HL 29: Poster II

The second poster session on the physics of semiconductors covers topics from 2D semiconductors and van der Waals heterostructures, the physics of the van der Waals magnetic semiconductor CrSBr, materials and devices for quantum technology, quantum dots and wires, transport properties, to ultrafast phenomena in semiconductors.

Time: Tuesday 18:00–20:00 Location: P1

HL 29.1 Tue 18:00 P1

Electrical Field Effect and Schottky Barriers in $FePSe_3$ Thin Films — •Paul Perl[1], Lars Thole[1], Sonja Locmelis[2], and Rolf J. Haug[1] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover, 30167 Hannover, Germany — [2]Institut für Anorganische Chemie, Leibniz Universität Hannover, 30167 Hannover, Germany

Transition metal selenophosphates (MTPs) are a group of promising 2D materials for applications like transistors and photodetectors [1,2]. Among MTPs, iron selenophosphate ($FePSe_3$) has one of the lowest band gap energies at 1.3 eV [2]. The goal of this work is to examine the influence of the electric field effect on electrical transport and to study the Schottky barriers formed at metal contacts. Moreover, the temperature dependence of the investigated effects is analyzed.

In order to investigate the electrical properties of $FePSe_3$ in thin films below 30 nm, layers are mechanically exfoliated onto a Si/SiO_2 substrate. Electrical contacts for the exfoliated flakes are fabricated via electron beam lithography and physical vapor deposition. $FePSe_3$ exhibits a hysteresis in its transport characteristics when the applied backgate voltage is altered, indicating favorable characteristics for memory devices. Furthermore, differences in Schottky barriers for various contact material compositions become apparent, showing their influence on electric transport properties.

[1] T. Xu et al., Advanced Electronic Materials, 7, 2100207 (2021)
[2] M. A. Susner et al., Advanced Materials, 29, 1602852 (2017)

HL 29.2 Tue 18:00 P1

Fabricating MoS_2 nanotube quantum dots on 2D heterostructures — •Korbinian Fink[1], Robin T. K. Schock[1], Stefan B. Obloh[1], Matthias Kronseder[1], Matjaž Malok[2], Maja Remškar[2], and Andreas K. Hüttel[1] — [1]Institute for Experimental and Applied Physics, Universität Regensburg, Regensburg — [2]Solid State Physics Department, Jožef Stefan Institute, Ljubljana, Slovenia

MoS_2, a transitional metal dichalcogenide (TMDC) with interesting optical and electronic properties, e.g., broken inversion symmetry and strong spin-orbit coupling leading to spin split bands, is at the center of manifold research efforts. Building a MoS_2 based QD remains challenging: the spatial quantization depends on the effective electron mass, which is high in MoS_2, and minuscule devices sizes are required.

In order to reduce the lithographic constraints we utilize nanotubes, as these confine charges in an additional dimension. However, these QDs are still limited by the disorder from the SiO_2 surface. This can be resolved by fabricating the devices on top of 2D heterostacks consisting of hBN and few layer graphite.[1]

The major challenge for creating such devices is reproducible contacts to the nanotubes, as nanogaps between the contact on the chip and the metal on top of the tube lead to high resistance variations. This can be solved by variation of the incident angle and heating during metalisation as well as fixing the tubes on the chip by cross linked resist. - [1] R. T. K. Schock et al., PSSb, 2400366 (2024)

HL 29.3 Tue 18:00 P1

Preparation of folded graphene heterostructures via dry transfer — •Hannes Kakuschke[1], Dustin Wittbrodt[2], Lina Bockhorn[1], and Rolf Haug[1] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover, 30167 Hannover, Germany — [2]Physikalisch-Technische Bundesanstalt, 38116 Braunschweig, Germany

Mono- and bilayer systems of graphene have been extensively researched due to their unique magnetic and electronic transport properties. In more recent work, folded graphene [1, 2] heterostructures exhibit fascinating phenomena. This is due to the topology of the folded region, causing effects such as snake states and zero line modes. However, in transport measurements of self-assembled, folded graphene [3], multiple effects occur simultaneously. This drastically complicates the analysis of individual contributions. To solve this problem, we use the dry transfer method to fold graphene around hBN, decoupling the overlapping graphene regions.

To simulate the behaviour of such samples, Tight-Binding model calculations [4], considering strain effects [5] at the folded edge have been carried out.

[1] J. C. Rode et al., Ann. Phys. 529, 1700025 (2017).
[2] J. C. Rode et al., 2D Mater. 6, 015021 (2018).
[3] L. Bockhorn et al., Appl. Phys. Lett. 118, 173101 (2021).
[4] M. Koshino & T. Ando, Solid State Commun. 149, 1123-1127 (2009).
[5] A. R. Botello-Méndez et al., JPC C. 122 (27), 15753-15760 (2018).

HL 29.4 Tue 18:00 P1

Ferroelectric Potential Investigations of 3R MoS_2 through fast Optical Measurements — •Jan-Niklas Heidkamp[1], Swarup Deb[1,2], Takashi Taniguchi[3], Kenji Watanabe[3], Rico Schwartz[1], and Tobias Korn[1] — [1]Institute of Physics, University of Rostock, Rostock, Germany — [2]Saha Institute of Nuclear Physics, Kolkata, India — [3]National Institute for Material Science, Tsukuba, Japan

In recent years, sliding ferroelectricity has emerged as a topic of significant interest due to its possible application in nonvolatile random-access memory. This phenomenon is unique to two-dimensional van der Waals materials, where vertical polarization switching is induced by in-plane sliding of the constituent layers. The resulting polarization is influenced by the intrinsic stacking order, creating distinct polarization regions separated by domain walls. These regions, along with the domain walls, can be manipulated using an external vertical electric field, enabling a switchable system that retains the environmental robustness of van der Waals materials under ambient conditions.

In this study, we investigate 3R-MoS_2 using various optical measurement techniques at room temperature. The spatially resolved measurements reveal clear signal changes corresponding to different ferroelectric stacking orders and variations in layer count. Our findings demonstrate that fast optical mapping at room temperature is a reliable method for probing ferroelectric potential steps in 3R-stacked samples. This approach does not require a conductive substrate or backing, making it more versatile than traditional Kelvin Probe Force Microscopy (KPFM) techniques.

