Q 25: Nano-Optics I

Time: Tuesday 14:30–16:45 Location: f342

Q 25.1 Tue 14:30 f342

Photon Statistics Excitation Spectroscopy of a Single Two Level System — •Janik Wolters[1,2], Max Strauss[2], Marlon Placke[2], Sören Kreinberg[2], Christian Schneider[3], Martin Kamp[3], Sven Höfling[3], and Stephan Reitzenstein[2] — [1]Universität Basel, Departement Physik, CH-4056 Basel — [2]Institut für Festkörperphysik, Quantum Devices Group, Technische Universität Berlin, Hardenbergstrasse 36, EW 5-3, 10623 Berlin, Germany — [3]Technische Physik, Universität Würzburg, Am Hubland, 97074 Würzburg, Germany

The interaction of coherent light with a single two level system (TLS) is one of the corner stones of quantum optics. In recent years experiments in this exciting field of quantum optics have been extended from atomic systems to semiconductor nanostructures, e.g. to the coherent control of self-assembled quantum dots (QDs). Here, we address the so far unexplored regime of resonance fluorescence in which the QD is excited not with a coherent laser, but with a narrowband chaotic light source. By analysing the resonantly scattered emission of the TLS, we find that the photon statistics of the excitation source greatly influences the TLS's dynamics in quantitative agreement with theoretical predictions.

Q 25.2 Tue 14:45 f342

All-optical coherent control of silicon vacancy color centers in diamond using picosecond laser pulses — •Jonas Nils Becker[1], Carsten Arend[1], Benjamin Pingault[2], Christian Hepp[2], Mete Atatüre[2], and Christoph Becher[1] — [1]Universität des Saarlandes, Saarbrücken, Germany — [2]Cavendish Laboratory, University of Cambridge, United Kingdom

In the last decade diamond-based impurity spins have been proven to be interesting systems for applications in quantum information processing. Besides the well known nitrogen vacancy center, in particular the negatively charged silicon vacancy center (SiV) has recently attracted attention because of its favourable spectral properties. In previous works we presented a detailed investigation of the electronic structure of the SiV [1] and we demonstrated access to its electronic spin within the excited state [2] as well as the ground state manifold [3]. However, the coherent optical manipulation of the SiV has not been demonstrated so far. Using picosecond laser pulses, we here present fast coherent control of the SiV employing Rabi oscillations. Furthermore, a Ramsey-type pulse sequence allows for a more general control of the created quantum state as well as for a measurement of the excited state coherence time scales. Both techniques are key requirements for applications in quantum information processing and for more complex manipulation schemes in the future.

[1] Hepp et al., Phys. Rev. Lett. 112, 036405 (2014).
[2] Müller et al., Nat. Commun. 5, 3328 (2014).
[3] Pingault, Becker et al., Phys. Rev. Lett. 113, 263601 (2014).

Q 25.3 Tue 15:00 f342

Probing non-Markovian dephasing processes in deterministic quantum-dot microlenses — •Alexander Thoma[1], Peter Schnauber[1], Manuel Gschrey[1], Marc Seifried[1], Janik Wolters[1], Jan-Hindrik Schulze[1], André Strittmatter[1], Sven Rodt[1], Alexander Carmele[2], Andreas Knorr[2], Tobias Heindel[1], and Stephan Reitzenstein[1] — [1]Institut für Festkörperphysik, TU Berlin, Berlin, Germany — [2]Institut für Theoretische Physik, TU Berlin, Berlin, Germany

Bright quantum light sources based on single semiconductor quantum dots (QDs) integrated into photonic microstructures are key building blocks for the realization of advanced quantum computation schemes. Further progress toward applications will rely on deterministic fabrication technologies. Despite practical aspects, a profound knowledge of decoherence processes affecting the photon-indistinguishability is crucial for any optimization of future devices. Here, we probe time-dependent dephasing processes in deterministic QD-microlenses [1]. In particular, we explore the photon-indistinguishability as a function of the time δt elapsed between consecutive photon emission events to gain experimental access to the underlying decoherence processes at a ns time-scale. Gradually increasing δt from 2 ns to 12 ns results in a plateau-like behaviour at low δt with visibilities close to unity, while the visibility decreases for larger δt ($>$ 8 ns). Our experimental observations are theoretically described by a non-Markovian noise process in agreement with fluctuating charge carriers in the QD's vicinity.

