Q 46: Nano-Optics I

Time: Thursday 10:30–12:30 Location: Q-H11

Invited Talk Q 46.1 Thu 10:30 Q-H11

Nanoscale heat radiation in non-reciprocal and topological many-body systems — •Svend-Age Biehs — Institut für Physik, Carl von Ossietzky Universität Oldenburg, Germany

I will start with a short introduction to the experimental and theoretical advances achieved in the rapidly evolving field of nanoscale heat radiation with a focus on the theoretical development of the many-body theory within the framework of fluctuational electrodynamics. Of particular interest are non-reciprocal systems giving rise to effects like the Hall effect for heat radiation and heat flux rectification by means of non-reciprocal surface waves. On the other hand, topological many-body systems offer the possibility to use edge modes for heat transport. I will discuss this heat flux channel in a topological Su-Schrieffer-Heeger chain and a honeycomb lattice of plasmonic nanoparticles.

Q 46.2 Thu 11:00 Q-H11

Shallow implantation of color centers in silicon carbide with high-coherence spin-optical properties — •Timo Steidl[1], Tobias Linkewitz[1], Raphael Wörnle[1], Charles Babin[1], Rainer Stöhr[1], Di Liu[1], Erik Hesselmeier[1], Marcel Krumrein[1], Naoya Morioka[1], Vadim Vorobyov[1], Andrej Denisenko[1], Mario Hentschel[1], Christian Gobert[2], Patrick Berwian[2], Georgy Astakhov[3], Wolfgang Knolle[4], Sridhar Majety[5], Pranta Saha[5], Marina Radulaski[5], Nguyen Tien Son[6], Jawad Ul-Hassan[6], Florian Kaiser[1], and Jörg Wrachtrup[1] — [1]Universität Stuttgart, GER — [2]Fraunhofer IISB, Erlangen, GER — [3]HZDR, Dresden, GER — [4]IOM, Leipzig, GER — [5]University of California, Davis, USA — [6]Linköping University, SWE

The accurate positioning of optically active color centers in the center of efficient photonic interfaces is a requirement for next-generation solid-state quantum information devices. Here, we report the creation of shallow V_{Si} centers in SiC with high spatial resolution using low ion energy implantation of protons, He ions and Si ions. We observe remarkably robust spin-optical properties attributed to the minimized collateral crystal damage. In particular, we show nearly lifetime limited absorption lines and the highest reported Hahn echo time of the system. We will also show our initial results on defect generation based on He focussed ion beam implantation, which is a promising solution for nanophotonic devices. Our results highlight the tremendous potential of the SiC platform, and provide a crucial step towards the integration of V_{Si} into nanophotonic resonators.

Q 46.3 Thu 11:15 Q-H11

High-resolution vibronic spectroscopy of a single molecule embedded in a crystal — •Johannes Zirkelbach[1,2], Masoud Mirzaei[1,2], Burak Gurlek[1,2], Irena Deperasińska[3], Boleslaw Kozankiewicz[3], Alexey Shkarin[1], Tobias Utikal[1], Stephan Götzinger[1,2,4], and Vahid Sandoghdar[1,2] — [1]Max Planck Institute for the Science of Light, 91058 Erlangen, Germany — [2]Department of Physics, Friedrich-Alexander University Erlangen-Nürnberg, 91058 Erlangen, Germany — [3]Institute of Physics, Polish Academy of Sciences, Al. Lotników 32/46, 02-668 Warsaw, Poland — [4]Graduate School in Advanced Optical Technologies (SAOT), Friedrich Alexander University Erlangen-Nuremberg, 91052 Erlangen, Germany

Vibrational states of single organic dye molecules in solid-state hosts are known to relax within 10 ps although they could last by up to seconds in some molecules in vacuum. The resolution of conventional grating spectrometers puts a lower bound on the observed linewidths of vibrational transitions, i.e., an upper limit on measured lifetimes. Here, we present high-resolution vibronic spectra of single dibenzoterrylene molecules in para-dichlorobenzene crystals at $T < 100$ mK. The spectra were recorded in electronic ground and excited states using stimulated emission depletion (STED) and fluorescence excitation spectroscopy, respectively. We identified several narrow lines associated with vibrational lifetimes up to 80 ps. Using DFT calculations, we explain the intensity distribution of the vibronic lines of the dopant molecules in the solid-state environment.

Q 46.4 Thu 11:30 Q-H11

Manipulating ground-state properties of hBN quantum emitters — •Chanaprom Cholsuk[1], Sujin Suwanna[2], Falk Eilenberger[1], and Tobias Vogl[1] — [1]Institute of Applied Physics, Friedrich-Schiller-University, Albert-Einstein-Straße 15, 07745 Jena — [2]Optical and Quantum Physics Laboratory, Department of Physics, Faculty of Science, Mahidol University, Bangkok, 10400, Thailand

Quantum key distribution exploits quantum properties such as unclonable single photon states for unconditionally secure communication. As a result, nanoscale single photon emitters (SPEs) have become highly sought-after. The color-centers or fluorescent defects in hexagonal boron nitride (hBN) emit single photons at room temperature with high brightness and short excited state lifetime. The specific types of defects, however, remain unclear and require some manipulation to enhance the quantum efficiency while preserving photon purity.