HL 29.5 Tue 18:00 P1

Probing TMD-nanowire hybrid structures with second harmonic generation. — •Benedikt Mathes, Maximilian Tomoscheit, Edwin Eobaldt, Alexander Zaunick, Carsten Ronning, and Giancarlo Soavi — Institut of Solid State Physics, University of Jena

Hybrid nanostructures have been drawing attention in fundamental science, since they allow to control and engineer the electronic and optical properties of samples. Transition metal dichalcogenide(TMD)-nanowire(NW) hybrid structures could have interesting applications beyond fundamental science, since they allow to tune the lasing properties of NW lasers. To understand the photo-physical response of the hybrid system, it is helpful to measure the optical and electronic response of each of its individual constituent. However, this is in general difficult to achieve. In this work, we solve this problem by showing that polarization-dependent second harmonic generation(SHG) can selectively probe each constituent of a WSe_2-ZnO NW hybrid, provided that the subsystems are properly and deterministically aligned. TMDs exhibit a threefold symmetry with two main axes, armchair(AC) and zigzag(ZZ). When excited along the ZZ axis, the SH is emitted along the AC axis, whereas the SH of the NW is always emitted parallel to its long axis. Hence, by aligning the NW along the ZZ axis one can differentiate the emission from NW and TMD with a polarizer in detection aligned along the ZZ or AC axis, respectively. This way, the subsystems of the hybrid structure can be investigated individually, offering new insights into their contribution to the hybrid system.

HL 29.6 Tue 18:00 P1

Raman and photoluminescence spectroscopy on differently

synthesised $MoSe_2$ — •Lara Blinov[1], Hendrik Lambers[1], Zdeněk Sofer[2], and Ursula Wurstbauer[1] — [1]Institute of Physics, University of Münster, Münster, Germany — [2]Department of Inorganic Chemistry, University of Chemistry and Technology Prague, Prague, Czech Republic

There are various synthesis methods for the widely researched transition metal dichalcogenides (TMDCs). We examine optical responses of $MoSe_2$ synthesised by chemical vapor transport (CVT) with different halogen contributions in the transport gas. Therefore, mono- and bilayers of those differently grown parental crystals are mechanically exfoliated and investigated by Raman and photoluminescence (PL) spectroscopy at room temperature as well as in temperature-dependent PL measurements.

We analyse and compare the energies and intensities corresponding to the neutral A and B excitons as well as a prominent A^- trion in the PL spectra and the frequency of the first order Raman modes. We conclude that the CVT synthesised crystals seem to have an inhomogeneous distribution of charge carrier densities or defects and that the defect density seems to be larger than in conventionally synthesised $MoSe_2$.

HL 29.7 Tue 18:00 P1

Optical Properties of Janus Transition Metal Dichalcogenides

— •Sai Shradha[1], Julian Picker[2], Nicole Engel[1], Lukas Krelle[1], Daria Markina[1], Roberto Rosati[3], Ermin Malic[3], Andrey Turchanin[2], and Bernhard Urbaszek[1] — [1]Institute for Condensed Matter Physics, TU Darmstadt, Darmstadt, Germany — [2]Institute for Physical Chemistry, Friedrich Schiller University, Jena, Germany — [3]Department of Physics, Philipps-Universität Marburg, Marburg, Germany

Janus transition metal dichalcogenides (JTMDs) have a crystal structure of X-M-Y where X and Y are chalcogens and M is a transition metal. Their asymmetric structure, with chalcogen atoms of different electronegativity above and below the transition metal, leads to an intrinsic out-of-plane electric dipole. This out-of-plane symmetry breaking in JTMDs causes Rashba splitting, vertical piezoelectricity and enhanced exciton-phonon coupling. Due to a reduced overlap of the electron and hole wave functions, excitons in JTMDs are predicted to have lower binding energies and longer lifetimes. This makes them promising candidates for photovoltaic devices. Via chemical vapour deposition (CVD), high-quality Janus monolayers have been synthesised [1]. This work investigates the optical properties of CVD-grown monolayer Janus MoSSe and WSSe. Photoluminescence, Raman and differential reflectivity spectroscopy performed at room temperature and 4K are used as the key techniques to identify and further analyse excitons and exciton-phonon coupling in such systems.

[1] Z. Gan et. al., Adv. Mater., 34, 2205226 (2022)

HL 29.8 Tue 18:00 P1

Microscopic, Optical, and Electrical Characterization of Spray-Coated Graphene Dispersions on Sapphire Substrates

— •Yasaman Jarrahi Zadeh[1], Lars Grebener[2], Muhammad Ali[3], Felix Schaumburg[1], Mohaned Hammad[2], Günther Prinz[1], Martin Geller[1], Hartmut Wiggers[3], Doris Segets[2], and Axel Lorke[1] — [1]Faculty of Physics, and CENIDE, University of Duisburg-Essen, Germany — [2]Institute for Energy and Materials Processes, and CENIDE, University of Duisburg-Essen, Germany — [3]Institute for Combustion and Gas Dynamics, and CENIDE, University of Duisburg-Essen, Germany

Processing graphene into thin films is crucial for its potential in cutting-edge applications. Here, we report on different characterization techniques to analyze the dispersion and coating performance of spray-coated graphene films on sapphire substrates. The deposited films were characterized using optical and scanning electron microscopy to evaluate coating morphology. Raman Spectroscopy and electrical characterization were used to assess the structural integrity and functional performance of the constituent graphene sheets. The deposited films fabricated from graphene sheets dispersed in water with carboxymethyl cellulose (CMC) exhibited uniform surface morphology compared to deposition with ethanol dispersion. Raman spectroscopy and electrical characterization confirmed the quality and structural integrity of the water-CMC dispersion. This study highlights key process-structure relationships for optimizing dry-synthesized graphene films for advanced technologies.

HL 29.9 Tue 18:00 P1

Vibrational fingerprint of 2D transition-metal dichalcogenide WSe_2

— •Kanivar Türk, Bastian Thomssen, Gerhard Berth, and Klaus Jöns — PhoQS Institute, CeOPP and Department of Physics, Paderborn University, Paderborn, Germany

Thin-layered transition-metal dichalcogenides (TMDC) are on high demand in the material science community [1]. The advantages of monolayer configurations of these TMDCs include the transition from indirect to direct band gap, which leads to way superior properties when compared to bulk, like optical, electrical, magnetic, thermal and mechanical improvements [2].

In this work, exfoliated 2D flakes of WSe_2 have been produced and analysed in terms of their vibrational properties via Raman spectroscopy. Beside a comprehensive phonon mode assignment, a layer number specific analysis has been performed and compared to results from photoluminescence measurements.

