Q 23: Nano-Optics (Single Quantum Emitters) I

Time: Wednesday 11:00–13:00 Location: a310

Group Report Q 23.1 Wed 11:00 a310

Inverse design of light-matter interactions — •Robert Bennett, Jonas Matuszak, and Stefan Yoshi Buhmann — University of Freiburg, Germany

Optimal designs for photonic elements (beamsplitters, demultiplexers etc) are usually found through a combination of intuition, symmetry and previous experience. By contrast, in inverse design optimal geometries are algorithmically discovered, often leading to much higher performance. Such techniques are well-developed in the field of nanophotonics, but have not yet been applied to surface-dependent light-matter interactions such as Casimir-Polder forces or medium-assisted resonance energy transfer (RET). In this talk I will outline a very general approach recently developed in our group that allows us to optimise the observables associated with such phenomena, and give an explicit examples of a design able to increase the RET rate by several orders of magnitude.

Q 23.2 Wed 11:30 a310

Level set methods in inverse design of light-matter interactions — •Jonas Matuszak, Robert Bennett, and Stefan Yoshi Buhmann — University of Freiburg, Germany

Inverse design approaches are used to find the optimal structures for photonic elements based on their desired functional characteristics. Often the efficiency of geometries discovered by those algorithms goes far beyond those found by a design approach by hand. The level-set technique is an inverse design algorithm which consists of gradually changing the shape of a initial object by moving its boundaries. In this talk I will outline how this method can be used to optimise medium-assisted resonance energy transfer (RET).

Q 23.3 Wed 11:45 a310

Processing nanodiamonds carrying single SiV$^-$ centers for their use in quantum technology applications — •Stefan Häussler[1], Lukas Hartung[1], Konstantin Fehler[1], Lukas Antoniuk[1], Liudmila Kulikova[2], Valery Davydov[2], Viatcheslav Agafonov[3], Fedor Jelezko[1], and Alexander Kubanek[1] — [1]Institut für Quantenoptik, Universität Ulm, 89081 Ulm, Germany — [2]L.F. Vereshchagin Institute for High Pressure Physics, Russian Academy of Sciences, Moscow 142190, Russia — [3]GREMAN, UMR CNRS CEA 6157, Université F. Rabelais, 37200 Tours, France

Color centers in nanodiamonds (NDs) offer one promising platform for a huge variety of quantum technology applications ranging from quantum networks to quantum sensors. In this course the negatively charged nitrogen-vacancy (NV$^-$) and silicon-vacancy (SiV$^-$) center have been extensively studied due to their outstanding spin and optical properties.

We present nanomanipulation of NDs exhibiting single SiV$^-$ centers. In particular we demonstrate the translation and rotation of a ND with the help of an AFM cantilever and explicitly show that the optical properties are conserved. We further investigate the potential of these NDs for their integration into quantum optics and photonics devices and the optical coupling of individual SiV$^-$ centers in NDs.

[1] S. Häußler et al, Preparing single SiV$^-$ center in nanodiamonds for external, optical coupling with access to all degrees of freedom, New Journal of Physics 21, 2019

Q 23.4 Wed 12:00 a310

Mechanically Isolated Quantum Emitters in Hexagonal Boron Nitride — •Michael Hoese[1], Prithvi Reddy[2], Andreas Dietrich[1], Michael K. Koch[1], Konstantin G. Fehler[1,4], Felix A. Breuning[1], Igor Aharonovich[3], Marcus W. Doherty[2], and Alexander Kubanek[1,4] — [1]Institute for Quantum Optics, Ulm University, D-89081 Ulm, Germany — [2]Laser Physics Centre, Australian National University, Canberra, ACT 0200, Australia — [3]Institute of Biomedical Materials and Devices, Faculty of Science, University of Technology Sydney, Ultimo, NSW 2007, Australia — [4]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 (hBN) revealed promising characteristics such as persisting Fourier limited linewidths from cryogenic [1] up to room temperatures [2]. This observation was attributed to decoupling from in-plane phonon modes. Here, we present our recent results towards identifying the origin of this mechanical decoupling, which could be caused by out-of-plane emitters. Our measurements contribute to a better understanding of single quantum emitters in hBN, thus paving the way for the implementation of novel hybrid quantum systems and quantum optics experiments at room temperature.

