon-vacancy (SiV) center in diamond can exhibit an emission linewidth of below 1 nm at room temperature. This holds promise to achieve much larger effective Purcell factors and emission rates. We will show first steps towards coupling SiV centers to microcavities.

Q 9.8 Mon 15:45 A 310

Photonic Rutherford Scattering — •Markus Selmke and Frank Cichos — Universität Leipzig, molecular nanophotonics

We show that the quantum mechanical (QM) description of Rutherford scattering has a photonic counterpart in a new form of single particle photothermal (PT) microscopy. Using a split detector we provide experimental evidence, that photons are deflected by a photonic potential which is created by a local refractive index change around a laser-heated absorbing nanoparticle. The deflection experienced is shown to be the analog to the deflection of a massive particle wave-packet in unscreened (spin-less) Coulomb scattering. The experimentally found focal detection geometry reveals an adjustable lateral split sub-volume feature which allows new correlation-based 3D-velocimetry experiments of absorbing nanoparticles with ultra-high sensitivity. Further, a framing of the whole spectrum of phenomena in PT single particle microscopy into the well-known QM scattering framework is hereby achieved.