[1] Saju Joseph et al.; Materials Chemistry and Physics 297: A review of the synthesis, properties, and applications of 2D transition metal dichalcogenides and their heterostructures (2023)

[2] Mingxiao Ye et al.; Photonics, 2: Recent Advancement on the Optical Properties of Two-Dimensional Molybdenum Disulfide (MoS_2) Thin Films (2015)

HL 29.10 Tue 18:00 P1

Tuning of excitonic emission of 2D-TMDs by hybridization with phase change materials

— •Jakob Cornelius Wurschi, Martin Hafermann, Edwin Eobaldt, and Carsten Ronning — Institut für Festkörperphysik FSU Jena

Transition metal dichalcogenides (TMDs) are a subject of growing interest, given their wide range of potential applications, such as transistors or biosensors. Especially in the context of optoelectronic devices a precise tuning of the emission behaviour can be a powerful tool for the realisation of advanced technologies. To gain insight into potential tuning mechanisms of the excitonic emission of TMD monolayers, we investigate the hybridization of 2D MoS_2 and WS_2 flakes with germanium-antimony-telluride (GST). This compound system is capable of undergoing a phase transition between an amorphous and two crystalline states accompanied with drastic changes in the electrical and optical properties. Thermal heating triggers the phase transitions of GST, which we monitor by measuring the reflectivity of the GST thin films on silicon. After 2D-TMD flake exfoliation, in-situ measurements of the TMD photoluminescence spectra were obtained during or after the phase transitions of the GST substrate. With our approach, we observe a significant spectral shift of the excitonic emission of MoS_2 on GST/Si by precisely tuning the phase of the underlying GST. Further, for WS_2 flakes on gold substrates we observed a GST layer thickness dependent spectral shift for the excitonic emission of WS_2.

HL 29.11 Tue 18:00 P1

Gate defined exciton confinement in $MoSe^2$.

— •Moritz Scharfstädt[1], Abdul R. Kanikode[1], Lasse Ebeling[2], Max Wegerhoff[1], Michael Köhl[1], Stefan Linden[1], Bernd Beschoten[2], Christoph Stampfer[2], Lutz Waldecker[2], and Andrea Bergschneider[1] — [1]Physikalisches Institut, Universität Bonn, 53115 Bonn, Germany — [2]II. Physikalisches Institut, RWTH Aachen University, 52074 Aachen, Germany

Excitons in transition metal dichalcogenides (TMDs) are ideal candidates for strong light-matter interactions due to their high oscillator strength. This has been demonstrated in numerous experiments where 2D semiconductors were embedded in photonic cavities. However, these systems lack strong nonlinearity, necessitating further efforts to realize applications such as single-photon sources. One possible approach could be the spacial confinement of excitons using an in-plane inhomogeneous electric field, as first demonstrated by [1].

We present measurements on a similar system that achieves 1D confinement of excitons along the edge of a few-layer graphene gate. While the excitons are polarized perpendicular to the edge, we observe two orthogonal linear polarization axes of the confined states. This raises questions about the selection rules in such a system.

Furthermore, we show our approach to shape the confinement into a 0D configuration to enhance exciton-exciton interactions and, presumably, the system's nonlinearity.

HL 29.12 Tue 18:00 P1

PROBING INTERLAYER EXCITONS IN PARALLEL STACKED FERROELECTRIC MOS2

— •Johannes Krause[1],

Jan-Niklas Heidkamp[1], Swarup Deb[3], Kenji Watanabe[2], Takashi Taniguchi[2], Rico Schwartz[1], and Tobias Korn[1] — [1]University of Rostock, Insitute of Physics, Germany — [2]International Center for Materials Nanoarchitectonics, National Institute for MAterials Science, Tsukuba — [3]Saha Institute of Nuclear Physics, Kolkata, India

2D Transtion Metal Dichalcogenides (TMDCs) garnered significant scientific interest, due to their unique optical properties. Interestingly, 3R-stacked TMDCs exhibit sliding ferroelectricity, which opens up new platforms for nanoelectronic and memory devices. Here, we investigate the photoluminescene (PL) associated with a 3R-stacked molybdenum disulfide homobilayer, particularly the signals attributed to the interlayer exciton. Additionally, electric fields are applied to control the characteristic properties of the stack. We employ mechanical exfoliation of bulk 3R-grown MoS2-crystals and the deterministic transfer technique to fabricate and transfer the homobilayers onto SiO2 wafers with pre-patterned electrical contacts. We utilize PL measurements to characterize the relevant optical signals. By applying gate voltages across the homobilayer, we explore the optical behavior of the homobilayer stack, enabling precise modulation of exciton properties by controlling charge carrier density and Stark effect.

HL 29.13 Tue 18:00 P1

Moiré superlattice effects in $MoSe_2$-WS_2 heterobilayers — •P. Parzefall[1], N. Paulik[1], M. Lorenz[1], C. Serati de Brito[1,2], J. Göser[3], J. Trapp[3], T. Taniguchi[4], K. Watanabe[4], A. Högele[3], Y. Galvão Gobato[2], and C. Schüller[1] — [1]Institut für Exp. und Angewandte Physik, Uni Regensburg (UR), Germany — [2]Physics Department, Federal University of São Carlos, Brazil — [3]Faculty of Physics, Munich Quantum Center and Center for NanoScience, LMU Munich, Germany — [4]NIMS, Tsukuba Ibaraki, Japan

We report about optical studies on type-I $MoSe_2$-WS_2 heterostructures at cryogenic temperatures. We confirm the influence of the moiré superlattice on excitonic features of angle aligned R- and H-type structures in photoluminescence spectroscopy. The moiré-exciton and moiré-trion features are further studied by resonant low-frequency Raman spectroscopy. Here, we tune a Ti:Sapphire laser into close resonance to the $MoSe_2$ intralayer excitonic transitions. We detect an efficient pumping of the moiré trion when exciting resonantly to the moiré exciton, as the binding energy is equivalent to a phonon energy.

In time-resolved measurements using a Streak camera, we measure the lifetimes of both H-type and R-type moiré-excitonic species. The detected short excitonic lifetimes in the R-type sample is indicative of a type-I band alignment and the longer moiré-exciton lifetimes in the H-type samples might be due to a hybridization in the conduction bands [1, 2]. [1] B. Polovnikov et al., Phys. Rev. Lett. 132, 076902 (2024), [2] Y. Galãvo Gobato et al., Nano Lett. 22, 8641 (2022)

HL 29.14 Tue 18:00 P1

Acousto-optic characterization of van der Waals systems — •Felix Ehring, Benjamin Mayer, Hubert Krenner, Ursula Wurstbauer, and Emeline Nysten — Institute of Physics, University of Münster, Germany

With wavelengths in the micrometer range at GHz frequencies, surface acoustic waves (SAWs) are a versatile tool for radio frequency control and probing of charge carrier dynamics in novel semiconductor nanostructures. They are generated on a piezoelectric chip and routed over long distances to couple either mechanically or electrically with almost any nanosystem [1]. In our experiments, we fabricated hybrid lithium niobate SAW-devices including SAW delay lines with design frequencies of 150-250MHz, on which different mechanically exfoliated transition metal dichalcogenide (TMDC) 2D materials can be placed. The dynamic strain and electric field of the SAW induce a band modulation in the TMDC structure. The focus of the experiments was the investigation of MoSe2-WSe2 heterostructures and their interlayer excitons. For the characterization, the influence of the SAW fields on the recombination time and energy was investigated. Since interlayer excitons provide a much longer lifetime than intralayer excitons, transport along the propagation direction of the wave should be possible and will be part of future experiments. [1] J. Phys. D:Appl. Phys. 52(35):353001 (2019)

