Q 12: Nano-Optics I

Time: Monday 17:00–19:00 Location: P 11

Q 12.1 Mon 17:00 P 11

Temperature dependent spectral properties of single point defects in hexagonal boron nitride — •Bernd Sontheimer[1], Merle Braun[1], Nikola Sadzak[1], Igor Aharonovich[2], and Oliver Benson[1] — [1]Humboldt-Universität zu Belrin — [2]University of Technology Sydney

Hexagonal boron nitride (hBN) is an emerging twodimensional wide-bandgap material.[1] Point defects in hBN show extraordinary bright single photon emission at various wavelengths in the visible and near infrared. Here we present our latest research on the temperature dependence of the spectral properties of different individual emitters in mono- and few-layer hBN flakes. Additionally, we show and analyze the apparent spectral diffusion at different time scales as well as optical coherence properties at cryogenic temperatures.

[1] Tran T., et al., Nat. Nanotechnol. 11, 37-41 (2016)

Q 12.2 Mon 17:15 P 11

Bright multicolor single photon emitter in hexagonal boron nitride at room temperature — •Merle Braun[1], Bernd Sontheimer[1], Igor Aharonovich[2], and Oliver Benson[1] — [1]Nano-Optics, Institute of Physics, Humboldt-Universität zu Berlin — [2]School of Mathematical and Physical Sciences, University of Technology Sydney

Single photon emitters play an important role in a variety of quantum technologies, including quantum communications and computing. The well studied color centers in diamonds present one way to produce single photons. Another promissing solid state material are two dimensional hexagonal boron nitride flakes. Due to the wide bandgap, included point defects allow generating single photons at different wavelengths. Here we report our study of the optical properties at room temperature and further our recent successes in preparing samples of hexagonal boron nitride flakes. We detected single photon emitters across the visible and near infrared spectral range (620nm - 750nm) using non-resonant excitation and took spectra, showing the expected intensity distribution: the main emission is within the zero phonon line, indicating a very high Debye-Waller factor. Even at room temperature all these stable emitters showed narrow linewidths below 5 nm as well as very short lifetimes below 5 ns, which lead to a high brightness. This property is an important requirement for many quantum optical experiments.

Q 12.3 Mon 17:30 P 11

Non-linear excitation of single quantum emitters in hexagonal boron nitride — •Andreas w. Schell[1], Hideaki Takashima[1], Toan Trong Tran[2], Igor Aharonovich[2] und Shigeki Takeuchi[1] — [1]Kyoto University, Kyoto, Japan — [2]University of Technology, Sydney, Australia

Recently, two-dimensional materials have gained much interest for various applications in nanophotonics and quantum optics, as they possess a strong luminescence and are able to host single quantum emitters. Excitation of quantum emitters via a two-photon process can be employed for high resolution imaging and has applications in quantum optics. Here, we present one- and two-photon excitation of single defects in hexagonal boron nitride (hBN) and analyse the properties of the emitted light [1]. We find clear antibunching signals that prove the single emitter character in both excitation cases. To gain further knowledge, we also obtain saturation curves. From a comparison of one- and two-photon case insights about the level structure of the defects can be obtained. These results will not only help the fundamental understanding of defects in hBN, but also help to introduce this class of emitters in optical imaging, as the defects in hBN are of small spatial extend, photostable and emit their fluorescence well in the wavelength region of the biological optical window. [1] A. W. Schell et al. APL Photonics 1, 091302 (2016)

Q 12.4 Mon 17:45 P 11

Studies on single perylene bisimide macrocyclesat strong photo-excitation — •Ulrich Müller[1], Peter Spenst[2], Matthias Stolte[2], Frank Würthner[2], and Jens Pflaum[1,3] — [1]Experimentelle Physik VI, Julius-Maximilians-Universität, Würzburg — [2]Institut für Organische Chemie, Julius-Maximilians-Universität, Würzburg — [3]ZAE Bayern, Würzburg

Quantum emitters like individual organic guest molecules within a matrix can serve as non-classical light sources in quantum communication and metrology applications. In this context, single Perylene Bisimides (PBIs) are interesting candidates for single photon emitters due to their chemically tunability, strong fluorescence and high photostability [1].

Using a confocal-microscopy set-up in combination with fluorescence correlation measurements we characterize the optical properties of PBIs as single quantum emitters at various excitation powers. We will highlight the rich excitation dynamics of para-xylylene bridged PBI-macrocycles and compare them to single chromophores:

At low excitation densities PBI-macrocycles act as bright and stable single photon emitters due to a fast energy transfer between the different chromophores of the macrocycle. Above intensity saturated excitation the co-existence of multi-excitonic states on the macrocycle becomes more likely and the process of exciton-exciton-annihilation controls the emission characteristics. We provide a model to consistently explain our observations and to advance the understanding of excitation and relaxation processes in multi-chromophoric systems.