[1] Thoma et. al, arXiv:1507.05900 (2015)

Q 25.4 Tue 15:15 f342

Sub-shot-noise emission from a single photon source — •Xiao-Liu Chu[1], Stephan Götzinger[2,1], and Vahid Sandoghdar[1,2] — [1]Max-Planck Institute for the Science of Light, D-91058 Erlangen, Germany — [2]Department of Physics, Friedrich Alexander University of Erlangen-Nürnberg, D-91058 Erlangen, Germany

Recently, we introduced the concept of a dielectric antenna, which allowed us to demonstrate collection efficiencies from a single emitter in excess of 99% [1][2][3]. Such near-unity collection efficiency paves the way for creating a truly deterministic single photon source, whose inherent statistics is radically different from that of a classical light source. In the present work, we couple a single molecule to a metallo-dielectric antenna and demonstrate sub-poissonian photon statistics. The structure consists of a standard coverglass coated with thin dielectric layers with decreasing refractive indices and a gold mirror. Using standard optics, we are able to measure both high count rates and a noise level below the shot-noise. These experiments bring us one step closer to a perfectly deterministic single photon source that would be highly desirable for information processing and metrology.

[1] K. G. Lee et al., Nat. Phot. 5, 166 (2011)
[2] X.-W. Chen, S. Götzinger, and V. Sandoghdar, Opt. Lett. 36, 3545 (2011)
[3] X.-L. Chu et al., Optica 1, 203 (2014)

Q 25.5 Tue 15:30 f342

Single molecules coupled to nano-photonic structures — •Oliver Neitzke[1], Guenther Kewes[1], Pietro Lombardi[2], Nico Gruhler[3], Wolfram Pernice[3], Costanza Toninelli[2], and Oliver Benson[1] — [1]Inst.f.Physk, Humboldt Universitaet zu Berlin, Germany — [2]LENS, Florence, Italy — [3]KIT, Karlsruhe, Germany

Organic dye molecules are well-suited candidates for hybrid single photon sources and optical nonlinearities for future integrated photonics and quantum photonic circuits. Embedded in a crystal host matrix, dye molecules are very bright stable single photon emitters with very narrow zero-phonon-line emission at cryogenic temperatures.

In order to integrate single photon emission into nano-optical structures, coupling of single emitters to waveguides, resonators, and plasmonic structures is investigated thoroughly by many research groups. Our studies focus on single DBT molecules in a protective anthracene host matrix. The crystal matrix stabilizes the photon emission and reduces the intersystem crossing rates significantly, thereby reducing blinking and bleaching of the molecules under laser excitation. The robust thin-film shell enables mechanical nano-manipulation techniques and easy deposition onto our fabricated structures. We designed and fabricated SiN waveguides with optimized grating coupler ports, allowing us to confocally excite and detect molecules and also observe the coupled fluorescence into the waveguide structures. We are employing different photonic structures, e.g. tapered fibers, slot waveguides, and nano antennas, to compare and improve the coupling efficiencies of the single molecule emitters.

Q 25.6 Tue 15:45 f342

Single molecules evanescently coupled to optical nanofibers — •Sarah Margaretha Skoff, Hardy Schauffert, David Papencordt, and Arno Rauschenbeutel — Institute of Atomic and Subatomic Physics, Vienna University of Technology, Stadionallee 2, 1020 Vienna, Austria

In recent years, single molecules in solids have gained increased interest as building blocks for quantum networks, quantum metrology and nanosensors. For all these applications strong light-matter interactions are essential.

A versatile tool to achieve such interactions is an optical nanofiber, which is the tapered part of a commercial optical fiber that has a sub-wavelength diameter waist. This allows an appreciable amount of light to propagate outside the fiber in the form of an evanescent waist. Due to the strong transverse confinement of the light field which prevails over the entire length of the nanofiber, the interaction with emitters close to the surface can be significant.

Here we will show how single terrylene molecules in a p-terphenyl matrix can be evanescently coupled to the guided modes of optical nanofibers. This presents a new platform based on solid state emitters that is used for quantum optics and can be naturally integrated into any optical fiber based quantum network.