HL 29.15 Tue 18:00 P1

Influence of interface dielectric disorder on interlayer excitons in mixed binary/ternary TMD heterostructures — •Mohammed Adel Aly[1,2], Emmanuel Oghenevo Enakerakpor[2], Hilary Masenda[2], and Martin Koch[2] — [1]Institute of Physics and Center for Nanotechnology, University of Münster, 48149 Münster, Germany — [2]Faculty of Physics and Materials Sciences Center, Philipps-Universität Marburg, 35032 Marburg, Germany

The unique properties of transition metal dichalcogenide (TMD) monolayers and their heterostructures offer exceptional tunability. In these heterostructures, interlayer excitonic emission can be tailored based on the selection of the monolayer materials. In this study, we fabricated heterostructures based on binary-ternary monolayers, which offer enhanced tunability of the interlayer exciton emission. To understand the physics behind the interlayer excitons and their photoluminescence linewidths, we measured the photoluminescence of excitons in two TMD heterostructures, MoSe2/Mo0.5W0.5Se2 and WSe2/Mo0.5W0.5Se2, at different temperatures ranging from 10 K - 300 K. Besides neutral excitons and trions, we found that the linewidths of interlayer excitons are significantly broadened due to dielectric disorder caused by the spatial inhomogeneity at the interfaces of the heterostructures. These are important for our understanding of the nature of the interlayer excitons and their tunability for future optoelectronic devices.

HL 29.16 Tue 18:00 P1

High-Pressure Optical Spectroscopy of Intralayer and Interlayer Excitons in 2H-MoS_2 Bilayers — •Vedhanth Senthiappan Vellaiappan Uthayasurian, Paul Steeger, Robert Schmidt, Steffen Michaelis de Vasconcellos, and Rudolf Bratschitsch — Institute of Physics and Center for Nanotechnology, University of Münster, 48149 Münster, Germany

Molybdenum disulfide (MoS_2) is a van der Waals material from the class of Transition Metal Dichalcogenides (TMDCs). In 2H-MoS_2 homo-bilayers, interlayer excitons, where the electron and hole are located in different layers, are observed with a large oscillator strength and distinct energy separation from intralayer excitons. We investigate these inter- and intralayer excitons in 2H-MoS_2 homo-bilayers under applied pressure using a diamond anvil cell [1]. Optical transmission spectra reveal that increasing pressure reduces the energy splitting between the A exciton and the interlayer exciton. Ab initio calculations, combined with our experimental observations, indicate that this behavior cannot be attributed to conventional hydrostatic compression. Instead, it results from the MoS_2 bilayer adhering to the diamond surface, which limits in-plane compression. Furthermore, we show that the unique real-space distributions and the associated contributions from the valence band are responsible for the differing pressure responses of the inter- and intralayer excitons in compressed MoS_2 bilayers. References : [1] P. Steeger et al, Nano Lett., 23, 8947 (2023)

HL 29.17 Tue 18:00 P1

Magneto-Optical Spectroscopy of van der Waals CrSBr — •Lukas Krelle[1], Ryan Tan Qai Shen[1], Daria Markina[1], Priyanka Mondal[1], Kseniia Mosina[2], Kevin Hagmann[1], Regine von Klitzing[1], Zdenek Sofer[2], and Bernhard Urbaszek[1] — [1]Institute for Condensed Matter Physics, TU Darmstadt, Hochschulstraße 6-8, D-64289 Darmstadt, Germany — [2]Department of Inorganic Chemistry, University of Chemistry and Technology Prague, Technicka 5, 166 28 Prague 6, Czech Republic

The layered antiferromagnet CrSBr is a promising Van der Waals material due to its quasi 1D nature and the strong coupling between excitons, phonons and magnons. In particular, the strong coupling of excitons to the magnetic order of the crystal opens new avenues for the study of correlated magnetic phases in optical spectroscopy. In this work, we perform magneto-optical spectroscopy on multilayer CrSBr. We use Photoluminescence and Reflectivity measurements to identify the different magnetic phases present in the sample. We report drastic changes of the emission and absorption depending on the magnetic phase of the material, which we control through the application of magnetic fields along specific directions.

HL 29.18 Tue 18:00 P1

Raman investigation of the 2D magnetic semiconductor $MnPS_3$ — •Thomas Kliewer[1], Pierre-Maurice Piel[1], Zdeněk Sofer[2], and Ursula Wurstbauer[1] — [1]Institute of Physics, University of Münster, Germany — [2]Department of Inorganic Chemistry, University of Chemistry and Technology Prague, Czech Republic

The van-der-Waals (vdW) material $MnPS_3$ is a member of the group of metal phosphorus trichalcogenides (MPX_3; X=S, Se) which experiences rising interest due to its rich physical, chemical and structural properties. $MnPS_3$ is a 2D magnetic semiconductor with an electronic bandgap of 2,79 eV[1]. Below the Néel-Temperature of 78 K, it exhibits an antiferromagnetic order within the layers and a ferromagnetic coupling between adjacent layers[2]. These properties are interesting for fundamental studies on magnetism in the 2D limit, the investigation of coupling between spin, lattice and charge degrees of freedom and for possible applications in spintronics. $MnPS_3$ flakes of various thicknesses have been studied by temperature dependent Raman spectroscopy to uncover the coupling of lattice and spin degree of freedom. The Raman-spectra of $MnPS_3$ show several phonon modes in accordance with the crystal structure. The intensity of the modes varies with the thickness of the crystal. Besides the expected hardening of the modes, the temperature-dependent measurements imply possible influence of the magnetic ordering on the observed modes. [1] Grasso et al. Physical Review B 44.20 (1991), p. 11060 [2] Wildes et al. Journal of Physics: Condensed Matter 6.24 (1994), p. L335

HL 29.19 Tue 18:00 P1

Polarisation dependant reflectance measurements of CrSBr — •Manuel Terbeck, Aleksandra Lopion, Pierre-Maurice Piel, and Ursula Wurstbauer — Institute of Physics, University of Muenster, Germany

The van der Waals layered material CrSBr has multiple interesting characteristics. It is an air-stable, optically active magnetic semiconductor. Magnetically, CrSBr exhibits ferromagnetic ordering in-plane and antiferromagnetic ordering between adjacent layers, with the easy axis being in-plane [1]. In this material the coupling between magnetic and optical properties is strong allowing us to study magnetic properties by measuring interband emissions and absorption spectra. The electronic structure is often described as quasi-1D due to the highly anisotropic properties [1]. Thus the polarisation of light is important when measuring CrSBr optically. With Raman scattering, we checked the symmetry of the crystal. Considering those axes, we measured reflectance from thin CrSBr flakes using different polarisation of light to get information about the excitonic states in this material. Unlike emission, reflectance measurements enables additional access to higher electronic states. [1] J. Klein, et al. ACS Nano, 17, 5316-5328 (2023)