In this presentation, we provide a rigorous density functional theory (DFT) calculation-based overview of the formation mechanism of SPEs in hBN. A large class of defects has been investigated and identified in the electronic structure. Consequently, we can now classify the emission wavelengths of such defects and attribute defect types to specific sources. Moreover, the DFT calculations allow us to explore tuning mechanisms as well as to tailor the photophysical properties of the emitters. We can therefore develop feasible approaches to enhance the quantum efficiency and use external strain to both manipulate the defect states as well as to reduce the defect formation energy to enhance the probability for a defect to form.

Q 46.5 Thu 11:45 Q-H11

Preparation of germanium-vacancy centers in diamond for metrological applications — •Justus Christinck[1,2], Franziska Hirt[1,2], Helmuth Hofer[1], Zhe Liu[2,3], Markus Etzkorn[2,3], Toni Dunatov[4], Milko Jakšić[4], Jacopo Forneris[5,6,7], and Stefan Kück[1,2] — [1]Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Germany — [2]Laboratory for Emerging Nanometrology (LENA), Braunschweig, Germany — [3]Technische Universität Braunschweig, Braunschweig, Germany — [4]Ruder Bošković Institute, Zagreb, Croatia — [5]University of Torino, Torino, Italy — [6]Istituto Nazionale di Fisica Nucleare (INFN), Torino, Italy — [7]Istituto Nazionale di Ricerca Metrologica (INRiM), Torino, Italy

Germanium-vacancy (GeV-) centers in diamond are promising candidates for metrological applications of single-photon sources, e.g., the calibration of single-photon avalanche diode (SPAD) detectors. We present the successful generation of GeV-centers in bulk diamond and their metrological characterization in a confocal microscope setup. Acid bath treatment has been evaluated to significantly reduce the background luminescence from the sample surface, which lead to a higher single-photon purity of the sample's emission. The Focused Ion Beam (FIB) technique was used to mill solid immersion lenses (SILs) into the diamond surface. Compared to untreated GeV-centers, an increase in photon flux was detected from the GeV centers that were below a SIL, and a careful analysis of the single photon purity was performed. Further details will be presented at the conference.

Q 46.6 Thu 12:00 Q-H11

Design of Novel Waveguide-coupled Diamond Nanostructures for Efficient Photonic Integration — •Julian M. Bopp[1,2], Matthias Plock[3], Maarten van der Hoeven[1], Tommaso Pregnolato[1,2], Sven Burger[3,4], and Tim Schröder[1,2] — [1]Department of Physics, Humboldt-Universität zu Berlin, Berlin, Germany — [2]Ferdinand-Braun-Institut, Berlin, Germany — [3]Zuse Institute Berlin (ZIB), Berlin, Germany — [4]JCMwave GmbH, Berlin, Germany

Defect centers in diamond are promising candidates for being used as quantum memories [1] and quantum emitters. Nowadays, it is still challenging to provide high coupling efficiencies between light emitted from a single defect center located in a diamond cavity and a travelling light mode of a connected waveguide [2]. Such high coupling efficiencies are required to apply the defect centers as single-photon sources in photonic integrated circuits (PICs) [3].

Here, we present our progress towards increasing the interaction strength between single tin-vacancy centers in diamond (SnV) and light fields by embedding the SnV in new types of waveguide-integrated resonators with high quality factors and small mode volumes. We investigate different design parameters of the waveguide-coupled resonator to

ensure efficient adiabatic coupling and propose a way for deterministic high-yield fabrication of the developed nanostructures.

[1] S. Mouradian et al., Phys. Rev. X 5, 031009 (2015)
[2] S. Mouradian et al., Appl. Phys. Lett. 111, 021103 (2017)
[3] N. H. Wan et al., Nature 583, pp. 226-231 (2020)

Q 46.7 Thu 12:15 Q-H11

Coherent splitting of a vibronic line in a single molecule — Johannes Zirkelbach[1,2], •Masoud Mirzaei[1,2], Burak Gurlek[1,2], Alexey Shkarin[1,2], Tobias Utikal[1,2], Stephan Götzinger[1,2,3], and Vahid Sandoghdar[1,2] — [1]Max Planck Institute for the Science of Light, 91058 Erlangen, Germany — [2]Friedrich-Alexander University Erlangen Nürnberg, 91058 Erlangen, Germany — [3]Graduate School in Advanced Optical Technologies (SAOT), Friedrich-Alexander University Erlangen Nürnberg, 91052 Erlangen, Germany

Single organic dye molecules in the solid state offer a promising platform for quantum technology because of their strong zero-phonon transitions. Coherent access to vibronic states of these molecules has so far not been considered in this context due to their fast relaxation rates. We now report on experimentally observed coherent splitting of a vibronic level obtained by tuning a strong laser beam to the transition between two vibronic states. The experiments were performed with a single dibenzoterrylene molecule in a para-dichlorobenzene crystals at $* < 100$ mK. In this scheme, the resulting non-Lorentzian resonance profiles can be described only by accounting for the coherent evolution of the density matrix elements.