DS 2: 2D Materials and their Heterostructures II: h-BN and WSe_2

Time: Monday 11:30–12:45 Location: SCH A 316

DS 2.1 Mon 11:30 SCH A 316

Engineering of exciton g-factors in van der Waals structures — •Tomasz Woźniak[1], Paulo Faria Junior[2], Andrey Chaves[3], Umm-e-hani Asghar[4], and Agnieszka Kuc[5] — [1]Wrocław University of Science and Technology, Poland — [2]Universitaet Regensburg, Germany — [3]Universidade Federal do Ceará, Brazil — [4]Jacobs Universitaet Bremen, Germany — [5]Helmholtz-Zentrum Dresden-Rossendorf, Germany

We develop a fully ab-initio based calculation scheme for excitonic g-factors, which describe their energy dependence on external magnetic field, and apply it to 1L TMDs and $MoSe_2/WSe_2$ heterobilayers, obtaining excellent agreement with experiments [1]. We identify a series of magneto-PL peaks in 1L WS_2 based on the calculated g-factors of excitons, trions and biexcitons, as well as phonon replicas of the dark trion [2]. We explain the reduction of g-factor measured in $MoSe_2/WS_2$ by the spatial confinement of the intralayer moiré exciton [3]. We find a significant strain dependence of excitonic g-factors and dipole strengths in 1L TMDs. It allows to explain the strain-induced hybridization of direct and indirect excitons in WS_2 [4,5]. We investigate a new class of hexagonal materials with formula MSi_2Z_4 (M: Mo, W; Z: N, P, As, Sb), which are isosymmetric to 1L TMDs. We find a new set of circularly polarized excitonic transitions with high binding energies and large positive g-factors [6].

[1] Phys. Rev. B 101, 235408 (2020) [2] Nano Lett. 21, 2519 (2021) [3] Nano Lett. 21, 8641 (2022) [4] Phys. Rev. Lett. 129, 067402 (2022) [5] New J. Phys. 24, 083004 (2022) [6] arXiv:2210.10679 (2022)

DS 2.2 Mon 11:45 SCH A 316

Phase-locked photon-electron interaction without a laser applied to 2D Materials — •Nahid Talebi[1], Masoud Taleb[1], Mario Hentschel[2], Kai Rossnagel[1], and Harald Giessen[2] — [1]Institute for Experimental and Applied Physics, Kiel University, 24118 Kiel, Germany — [2]4th Physics Institute and Research Center SCoPE, University of Stuttgart, 70569 Stuttgart, Germany

Ultrafast electron-photon spectroscopy in electron microscopes commonly requires ultrafast laser setups. Photoemission from an engineered electron source is used to generate pulsed electrons, interacting with a sample that is excited by the ultrafast laser pulse at a specified time delay. Here, we present an inverse approach based on cathodoluminescence spectroscopy to introduce internal radiation sources in an electron microscope. Our method is based on a sequential interaction of the electron beam with an electron-driven photon source (EDPHS) and the investigated sample. An electron-driven photon source in an electron microscope generates phase-locked photons that are mutually coherent with the near-field distribution of the swift electron. We demonstrate the mutual coherence between the radiations from the EDPHS and the sample by performing interferometry with a combined system of an EDPHS and a WSe2 flake. Our method has the advantage of being simple, compact and operating with continuous electron beams. It will open the door to local electron-photon correlation spectroscopy of quantum materials, single photon systems, and coherent exciton-polaritonic samples with nanometric resolution.

DS 2.3 Mon 12:00 SCH A 316

Phase-locked photon-electron interaction without a laser applied to 2D Materials — •Nahid Talebi — Institute for Experimental and Applied Physics, Kiel University, 24118 Kiel, Germany

Ultrafast electron-photon spectroscopy in electron microscopes commonly requires ultrafast laser setups. Photoemission from an engineered electron source is used to generate pulsed electrons, interacting with a sample that is excited by the ultrafast laser pulse at a specified time delay. Thus, developing an ultrafast electron microscope demands the exploitation of extrinsic laser excitations and complex synchronization schemes. Here, we present an inverse approach based on cathodoluminescence spectroscopy to introduce internal radiation sources in an electron microscope. Our method is based on a sequential interaction of the electron beam with an electron-driven photon source (EDPHS) and the investigated sample. An electron-driven photon source in an electron microscope generates phase-locked photons that are mutually coherent with the near-field distribution of the swift electron. We demonstrate the mutual coherence between the radiations from the EDPHS and the sample by performing interferometry with a combined system of an EDPHS and a WSe2 flake. Our method has the advantage of being simple, compact and operating with continuous electron beams. It will open the door to local electron-photon correlation spectroscopy of quantum materials, single photon systems, and coherent exciton-polaritonic samples with nanometric resolution.

DS 2.4 Mon 12:15 SCH A 316

Mobile interlayer excitons at the Mott transition in Moiré-free heterostructures — •Edith Wietek[1], Mikhail M. Glazov[2], Matthias Florian[3], Takashi Taniguchi[4], Kenji Watanabe[4], Alexander Steinhoff[5], and Alexey Chernikov[1] — [1]Technische Universität Dresden — [2]Sankt Petersburg — [3]University of Michigan — [4]NIMS, Ibaraki — [5]Universität Bremen

Vertically stacked heterostructures of transition metal dichalcogenides present an exciting platform to study electronic and excitonic many-particle states. In this study we investigate propagation of excitons in these systems from low to very high densities to disentangle the effects of dipolar excitons from those stemming from moiré effects. We take advantage of hBN-encapsulated WSe2/MoSe2 heterostructures studied in the moiré-free limit of large, atomically reconstructed domains. Using ultrafast microscopy, we show that the interlayer excitons propagate freely even at cryogenic temperatures and low densities. At elevated exciton densities, we demonstrate that in addition to broadly assumed exciton-exciton repulsion, the non-linear increase of the diffusion coefficient also originates from efficient exciton-exciton annihilation. Remarkably, at the exciton ionization threshold of the Mott transition and beyond, we reveal a highly unusual regime of negative effective diffusion that persist for many 100's of ps after the excitation. This observation presents a particularly interesting case of non-equilibrium phenomena in composite many-particle systems, highlighting the rich physics of optical excitations in van der Waals heterostructures.

DS 2.5 Mon 12:30 SCH A 316

Atomic structures of single photon emitters in hexagonal boron nitride — •Tjorben Matthes[1], Anand Kumar[1], Chanaprom Cholsuk[1], and Tobias Vogl[1,2] — [1]Institute of Applied Physics, Friedrich-Schiller-University Jena, Albert-Einstein-Straße 15, 07745 Jena — [2]Fraunhofer-Institute for Applied Optics and Precision Engineering IOF, Albert-Einstein-Str. 7, 07745 Jena

Single photon emitters in solid-state crystals have received a lot of attention as building blocks for numerous quantum technology applications. Fluorescent defects in hexagonal boron nitride (hBN) stand out due to their high luminosity and robust operation at room temperature. The fabrication of identical emitters at pre-defined sites is still challenging, which hampers the integration of these defects in optical systems and electro-optical devices. Additionally, the atomic structure of many defects remain unclear or are subject to ambiguous guess-work. Here, we show an analysis on the atomic structures of defects we created by electron beam irradiation using a standard scanning electron microscope with deep sub-micron lateral precision. The emitters are created with a high yield and a reproducible spectrum peaking at 575 nm. We also present results on correlating crystal structure properties and polarization dynamics. Our results indicate that these emitters that all emitters are identical, which is a crucial advantage for the realization of quantum integrated devices, as well as for the identification of these fluorescent defects.