HL 29.20 Tue 18:00 P1

Semiconductor-Metal Interfaces in 2D TMDCs for High-Efficiency Optoelectronic Devices — •Linus Schneider[1], Ariane Ufer[1], Elena Vinnemeier[1], Rebecca Saive[2], and Ursula Wurstbauer[1] — [1]Institute of Physics, University of Münster, Münster, Germany — [2]MESA+ Institute for Nanotechnology University of Twente, Enschede, Netherlands

Efficient solar energy conversion requires new materials and technologies that enhance solar cell performance while minimizing material usage. Two-dimensional (2D) materials, specifically transition metal dichalcogenides (TMDCs) like molybdenum disulfide (MoS_2), exhibit strong exciton-mediated light-matter interactions, making them ideal for optoelectronic devices and solar energy conversion. A critical challenge for implementation is effective charge carrier extraction at the metal-semiconductor interface. We prepare TMDC flakes using mechanical exfoliation and fabricate semiconductor-metal junctions by transferring these layers onto metallic contacts using a dry viscoelastic stamping technique. The structural and optical properties of these samples are characterized using photoluminescence (PL) and Raman spectroscopy. The charge transfer behavior at the 2D semiconductor-metal interface is probed by localized laser beam-induced current measurements and the local potential change across the junction regions by kelvin probe force microscopy (KPFM).

HL 29.21 Tue 18:00 P1

Advancing 2D Materials for Optoelectronic and Photonic Devices: Insights from WSe_2 — •Bastian Thomssen, Ioannis Caltzidis, and Klaus D. Jöns — PhoQS Institute, CeOPP and Department of Physics, Paderborn University, Paderborn, Germany

Two-dimensional (2D) materials have garnered significant attention due to their unique structural, electronic, and optical properties, which make them ideal candidates for next-generation optoelectronic and photonic devices. [1] Transition metal dichalcogenides (TMDs), such as tungsten diselenide (WSe_2), exhibit remarkable characteristics: in monolayer form, WSe_2 transitions from an indirect to a direct bandgap semiconductor, enhancing light-matter interactions. This property positions WSe_2 as a promising material for applications in light-emitting diodes, lasers, and quantum emitters. [1] The layer-dependent properties of WSe_2, including the transition from an indirect to a direct bandgap, can be effectively characterized using photoluminescence measurements. These allow for precise determination of the layer number, providing valuable insights into the electronic and optical behavior of the material. Such measurements are essential for tailoring the material's properties for specific optoelectronic and photonic applications.

[1] Maja Groll et al. https://doi.org/10.1002/smll.202311635

HL 29.22 Tue 18:00 P1

Having a Good Vibe: Electron-Phonon Coupling in 1L-TMDCs Measured by Transient Absorption Spectroscopy — Tim Völzer[1,2], •Julian Schröer[1,2], Marvin Krupp[1,2], Annika Bergmann[1,2], Tobias Korn[1,2], and Stefan Lochbrunner[1,2] — [1]University of Rostock, Institute of Physics — [2]Department "Life, Light & Matter, University of Rostock

The optoelectronic properties of monolayer transition metal dichalcogenides (1L-TMDCs) are strongly determined by their electronic dynamics after light excitation. In this work, we present insights on the ultrafast dynamics of three different 1L-TMDCs by employing transient absorption (TA) spectroscopy. Our findings show that the basic processes after optical excitation can be divided into cooling of the electronic and phononic system and the subsequent recombination of the excited species. We reveal the importance of the differing coupling strengths to high- versus low-energy phonons. Due to the ultrashort pump pulse excitation, we are also able to trigger the displacive excitation of coherent phonons, which we assign to the A'_1 Raman mode of the system. Our results demonstrate the strong coupling between the electronic and phononic systems and lead to better understanding of excited state carrier dynamics in 1L-TMDC materials.

HL 29.23 Tue 18:00 P1

Probing time-reversal symmetry breaking in graphene — •Konrad Krieghoff[1], Nele Tornow[1], Omid Ghaebi[1], and Giancarlo Soavi[1,2] — [1]Institute of Solid State Physics, Friedrich Schiller University Jena, Jena, Germany — [2]Abbe Center of Photonics, Friedrich Schiller University Jena, Jena, Germany

In graphene, space inversion symmetry (SIS) and time-reversal symmetry (TRS) combined with a hexagonal lattice give rise to a linear band dispersion at the +/−K points of the Brillouin zone. Breaking TRS can result in exotic phenomena, such as the realization of the Haldane model and the photoinduced anomalous quantum Hall effect. Thanks to its high sensitivity to changes in the crystal symmetry, nonlinear optical spectroscopy provides an excellent tool to study these effects.

In our work, we use an elliptically polarized laser beam to excite monolayer graphene, where the circular polarization component breaks TRS. This symmetry breaking induces new nonzero elements in the third-order nonlinear susceptibility tensor, which are then probed by the linear component of the excitation beam. The combination of the already existing and the light induced tensor elements results in a rotation of the emitted third harmonic signal. Preliminary experimental results further indicate an impact of both excitation power and doping of the sample. Since SIS is still intact, our approach offers a new method for exploring broken TRS and topology in centrosymmetric materials.

HL 29.24 Tue 18:00 P1

Optical Probing of the K-Point Band Structure in Monolayer TMDs *via* SHG — •Jonas Margraf[1], Paul Herrmann[1], Sebastian Klimmer[1,2], Shridhar Sanjay Shanbhag[3], Jan Wilhelm[3], and Giancarlo Soavi[1,4] — [1]Institute of Solid State Physics, University of Jena, Germany — [2]ARC Centre of Excellence for Transformative Meta-Optical Systems, Department of Electronic Materials Engineering, Research School of Physics, The Australian National University, Canberra, Australia — [3]Institute of Theoretical Physics and Regensburg Center for Ultrafast Nanoscopy (RUN), University of Regensburg, Germany — [4]Abbe Center of Photonics, Institute of Applied Physics, University of Jena, Germany.

Crystal properties are ultimately defined by their band structure and dispersion relation, which are typically measured *via* angle-resolved photoemission spectroscopy. Recently, all-optical approaches based on non-perturbative nonlinear optics (NLO) have been proposed as a promising alternative. While optical probing of the band structure requires non-perturbative measurements of the entire Brillouin zone, it is often sufficient to probe the dispersion relation in the vicinity of optical resonances. In this work, we aim to measure the dispersion relation of a transition metal dichalcogenide monolayer at the ±K valleys using perturbative NLO. We investigate a modulation of the total second harmonic (SH) intensity as a function of the fundamental polarization angle upon two-photon resonant SHG. We assign this modulation of the SH intensity to the specific dispersion relation of the ±K valleys induced by trigonal warping.