Q 25.7 Tue 16:00 f342

All-optical preparation of coherent dark states of a single rare earth ion spin in a crystal — •Kangwei Xia[1], Roman Kolesov[1], Petr Siyushev[2], Rolf Reuter[1], Thomas Kornher[1], Andreas D. Wieck[3], and Jörg Wrachtrup[1] — [1]Universität Stuttgart — [2]Universität Ulm — [3]Ruhr-Universität Bochum

Rare-earth-doped crystals are excellent hardware for quantum storage of optical information. In quantum memories the quantum state of a photon is stored in an ensemble of spins. This type of memory is an essential ingredient of quantum repeaters and quantum computing protocols based on linear optics. Despite progress made with ensembles of rare-earth ions, the detection and manipulation of individual ions is one of the ways to reach scalability of rare earth-based quantum devices. Here, we present high-fidelity optical initialization, coherent manipulation, and optical readout of a single electron spin of Ce ion in YAG. Under dynamic decoupling, spin coherence lifetime reaches 2ms. The generation of coherent dark state of a single Ce in YAG will be also present. The dark state was formed under the condition of coherent population trapping. In addition, high-resolution spectroscopic studies of single Ce ions have been performed. They revealed narrow and spectrally stable optical transitions between the spin sublevels of the ground and excited optical states, indicating the feasibility of interfacing single photons with a single electron spin of a cerium ion. Combined with high brightness of Ce3+ emission and a possibility of creating photonic circuits out of the host material, this makes cerium spins an interesting option for integrated quantum photonics.

Q 25.8 Tue 16:15 f342

Low temperature spectroscopy of defect in diamond showing positive ODMR signature — •Mathias H. Metsch[1], Priyadharshini Balasubramanian[1], Lachlan J. Rogers[1], Marcus W. Doherty[2], and Fedor Jelezko[1] — [1]Institute for Quantum Optics and Center for Integrated Quantum Science and Technology, University Ulm, D-89081 Germany — [2]Laser Physics Centre, Research School of Physics and Engineering, Australian National University, ACT 0200, Australia

Natural diamonds may contain a wide variety of defects of which only a hand full have been intensively studied. The most well known color center in diamond is the negatively charged nitrogen vacancy center, and it is of particular interest as it provides spin polarization and an optical spin read-out mechanism at ambient temperature (via optically detected magnetic resonance - ODMR). This ability to manipulate individual spins in the solid state has a wide range of exciting applications in quantum sensing, quantum information processing, and quantum communication. Only a few other color centres in diamond have been demonstrated to provide the ability to manipulate individual spins, including the silicon-vacancy (SiV)and an unidentified defect named ST1.

In this talk I will present results of low temperature spectroscopy measurements on a novel defect showing these properties which is found in natural diamond. The ODMR properties of this defect resemble those of the ST1 center. One aim of these measurements is to identify the defect responsible.

Q 25.9 Tue 16:30 f342

Optical dynamic nuclear spin polarisation in diamond — •Jochen Scheuer[1], Ilai Schwartz[2], Qiong Chen[2], David Schulze-Sünninghausen[3], Patrick Carl[4], Peter Höfer[4], Alexander Retzker[5], Hitoshi Sumiya[6], Junichi Isoya[7], Burkhard Luy[3], Martin B. Plenio[2], Boris Naydenov[1], and Fedor Jelezko[1] — [1]Institute of Quantum Optics, Ulm University, Germany — [2]Institute of Theoretical Physics, Ulm University, Germany — [3]Institute of Organic Chemistry and Institute for Biological Interfaces, Karlsruhe Institute of Technology, Germany — [4]Bruker BioSpin GmbH, Rheinstetten, Germany — [5]Racah Institute of Physics, The Hebrew University of Jerusalem, Israel — [6]Sumitomo Electric Industries Ltd., Itami, Japan — [7]Research Centre for Knowledge Communities, University of Tsukuba, Japan

The sensitivity of Magnetic Resonance Imaging (MRI) depends critically on nuclear spin polarisation and therefore dynamical nuclear spin polarisation has recently been applied to enhance MRI protocols. 13C nuclear spins in diamond possess uniquely long spin lattice relaxation times. If present in nanodiamods, especially when strongly polarised, they form a promising contrast agent for MRI. Available schemes for achieving hyperpolarization, however, require cryogenic temperatures. We present an efficient scheme that realises 13C nuclear spin hyperpolarisation at room temperature and low magnetic field, which is robust against misalignment. Optical pumping of a Nitrogen-Vacancy (NV) centre creates a continuously renewable electron spin polarisation which can then be transferred to surrounding 13C nuclear spins.