Q 70: Nanophotonics I

Time: Friday 11:00–13:00 Location: HS I PI

Q 70.1 Fri 11:00 HS I PI

Exciton-Phonon Interactions at hBN/Perovskites Interfaces — •Sara Darbari[1,2], Masoud Taleb[1], Leon Multerer[1], Yaser Abdi[1], and Nahid Talebi[1] — [1]Institute for Experimental and Applied Physics, Christian Albrechts University in Kiel, Kiel, Germany — [2]Electrical and Computer Engineering Faculty, Tarbiat Modares University, Tehran, Iran

2D perovskites have attracted significant interests due to their optical properties, especially high exciton binding energies at the room temperature. Despite higher stability in comparison with their 3D counterparts, 2D perovskites still suffer from photo-induced degradation that can be diminished by encapsulating them with other 2D materials like hexagonal boron nitride (hBN). hBN is a widegap and stable material, which is promising for quantum technologies owing to multiple classes of phonon-assisted quantum emitting defects. Here, we have transferred hBN on top of 2D Ruddlesden-Popper perovskite (RPP) flakes ((BA)2PbI4 with n=1), and investigated the hBN/RPP heterostructure by cathodoluminescence spectroscopy. Our results prove not only significantly retarded e-beam induced degradation of RPPs, but also an enhancement in the luminescent behavior at the excitonic wavelength of RPP and phonon sidebands. Furthermore, the excitonic peak bandwidth is reduced, coincident with a slight red shift. This sharp excitonic luminescent peak of hBN/RPP is detectable, when we excite the extruded parts of hBN, even micrometers away from the RPP edge. The observed behaviors are attributed to hBN phonons coupling to perovskite excitons in their heterostructure.

Q 70.2 Fri 11:15 HS I PI

Electron Beam Shaping with Ultrafast Plasmonic Rotors — •Fatemeh Chahshouri[1] and Nahid Talebi[1,2] — [1]Institute of Experimental and Applied Physics, Kiel University, 24098 Kiel, Germany — [2]Kiel, Nano, Surface, and Interface Science KiNSIS, Kiel University, 24098 Kiel, Germany

Recent advances in coherent quantum interactions between free-electron pulses and ultrafast laser-induced near-field oscillations have unlocked exciting possibilities for manipulating the electron wavepackets. In this study, we investigate the interaction between a slow electron beam and the rotating dipolar plasmon fields of a gold nanorod. By precisely controlling the phase offset between two orthogonal laser pulses with perpendicular polarizations, we generate plasmonic fields in the nanorod circulating in clockwise or counterclockwise directions. Our findings demonstrate that the rotational direction of these plasmons plays a critical role in modulating electron dynamics in both real and reciprocal space, significantly influencing its longitudinal and transverse recoil. Additionally, by synchronizing the interaction time of the electron wavepacket with these directional plasmonic oscillations, we observe alterations in the probability amplitude of the electron angular momentum. This strong directional dependence highlights the potential of rotating plasmons as a powerful tool for shaping electron wavepackets. These findings pave the way for advancements in ultrafast electron microscopy and spectroscopy, enabling coherent control of slow electron beams and contributing to the development of quantum information processing technologies.

Q 70.3 Fri 11:30 HS I PI

A high-throughput characterisation setup for colour centres in SiC — •Jonah Heiler[1,2], Flavie D. Marquis[1,2], Leonard K.S. Zimmermann[1,2], Sushree Swateeprajnya Behera[1,2], Nien-Hsuan Lee[1,2], Stephan Kucera[1], Jonathan Körber[3], Raphael Wörnle[3], Jörg Wrachtrup[3], and Florian Kaiser[1,2] — [1]Smart Materials Unit, Luxembourg Institute of Science and Technology, Belval, Luxembourg — [2]Department of Physics and Materials Science, University of Luxembourg, Belvaux, Luxembourg — [3]3rd Institute of Physics, University of Stuttgart, Stuttgart, Germany

Optically active spins in solids, so-called colour centres, build a promising quantum technology platform, in parts due to their inherent spin-photon interface. Silicon carbide emerged as a popular host for colour centres due to its wafer-scale availability and its developed manufacturing processes. An ongoing challenge in the field, the low efficiency of the spin-photon interface, can be overcome using nanophotonic structuring. However, this process often leads to a degradation of the optical properties since it increases the susceptibility to surface charge noise. The conventional method to investigate these effects, confocal microscopy, by design, can only investigate a single emitter at a time. We report on the development of a widefield cryogenic microscope setup that allows for an investigation of 100–1000 colour centres in silicon carbide simultaneously. In our first investigation, we investigate divacancies in nanopillars, fabricated using a combination of e-beam lithography, ion implantation, and reactive ion etching.