HL 29.25 Tue 18:00 P1

Optical properties of transition metal dichalcogenides under high pressure — •Paul Luca Grosserhode, Paul Steeger, Robert Schmidt, Steffen Michaelis de Vasconcellos, and Rudolf Bratschitsch — Institute of Physics, University of Münster, Germany

Transition metal dichalcogenides (TMDCs), such as MoS_2 or WS_2, have received growing attention during the last years. Using micromechanical exfoliation, single semiconducting layers can be readily prepared. Furthermore, multi-layered artificial crystals can be fabricated with single layer precision. In this study, we use a diamond anvil cell to apply pressures in the gigapascal range on such samples and observe how their optical properties change due to the induced deformation.

HL 29.26 Tue 18:00 P1

Analytical Theory Of Third Harmonic Generation In Two-Dimensional Materials — •Shridhar Sanjay Shanbhag[1], Florentine Friedrich[2], Paul Herrmann[2], Giancarlo Soavi[2,3], and Jan Wilhelm[1] — [1]Institute of Theoretical Physics and Regensburg Center for Ultrafast Nanoscopy (RUN), University of Regensburg, 93053 Regensburg, Germany — [2]Institute of Solid State Physics, Friedrich Schiller University Jena, 07743 Jena, Germany — [3]Abbe Center of Photonics, Friedrich Schiller University Jena, 07745 Jena, Germany

Valleytronics explores the valley degree of freedom in materials like transition metal dichalcogenides, using electrons in *K valleys as binary states for information encoding. In valleytronics, efficient valley readout is crucial, and third harmonic generation (THG) could provide an ultrafast solution to valley readout for any material, regardless of inversion symmetry.

We derived an analytical expression for THG by solving the semiconductor Bloch equations perturbatively to obtain an expression for the polarization state of the outgoing third harmonic. Our compact expression reveals how material parameters influence the polarization and attributes polarization rotation to valley-dependent optical Stark and Bloch-Siegert shifts. Our theoretical predictions closely align with experiments, providing the microscopic mechanism and thus helping to advancing valleytronic readout mechanisms.

HL 29.27 Tue 18:00 P1

Plasma-Induced Defect Emission in Hexagonal Boron Nitride — •Felix Schaumburg, •David Plitt, Timo Wagner, Nicolas Wöhrl, Martin Geller, Günther Prinz, and Axel Lorke — Faculty of Physics, University of Duisburg-Essen and CENIDE, Germany

Hexagonal boron nitride (hBN) has been the subject of numerous research efforts in the last decade. Of particular interest is the creation of single emitters in hBN because of their easy integration, e.g. in van-der-Waals heterostructures, and their room temperature photon emission. Many methods to create single emitters in hBN are still under investigation. We present our approach to create single quantum emitters in hBN using a remote plasma with different plasma species. We have used argon, nitrogen, and oxygen plasmas and present statistics on the emitters, produced by the different gas species, and their optical properties. In particular, we examine the emission of the exfoliated flakes before the plasma processes *without* an annealing step to avoid creating emitters that are not caused by the plasma exposure. Our findings suggest that the purely physical argon plasma treatment is the most promising route for creating optically active single emitters in hBN by plasma exposure.

HL 29.28 Tue 18:00 P1

Single-photon emission in the van der Waals material hBN — •Akhilesh Dubey, Janne Becker, Robert Schmidt, Steffen Michaelis de Vasconcellos, and Rudolf Bratschitsch — Institute of Physics and Center for Nanotechnology, University of Münster, 48149 Münster, Germany

Single-photon sources are crucial components for quantum networks and communications. Recently, single-photon sources in 2D materials have emerged as robust solid-state light emitters. Promising materials include transition metal dichalcogenides, such as WSe_2, transition metal monochalcogenides (e.g. GaSe), and also hexagonal boron nitride (hBN). Here, we investigate the light emission from single-photon emitters in hBN. We measure photoluminescence spectra of individual centers in hBN nanocrystals and analyze their prominent phonon sidebands. Time-resolved photoluminescence measurements reveal typical lifetimes. Our results are important for devising novel nanoscale devices based on these robust quantum light emitters.

HL 29.29 Tue 18:00 P1

Spectroscopic investigation of defects in strained WSe_2 van-der-Waals heterostructures — •F. Stechemesser[1], F. Schaumburg[1], J. König[2], C. Dietrich[2], C. Steiner[3], P. Pesch[3], G. Prinz[1], M. Geller[1], and A. Kurzmann[2] — [1]Faculty of Physics and CENIDE, University Duisburg-Essen, Germany — [2]University of Cologne, Physics Institute II, Germany — [3]2nd Institute of Physics, RWTH Aachen University, Germany

Van-der-Waals heterostructures offer a versatile platform for tailoring material properties through diverse layer compositions, making them suitable for a wide range of applications. We investigated the single photon emitting behavior of the Van-der-Waals heterostructure, that is composed of stacked layers containing graphene as a front and back gate, hexagonal boron nitride as dielectric layers and the transition metal dichalcogenide tungsten diselenide (WSe_2) as the host of optical emitters. The WSe_2 heterostructure was biaxially strained by nanopillars on the silicon wafer, which was used as substrate. By irradiating the points of large strain with an electron beam, point defects in the lattice structure of WSe_2 were created. The point defects, in the strained area, act as artificial atoms in the structure and can show single photon emission. We studied the samples using spacially resolved photoluminescence spectroscopy using a He-Ne laser. Applying this method, it is possible to localize an emitter and perform temperature, time and power dependent measurements. Finally, to prove the single photon characteristic of the emitter sites, we conducted second order correlation ($g^2(0) = 0.323$) measurements.

HL 29.30 Tue 18:00 P1

Tailoring Quantum Emission in Bilayer WSe2 via Strain Engineering — •Jasleen Kaur Jagde[1], Palwinder Singh[1], Grant Wilbur[1], Megha Jain[1], Edith Yeung[2], David Northeast[2], Seid Mohammad[2], Jean Lapointe[2], Dan Dalacu[2], and Kimberley Hall[1] — [1]Department of Physics and Atmospheric Science, Dalhousie University, Halifax, Nova Scotia B3H 4R2, Canada — [2]National Research Council Canada, Ottawa, Ontario K1A 0R6, Canada

Two-dimensional semiconductors subjected to strain have shown exceptional promise as single-photon emitters, due to their direct bandgap and an ease of integration with photonic structures. Emitters have been observed in a host of monolayer (ML) materials including MoS2, WSe2, WS2, MoTe2 and hBN. Quantum emitters have also recently been discovered in bilayers of TMDs, however their optical properties are less well understood. In this study, we demonstrate site-selective quantum emission in bilayer (BL) WSe2 using strain localized by engineered dielectric nanopillars of varying diameters. Through a systematic investigation of the dependence of quantum emitter properties on strain, we determine the optimum conditions for the observation of bright and narrow photoluminescence emission peaks. We observe a strain-driven blue shift in the emission wavelength that is controllable by the characteristics of the nanopillar. A strong antibunching (g (2)(0) = 0.139) is observed, confirming single photon emission behavior. These results highlight strain engineering of 2D materials as a scalable strategy for on-demand quantum light sources.