[1] A. Dietrich et al., Phys. Rev. B 98, 081414(R) (2018)
[2] A. Dietrich et al., arXiv:1903.02931 (2019)

Q 23.5 Wed 12:15 a310

Preparing SiV$^-$ nanodiamonds towards a tailored single photon source — •Richard Waltrich[1], Elena Steiger[1], Stefan Häussler[1], Konstantin Fehler[1], Niklas Lettner[1], Liudmila Kulikova[2], Valery Davydov[2], Viatcheslav Agafonov[3], and Alexander Kubanek[1] — [1]Institut für Quantenoptik, Universität Ulm, 89081 Ulm, Germany — [2]L.F. Vereshchagin Institute for High Pressure Physics, Russian Academy of Sciences, Moscow 142190, Russia — [3]GREMAN, UMR CNRS CEA 6157, Université F. Rabelais, 37200 Tours, France

Defect centers in large band gap solid state materials such as the NV$^-$ or the SiV$^-$ color center in diamond have proven as a reliable source for many quantum optical experiments. With almost bulk like optical properties, using nanodiamonds (ND) as a host for SiV$^-$ centers gives rise to flexible and scalable quantum systems. We investigate the optical properties of nanodiamonds and the influence of different preparation methods. Our work paves the way to quantum optical applications.

Q 23.6 Wed 12:30 a310

Highly enhanced photostability of single molecules in vacuum — •Randhir Kumar[1], Hsuan-Wei Liu[1], Stephan Götzinger[2,1], and Vahid Sandoghdar[1,2] — [1]Max Planck Institute for the Science of Light, Erlangen, Germany — [2]Friedrich Alexander University of Erlangen-Nürnberg, Erlangen, Germany

Single dye molecules present an excellent source of single photons with high brightness and flexibility of wavelengths. To protect them against photobleaching, one needs to shield them from the surrounding reactive agents, e.g. by embedding them in special thin films [1]. However, the finite thickness of such a medium also prevents the molecules from being placed in very small gaps necessary for very large plasmonic enhancements [2] and high spontaneous emission rate enhancement [3]. We, therefore, investigate the use of bare single dye molecules on a glass substrate. To prevent photobleaching under ambient conditions, we place the molecules in a home-built vacuum microscope that operates with a high numerical aperture at 1e-6 mbar pressure. We report on more than one order of magnitude enhancement in photostability in vacuum compared to the ambient conditions and present some prospects for exploiting our findings.

[1] Chu, Götzinger, Sandoghdar, Nature Photonics 11, 58 (2017). [2] Chikkaraddy et al., Nature 535, 127-130 (2016). [3] Matsuzaki et al., Sci. Rep. 7, 42307 (2017).

Q 23.7 Wed 12:45 a310

Optical Ramsey Spectroscopy on a Single Molecule — •Yijun Wang[1], Guilherme Stein[1], Vladislav Bushmakin[1], Jörg Wrachtrup[1,2], and Ilja Gerhardt[1] — [1]3. Institute of Physics, University of Stuttgart, Pfaffenwaldring 57, D-70569 Stuttgart, Germany — [2]Max Planck Institute for Solid State Research, Heisenbergstraße 1, D-70569 Stuttgart, Germany

High-quality single photon emitters are an important building block in the field of quantum technologies. The organic dye molecule dibenzanthanthrene (DBATT, $C_{30}H_{16}$) is a notable single photon emitter that allows for high single photon purity, high photon flux and narrow-band emission simultaneously. In this work, we validate that the linewidth of the emission from the molecule can reach the Fourier limit under cryogenic conditions. We measure the transverse relaxation time T_2 by the Ramsey Spectroscopy, i.e. by applying two optical $\frac{\pi}{2}$ pulses with an interval τ on the molecule. Alternatively, we also get T_2 from the linewidth at low power limit. By confirming that T_2 is governed by the longitudinal relaxation time T_1, we conclude that the dephasing processes in the system are negligible and the linewidth of the emitted photon is truly Fourier limited, which makes the emitter ideal for quantum interference experiments.