[1] F. Schlosser et al., *Chem. Sci.* **3**, 2778 (2012)

Q 12.5 Mon 18:00 P 11

Generation of single photons with tailored waveforms using a quantum dot emitting near the Rb D2 line — •Janik Wolters[1], Jan-Philipp Jahn[1], Lucas Beguin[1], Mathieu Munsch[1], Yongheng Huo[2], Fei Ding[3], Rinaldo Trotta[2], Markus Reindl[2], Oliver G. Schmidt[3], Armando Rastelli[2], Philipp Treutlein[1], and Richard J. Warburton[1] — [1]University of Basel — [2]Johannes Kepler University Linz — [3]IFW Dresden

Semiconductor quantum dots are excellent single photon sources, providing triggered single photon emission at a high rate and with high spectral purity. Independently, atomic ensembles have emerged as one of the best quantum memories for single photons, providing high efficiency storage and long memory lifetimes. We have recently demonstrated the emission of high quality photons from a single droplet quantum dot emitting at the Rb D2 transition [1]. However, there is a significant mismatch between the large bandwidth of the quantum dot photons and the relatively small bandwidth of a Rb ensemble. We present here a route to creating photons with a tailored waveform by exploiting a long-lived hole spin in a droplet quantum dot. The quantum dot spin is prepared in one of the spin states and is then driven into the other spin state by a control laser whose waveform determines the waveform of the photon. We demonstrate the creation of $10 - 100$ ns duration waveforms with single-photon character thereby overcoming the bandwidth mismatch.

[1] J.-P. Jahn *et al.*, Phys. Rev. B **92**, 245439 (2015)

Q 12.6 Mon 18:15 P 11

QD single photons delayed in cesium vapor — •Tim Kroh[1], Janik Wolters[2], Alexander Thoma[3], Stephan Reitzenstein[3], Rinaldo Trotta[4], Eugenio Zallo[5], Armando Rastelli[4], Oliver G. Schmidt[6], and Oliver Benson[1] — [1]Humboldt-Universität zu Berlin — [2]Universität Basel — [3]Technische Universität Berlin — [4]Johannes Kepler Universität Linz — [5]Paul-Drude-Institut für Festkörperelektronik, Berlin — [6]IFW Dresden

In forthcoming quantum networks various quantum systems might be involved to accomplish individual tasks, including storage of quantum states, quantum logic operations, error correction, or entanglement distillation. An interface between a single photon emitter and a potential photon storage could provide one fundamental building block of such a hybrid quantum system.

In our experiment this is realized by setting the exciton emission of a strain-tunable InGaAs quantum dot to the cesium D1 line at 894 nm. Under pulsed, non-resonant excitation the QD single photons are delayed in atomic cesium vapor by strong dispersion between two hyperfine-split levels of the D1 transition. This allows for delay times of a few nanoseconds even at low optical densities, resulting in a propagation velocity at the order of 1/20 of the vacuum speed of light. Such a single photon - atom interface might lay the foundations for a low-loss quantum memory in a future hybrid quantum network.

Q 12.7 Mon 18:30 P 11

A deterministic twin-photon source in the solid-state — •Tobias Heindel[1], Alexander Thoma[1], Martin von

Helversen[1], Marco Schmidt[1,2], Alexander Schlehahn[1], Manuel Gschrey[1], Peter Schnauber[1], Jan-Hindrik Schulze[1], André Strittmatter[1], Jörn Beyer[2], Sven Rodt[1], Alexander Carmele[3], Andreas Knorr[3], and Stephan Reitzenstein[1] — [1]Institut für Festkörperphysik, Technische Universität Berlin, 10623 Berlin, Germany — [2]Physikalisch-Technische Bundesanstalt, Abbestraße 1, 10587 Berlin, Germany — [3]Institut für Theoretische Physik, Technische Universität Berlin, 10623 Berlin, Germany

To realize an integrated light source capable of emitting non-classical multi-photon states, is a fascinating, yet equally challenging task at the heart of quantum optics. Here, we propose and experimentally demonstrate the efficient, triggered generation of photon twins using the energy-degenerate biexciton-exciton radiative cascade of a single semiconductor quantum dot [1]. For this purpose, we select a quantum emitter whose exciton's finestructure splitting equals the biexciton binding energy. Deterministically integrated within a microlens, this nanostructure emits photon twins at a rate of up to (234 ± 4) kHz. To directly observe the emitted twin-photon state, we employ a photon-number-resolving detection system based on a transition edge sensor, which enables the reconstruction of the emitted photon number distribution.

[1] A. Thoma, T. Heindel et al., A bright triggered twin-photon source in the solid state, arXiv:1608.02768 (2016)

Q 12.8 Mon 18:45 P 11

Time reordering of paired photons in a dressed three-level cascade — •Max Strauss, Samir Bounouar, Alexander Carmele, Peter Schnauber, Alexander Thoma, Manuel Gschrey, Jan-Hindrik Schulze, Andre Strittmatter, Sven Rodt, Andreas Knorr, and Stephan Reitzenstein — TU Berlin, Hardenbergstrass e 36, 10623 Berlin

The biexcitonic cascade in semiconductor quantum dots can act as a versatile tool for quantum optical experiments, e.g. as a source of polarisation or time-bin entangled photons. In our experiments, we use continuous-wave two-photon excitation to resonantly excite this three level system and observe the emergence of dressed states under strong excitation. Likewise, we evidence the coherent interaction by the observation of two-photon Rabi oscillations in the time domain. Finally, using photon correlation experiments we demonstrate that the time ordering of the emitted photons in the dressed cascade can be manipulated by increasing the strength of the driving laser field.