HL 29.31 Tue 18:00 P1

Electrical impact of He ion broad beam irradiation on multi-layer WSe2 — •Madhuri Chennur[1,2], Zahra Fekri[1,2], Ulrich Kentsch[1], Gregor Hlawacek[1], Jens Zscharschuch[1,2], and Artur Erbe[1,2] — [1]Helmholtz-Zentrum Dresden Rossendorf, Institute of Ion Beam Physics and Materials Research, 01328Dresden, Germany — [2]TUD Dresden University of Technology, 01062 Dresden, Germany

Nanoelectronics enables the development of innovative, cost-effective, miniaturized, and versatile materials. Among these, 2D materials hold immense potential for tailoring nanoscale functionalities. Structural defects in such materials play a significant role. By analyzing defect types, densities, and distributions, it is possible to unlock insights and exploit them for various applications, such as doping, tuning band gaps, or enhancing catalytic activity.

In this work, the impact of defects in multi-layer WSe2 is explored under the influence of Si/SiO2 and hBN substrates, introduced via a single broad-beam Helium ion irradiation at 7.5 keV. Electrical contacts are patterned using electron beam lithography (EBL), and all measurements are conducted under ambient conditions to assess changes in defect states post-irradiation.

The evolution of defects is monitored over time, with observations made one and two weeks following irradiation. Initially, the devices demonstrate degraded performance but later, their current exceeds pre-irradiation levels. Raman spectroscopy before and after irradiation provides deeper insights into the material's behavior. Additionally, the findings reveal the role of defects in influencing gas-sensing capabilities.

HL 29.32 Tue 18:00 P1

Probing the Band Splitting near the Γ Point in the van der Waals Magnetic Semiconductor CrSBr — •Kaiman Lin[1,2], Yi Li[1,3], Mahdi Ghorbani-Asl[1], Zdenek Sofer[4], Stephan Winnerl[1], Artur Erbe[1,3], Arkady V. Krasheninnikov[1], Manfred Helm[1,3], Shengqiang Zhou[1], Yaping Dan[2], and Slawomir Prucnal[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [2]Shanghai Jiaotong University, Shanghai, China — [3]TU- Dresden, Germany — [4]University of Chemistry and Technology Prague, Czech Republic

As a van der Waals magnetic semiconductor, CrSBr has a direct bandgap of approximately 1.5 eV and undergoes an antiferromagnetic transition around 131 K [1]. In this study, the electronic band structure of CrSBr is investigated through comprehensive photoluminescence (PL) characterization [2]. We distinctly identify low-temperature optical transitions between two closely adjacent conduction-band states and two different valence-band states. The analysis of the PL data robustly reveals energy splittings, bandgaps, and excitonic transitions across different CrSBr thicknesses, ranging from monolayer to bulk. Temperature-dependent PL measurements shed light on the stability of band splitting below the Néel temperature, suggesting that magnons coupled with excitons are responsible for the symmetry breaking and the brightening of transitions from the secondary conduction band minimum (CBM2) to the global valence band maximum (VBM1). [1] N. P. Wilson, K. Lee, J. Cenker et al., Nat. Mater. 20, 1657 (2021). [2] K. Lin, et al. J. Phys. Chem. Lett. 15, 6010-6016 (2024).

HL 29.33 Tue 18:00 P1

Tuning of non-radiative decay channels in CrSBr by a magnetic phase transition — •Fabian Glatz[1], Minjiang Dan[1,2], Till Weickhardt[1], Zdeněk Sofer[3], Marie-Christin Heissenbüttel[4], Julian Klein[5], and Giancarlo Soavi[1,6] — [1]Friedrich Schiller University Jena, Germany — [2]Southwest University of Science and Technology, Mianyang, China — [3]University of Chemistry and Technology Prague, Czech Republic — [4]Westfälische Wilhelms-Universität Münster, Germany — [5]Massachusetts Institute of Technology, USA — [6]Abbe Center of Photonics, Jena, Germany

CrSBr is a layered magnetic semiconductor with a direct bandgap [1]. Magnetic measurements have shown that below the Néel temperature (132 K) the spins within a single layer arrange ferromagnetically, while multiple layers couple antiferromagnetically (AFM) [2]. Here, we investigate the evolution of CrSBr under a magnetic phase transition by using nonlinear optics. In agreement with existing literature, second harmonic generation (SHG) becomes allowed due to the symmetry-breaking by AFM ordering at low temperatures [3]. Additionally, this phase change from paramagnetic (PM) to AFM leads to a change in the band structure that enhances third harmonic generation (THG) at the lowest energy optical resonance while quenching the photoluminescence quantum yield. This indicates the opening of a phonon mediated non-radiative decay channel upon transition from PM to AFM phase.

[1] Wang et al., Nat. Commun. 14, 5966 (2023). [2] Telford et al., Adv. Mater. 32, 2003240 (2020). [3] Lee et al., Nano Lett. 21, 3511-3517 (2021).

HL 29.34 Tue 18:00 P1

Defect induced magnetic phase transition in CrSBr — •Fangchao Long[1,2], Mahdi Ghorbani-Asl[1], Kseniia Mosina[3], Joachim Thomsen[4], René Hübner[1], Zdenek Sofer[3], Florian Dirnberger[5], Arkady V. Krasheninnikov[1], Slawomir Prucnal[1], Manfred Helm[1,2], and Shengqiang Zhou[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Germany — [2]Technische Universität Dresden, Germany — [3]University of Chemistry and Technology Prague, Czech Republic — [4]Forschungszentrum Jülich, Germany — [5]Institute of Applied Physics and Würzburg-Dresden Cluster of Excellence ct.qmat, Germany

As an air-stable van der Waals magnetic semiconductor, CrSBr is receiving great research attention due to its exceptional properties. Below the Néel temperature of 132 K, CrSBr exhibits a typical A-type antiferromagnetic order comprised of antiferromagnetically coupled ferromagnetic monolayers. This special structure makes it susceptible to external stimuli, such as ion irradiation. In this work, we present the magnetic phase transition from antiferromagnetic to ferromagnetic in CrSBr crystals irradiated by non-magnetic ions. We observe the rise and fall of the ferromagnetic phase in antiferromagnetic CrSBr with increasing the irradiation fluence. Raman spectroscopy reveals phonon softening, suggesting the formation of defects. Structure analysis of the irradiated crystals in conjunction with density functional theory calculations suggest that the displacement of constituent atoms due to collisions with ions and the formation of interstitials favor a ferromagnetic order between the layers.

