Q 6: Nano-Optics (Single Quantum Emitters) I

Time: Monday 10:30–12:15 Location: S SR 112 Maschb.

Q 6.1 Mon 10:30 S SR 112 Maschb.

Colour centres in Nanodiamonds — •Ou Wang[1,2], Andrea Filipovski[1], Lachlan Rogers[3,4], Valery Davydov[5], Viatcheslav Agafonov[6], Fedor Jelezko[1,2], and Alexander Kubanek[1,2] — [1]Institute for Quantum Optics, University Ulm, Albert-Einstein-Allee 11, D-89081 Ulm, Germany — [2]Center for Integrated Quantum Science and Technology (IQST), University Ulm, Albert-Einstein-Allee 11, D-89081 Ulm, Germany — [3]Department of Physics and Astronomy, Macquarie University, New South Wales 2109, Australia — [4]ARC Centre of Excellence for Engineered Quantum Systems (EQUS) — [5]L.F.Vereshchagin Institute for High Pressure Physics, Russian Academy of Sciences, Troitsk, Moscow, 142190, Russia — [6]GREMAN, UMR CNRS CEA 6157, Universit F. Rabelais, F-37200 Tours, France

In recent years colour centres in Diamond has gained growing interest as qubit candidate with their excellent optical properties. By introducing colour centres into nanodiamonds, higher flexibility of quantum system adaptation as well as further optical propertie engineering can be achieved. Yet the biggest challenge is to recover the bulk-like optertical properties. In this presentation we discuss the most recent progress from our investigation into colour centres in Nanodiamonds, offering insights into the on-going progress improving optical properties of colour centres in nanodiamonds

Q 6.2 Mon 10:45 S SR 112 Maschb.

Coherent coupling of single molecules to on-chip microresonators — •Dominik Rattenbacher[1], Alexey Shkarin[1], Jan Renger[1], Tobias Utikal[1], Stephan Götzinger[2,1], and Vahid Sandoghdar[1,2] — [1]Max Planck Institute for the Science of Light (MPL), Erlangen, Germany — [2]Friedrich-Alexander University (FAU) Erlangen-Nürnberg, Erlangen, Germany

One-dimensional subwavelength waveguides (nanoguides) are an ideal system to realize light-matter interactions between photons in the waveguide mode and individual emitters separated on length scales much longer than their transition wavelength [1]. However, as with most mode-matching approaches, the overall coherent coupling efficiency is limited by geometric/material constrains and a rich internal level structure of the emitters. Both limitations could recently be overcome in a free-space geometry by using a high-finesse Fabry-Pérot cavity [2]. In this presentation we discuss the coherent coupling of single molecules to ring resonators and nanoguides on a chip. Together with the possibility to manipulate the resonance frequencies of the molecules by static electric fields, we expect our platform to offer an ideal candidate for the investigations of cooperative effects among several emitters [3].

[1] P. Türschmann et al., Nano Lett. **17**, 4941 (2017)
[2] D. Wang et al., arXiv:1809.07526 (2018)
[3] H. R. Haakh et al., Phys. Rev. A **94**, 053840 (2016).

Q 6.3 Mon 11:00 S SR 112 Maschb.

Investigation of the optical properties of single emitter in hBN — •Andreas W. Schell[1,2,3], Mikael Svedendahl[2], Romain Quidant[2], Hideaki Takashima[3], and Shigeki Takeuchi[3] — [1]Quantum Optical Technology Group, CEITEC, Brno, Czech Republic — [2]ICFO, Barcelona, Spain — [3]Kyoto University, Koyto, Japan

Among the quantum systems capable of emitting single photons, the class of recently discovered defects in hexagonal boron nitride (hBN) is especially interesting, as these defects offer much desired characteristics such as narrow emission lines and photostability. Like for any new class of quantum emitters, the first challenges to solve are the understanding of their photophysics as well as to find ways to facilitate integration in photonics structures. Here, we will show our investigation of the optical transition in hBN with different methods: Employing excitation with a short laser pulse the emission properties in case of linear and non-linear excitation can be compared [1]. The possibility to perform two-photon excitation makes this single photon emitter an interesting candidate as a biosensor. We further show the behaviour of defects in hBN when being excited with different wavelengths and deduce the consequences for its level scheme. Here, it is found that the quantum efficiency of the emitters varies strongly with excitation wavelength, a strong indication of a branched level system with different decay pathways.

[1] A W Schell et al., APL Photonics 1, 091302 (2016) [2] A W Schell et al., Advanced Materials 30, 1704237 (2018)

Q 6.4 Mon 11:15 S SR 112 Maschb.