Q 70.4 Fri 11:45 HS I PI

Skyrmion Bag Robustness in Plasmonic Bilayer and Trilayer Moiré Superlattices — •Julian Schwab[1], Florian Mangold[1], Bettina Frank[1], Timothy J. Davis[1,2], and Harald Giessen[1] — [1]4th Physics Institute, Research Center SCoPE, and Integrated Quantum Science and Technology Center, University of Stuttgart, Germany — [2]School of Physics, University of Melbourne; Parkville Victoria 3010, Australia

Twistronics is studied intensively in twisted 2D heterostructures and its extension to trilayer moiré structures has proven beneficial for the tunability of unconventional correlated states and superconductivity in twisted trilayer graphene. Just recently, the concept of twistronics has been applied to plasmonic lattices with nontrivial topology, demonstrating that bilayer moiré skyrmion lattices harbor multi-skyrmion textures called skyrmion bags. Here, we explore the properties of plasmonic trilayer moiré superlattices that are created by the interference of three twisted skyrmion lattices. More specifically, we explore the properties of periodic superlattices and their topological invariants. We also demonstrate that twisted trilayer skyrmion lattices harbor the same skyrmion bags as twisted bilayer skyrmion lattices. We quantify the robustness of these skyrmion bags by the stability of their topological numbers against certain disturbance fields that leads to experimental designs for topological textures with maximum robustness.

Q 70.5 Fri 12:00 HS I PI

On the Development a Room-Temperature Quantum Register based on Modified Divacancies in 4H-SiC in Luxembourg — •Flavie D. Marquis[1,2], Jonah Heiler[1,2], Leonard Zimmermann[1,2], Raphael Wörnle[3], Jörg Wrachtrup[3], Stephan Kucera[1], and Florian Kaiser[1,2] — [1]MRT Department, Luxembourg Institute of Science and Technology (LIST), Belvaux, Luxembourg — [2]University of Luxembourg, 4365 Esch-sur-Alzette, Luxembourg — [3]3rd Institute of Physics, University of Stuttgart, Stuttgart, Germany

Recent studies on the nature of modified divacancies in 4H silicon carbide (notably the PL6) have shown their remarkable stability under ambient conditions as well as readout contrast and count rates comparable to the nitrogen vacancy in diamond. Next steps towards quantum applications must now address the coherent control of nuclear spin qubit registers. Here, I will present the first steps towards the implementation of a few-qubit register at room-temperature. I will introduce different measurement methods based on pulsed EPR to brush a portrait of the spin-optical properties and capabilities of the divacancy-nuclear spin system. Technical realization of electron and nuclear spin control is also discussed. With this system, we strive to demonstrate small quantum algorithms, such as Grover and Deutsch-Josza.

Q 70.6 Fri 12:15 HS I PI

Plasmonic colors made easy: how ultra-thin metal films make bright colors — •Manuel Gonçalves — Ulm University - Inst. of Experimental Physics

Several different methods of plasmonic color generation have been demonstrated: nanostructured metal surfaces, metasurfaces based on particles and gratings, arrays of nanoparticles on a mirror, laser modification of deposited thin films. These methods are usually based on percolated films, with optical properties similar to those of bulk. However, when films of gold and silver of only few nanometers of average thickness are deposited on top of a mirror, vivid colors arise. The colors are only dependent on thickness of the spacer. Moreover, it was found that quantum-mechanical effects arise in the photoluminescence of crystalline gold UTMFs and they are advantageous in hot carrier generation and in nonlinear optics. A comparison between the optical properties of crystalline and polycrystalline UTMFs is provided.

Q 70.7 Fri 12:30 HS I PI

Active Physics-Informed Deep Learning: Surrogate Modeling for Non-Planar Wavefront Excitation of Topological Nanophotonic Devices — •Fatemeh Davoodi — Institute for Experimental and Applied Physics, Kiel, Germany

Topological plasmonics provides innovative ways to manipulate light by combining principles of topology and plasmonics, akin to topological edge states in photonics. However, designing such states is challenging due to the complexity of the high-dimensional design space. In this work, we introduce a supervised, physics-informed deep learning framework combined with surrogate modeling to design topological devices for specific wavelengths. By embedding physical constraints into the neural network training process, our model efficiently navigates the design space, significantly reducing simulation time and computational cost.

Additionally, we incorporate non-planar wavefront excitations to probe topologically protected plasmonic modes, introducing nonlinearity into the design and training process. Using this approach, we successfully design a topological device featuring unidirectional edge modes in a ring resonator operating at specific frequencies. This method demonstrates the effectiveness of integrating machine learning with advanced physical modeling for photonic device innovation, achieving high accuracy while optimizing computational efficiency.

Q 70.8 Fri 12:45 HS I PI

Luminescence thermometry based on photon emitters in nanophotonic silicon waveguides — Kilian Sandholzer[1,2], Stephan Rinner[1,2], Justus Edelmann[1,2], •Nilesh Goel[1,2], and Andreas Reiserer[1,2] — [1]Technical University of Munich, TUM School of Natural Sciences, 85748 Garching, Germany — [2]Munich Center for Quantum Science and Technology (MCQST), 85748 Garching, Germany

The reliable measurement and accurate control of the temperature within nanophotonic devices is a crucial prerequisite for their application in classical and quantum technologies. Established approaches use sensors attached to the components, which offer a limited spatial resolution and thus impede the measurement of local heating effects. We study an alternative temperature sensing technique based on measuring the luminescence of erbium emitters directly integrated into nanophotonic silicon waveguides. To cover the entire temperature range from 295 K to 2 K, we investigate two approaches: The thermal activation of non-radiative decay channels for temperatures above 200 K and the thermal depopulation of spin- and crystal-field levels at lower temperatures. The achieved sensitivity is 0.22(4) %/K at room temperature and increases up to 420(50) %/K at approximately 2 K. Combining this with spatially selective implantation promises precise thermometry from ambient to cryogenic temperatures with a spatial resolution down to a few nanometers.