Single photons, $g^{(2)}(0) < 1/2$, and vacuum — •Peter Grünwald — Escuela de Ingeniería y Ciencias, ITESM, Monterrey, Mexico

In modern quantum technologies, the measurement of a second-order correlation function $g^{(2)}(0) < 1/2$ is used to imply that the source field is a good single-photon light source [1,2]. We analyze and expand on this concept [3]. A quantum state of light having no projection on the single-photon Fock state can not give a value of $g^{(2)}(0) < 1/2$. However, the amplitude of this single-photon projection can be arbitrarily small or large. Instead, we can determine a lower bound on the ratio of single-to-multi-photon emission from $g^{(2)}(0) < 1/2$. For a fixed ratio of single-to-multi-photon emission, $g^{(2)}(0)$ is artificially enhanced by vacuum contributions. We derive an effective second-order correlation function, which takes this enhancement into account, substantially improving the lower bound. The results are applied to theoretical and realized experimental setups and indicate that the quality of solid-state single-photon sources, at least with respect to this criterion, is often underestimated.

References:
[1] P. Michler et al., Science 290, 2282 (2000).
[2] S. Buckley et al., Rep. Prog. Phys. 75, 126503 (2012).
[3] P. Grünwald, arXiv:1711.05897.

Q 6.5 Mon 11:30 S SR 112 Maschb.

Very large and reversible Stark Shift tuning of single emitters in layered hexagonal boron nitride — •Niko Nikolay[1], Noah Mendelson[2], Nikola Sadzak[1], Florian Böhm[1], Toan Trong Tran[2], Bernd Sontheimer[1], Igor Aharonovich[2], and Oliver Benson[1] — [1]AG Nanooptik & IRIS Adlershof, Humboldt Universität zu Berlin, Newtonstraße 15, D-12489 Berlin, Germany — [2]The Racah Institute of Physics, The Hebrew University of Jerusalem, Jerusalem 9190401, Israel

To exploit the functionality of an single photon emitter (SPE) - cavity system, it is essential to tune the SPEs' zero phonon line to a cavity's resonance. In this work we show very large Stark shifts of selected bright and stable SPEs embedded in a few layer hexagonal boron nitride (hBN). We applied an electrostatic field to individual SPEs by sandwiching the hBN between a conductive atomic force microscope tip and an indium tin oxide coated glass slide. Stark shifts of 5.5(3) nm at a resonance wavelength of 670 nm were induced by the application of 20 V, which is larger than the typical resonance line widths of nanodielectric and even nanoplasmonic resonators. A determination of the polarizability, the dipole moment and the dipole orientation of the SPEs completes the full characterization of the selected SPEs. Our results are important to further understand the physical origin of SPEs in hBN, as well as for practical quantum photonic applications requiring broad spectral tuning and on/off resonance switching.

Q 6.6 Mon 11:45 S SR 112 Maschb.

Photoluminescence Excitation Spectroscopy of Single Quantum Emitters in Hexagonal Boron Nitride (h-BN) — •Michael Höse[1], Andreas Dietrich[1], Rebecca Bernsdorff[1], and Alexander Kubanek[1,2] — [1]Institute for Quantum Optics, Ulm University, D-89081 Ulm, Germany — [2]Center for Integrated Quantum Science and Technology (IQst), Ulm University, D-89081 Ulm, Germany

Single photon sources are crucial building blocks for novel hybrid quantum systems, which will allow for implementing quantum repeaters or other quantum network architectures. Quantum Emitters in hexagonal boron nitride (h-BN) revealed promising characteristics including Fourier limited linewidths under resonant excitation [1]. However, the full level structure including detailed characteristics of the phononic sideband lack full understanding.

Here, we present our recent results towards a complete characterization of single quantum emitters in h-BN. Mainly, we use resonant and off-resonant photoluminescence (PLE) spectroscopy to probe the emitter level structure. Our measurements contribute to a better understanding of single quantum emitters in h-BN, thus paving the way for the implementation of novel hybrid quantum systems.

[1] A. Dietrich et al., Phys. Rev. B 98, 081414 (2018).

Q 6.7 Mon 12:00 S SR 112 Maschb.

Recent activities on the metrological realization of an absolute single-photon source based on a nitrogen-vacancy center in nanodiamond — •Beatrice Rodiek, Justus Christinck, Helmuth Hofer, Hristina Georgieva, Marco López, and Stefan Kück — Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Germany

Single-photon sources play an important role in several fields of research, e.g. in quantum key distribution and quantum-enhanced measurements. In radiometry, a single-photon source is very favorable, compared to a classical source, as a standard source for the detection efficiency calibration of single-photon detectors. Furthermore, such source is necessary to close the gap between classical and quantum radiometry, i.e. for the direct comparison between classical analogue detectors and single-photon detectors. We present the metrological realization of an absolute single-photon source based on a nitrogen-vacancy (NV-) center in nanodiamond, which is under development at the Physikalisch-Technische Bundesanstalt (PTB), the German national metrology institute. This source is traceable to national standards for optical radiant power and spectral power distribution via an unbroken chain in terms of its absolute spectral photon flux per wavelength and absolute spectral radiant flux per wavelength. This investigation includes a full determination of the measurement uncertainty. Besides this, we calculated the angular emission behavior of such a NV-center and compared the results with the measurement of the angle-dependent emission of an NV-center in nanodiamond.