HL 29.35 Tue 18:00 P1

Self-Driven Photodetectors Based on Intercalated CrSBr — •Aljoscha Söll[1], Kseniia Mosina[1], Martin Vesely[1], Jiří Šturala[1], Florian Dirnberger[2], and Zdeněk Sofer[1] — [1]Department of Inorganic Chemistry, University of Chemistry and Technology Prague, 166 28 Prague 6, Czech Republic. — [2]Department of Physics, Technical University of Munich, 85748 Munich, Germany.

The intercalation of lithium ions into layered materials has been an important field of research, leading not only to the development of lithium-ion batteries but also to countless insights in solid-state physics. Recently, it was shown that the intercalation of the quasi-1D semiconductor CrSBr can drastically alter its electronic structure, enhancing conductivity and potentially causing a transition from semiconductor to metal. Since the location and degree of intercalation can be precisely controlled, it allows us to fabricate devices using partially or fully intercalated CrSBr, harnessing properties of both the pristine and intercalated phases. Here we present a self-driven photodetector based on intercalated CrSBr, demonstrating high photoresponsivity across the entire NUV to NIR range with a response time in the millisecond range. Our findings not only deepen the understanding of intercalation effects in low-dimensional materials but also pave the way for the development of advanced optoelectronic devices using intercalated CrSBr.

HL 29.36 Tue 18:00 P1

Strong coupling of metal nanoparticles and 2d semiconductors: Physics behind a minimal model — •Lara Greten and Andreas Knorr — Institut für Theoretische Physik, Technische Universität Berlin, Germany

Transition metal dichalcogenide monolayers (TMDCs) feature strong light-matter interaction, governd by tightly bound, 2d-delocalized excitons. Metal nanostructures exhibit localized plasmons allowing for extreme electric field enhancements on the nanoscale. Hybrids of TMDCs and metal nanoparticles combine excitons and plasmons and may reach strong coupling as shown in numerous experiments. These experimental results are typically quantified via the coupled oscillator model (COM) employing a phenomenological coupling constant as a fitting parameter. To provide physical background to this model, we develop an analytical theory based on a microscopic perspective of the material dynamics and Maxwell's equations [1]. The emergent minimal model [2] provides a clear physical interpretation that highlights the importance of the spatial dispersion of 2d excitons. Depending on geometry and material properties we derive analytic expressions for all coupling and dephasing constants in a COM combining three oscillators: plasmons, bright and momentum-dark excitons. Strong coupling, that manifests as a peak splitting in optical spectra, is observed between momentum-dark excitons and plasmons, while the weakly coupled bright exciton yields a distinct third peak.

[1] L. Greten et al., ACS photonics 11.4, 1396-1411 (2024)
[2] L. Greten et al., arXiv preprint arXiv:2410.16796 (2024)

HL 29.37 Tue 18:00 P1

Non-Local Effects in Landau Quantized Two-Dimensional Electron Gases — •Sabrina Meyer[1], Andreas Knorr[1], Stephen Hughes[2], and Lara Greten[1] — [1]Institut für Theoretische Physik, Technische Universität Berlin, Germany — [2]Department of Physics, Queen's University, Kingston, Canada

Landau levels are the quantum analogon of the cyclotron motion under a strong magnetic field in two-dimensional electron gases, as present in high quality GaAs films. Even though recent experimental work examines nanopatterning - introducing metal gaps to localize and amplify electric fields on the nanoscale - current theoretical descriptions still rely on a local susceptibility for excitation with large wavelengths.

This study includes non-local effects in a microscopic theory for the electron dynamics: We find modified selection rules beyond the dipole approximation that allow for the direct excitation of ground state electrons to higher Landau levels, that are forbidden in a local description. These modifications become especially important when the electric field varies significantly within the spatial extend of the Landau level wave function ($\propto$ 100 nm). This applies for nanopatterned devices as well as for light scattering with wavelength on the order of the Landau level radius.

HL 29.38 Tue 18:00 P1

Visualizing Atomic-Scale Charge Fluctuations in Real-Space Dielectric Response — •Bernadette Christ and Claudia Rödl — Institut für Festkörpertheorie und -optik, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena, Germany

The wave-vector and frequency-dependent dielectric function contains a plethora of information on the response of a given material to external perturbing electromagnetic fields that is rarely fully exploited. Its off-diagonal elements are known as local-field effects and encode the atomic-scale charge fluctuations that occur due to light-matter interaction or screening within the material.

We aim for developing a tool to visualize the impact of such an external perturbation on the electron density in the material in real space. In a first step, we calculate the independent-particle dielectric response function from first principles using density-functional theory. In this mean-field approach, we expect to see how interband transitions excite individual orbitals and how collective excitations such as plasmon waves propagate in the material. Later on, we will also consider inclusion of many-body effects in the evaluation of the response function to visualize the formation of excitons. This will help us to better understand the intricate interplay between the numerous electronic degrees of freedom and contribute to the analysis of spectroscopic experiments. As first benchmarks, we will study bulk semiconductors heading for more complex, technologically relevant materials systems afterwards.

HL 29.39 Tue 18:00 P1

Assessing Wafer Growth Success in Quantum Dot Photonic Device Fabrication — •Severin Krüger[1,2], Elias Kersting[1], and Arne Ludwig[1] — [1]Ruhr-Universität Bochum, Bochum, Germany — [2]Sparrow Quantum Aps, Copenhagen, Denmark

Molecular beam epitaxy (MBE) is crucial for fabricating photonic devices, including commercially viable single photon sources (SPS) based on quantum dots (QDs) [1]. Precise control of QD properties and surrounding layer design is essential for optimal device performance. We employ bandstructure and photonic simulations to design heterostructures, followed by comprehensive optical characterization of reference samples using photoluminescence (PL) mapping, Hall measurements, and surface analysis. This efficient characterization cycle allows rapid optimization of growth parameters on full 3” wafers, significantly reducing development time compared to direct SPS fabrication and testing. However, distributed Bragg reflectors in SPS wafers introduce PL signal artifacts due to reflectivity oscillations and stop bands, which significantly modulate the collectable photon yield across different wavelengths, alternately enhancing and suppressing the signal. We present our reference sample approach, characterization methods, and techniques to correct for optical stack-induced PL artifacts, enabling accurate assessment of MBE-grown structures for SPS applications.

[1] R. Uppu et al., Nature Technology 16, 1308-1317, (2022) [2] H.G. Babin et al., Nanomaterials 11, 2703, (2021)

HL 29.40 Tue 18:00 P1

Effect of TiO_2 thin films on the charge state of shallow NV centers in diamond. — •Arthur Witte, Tobias Lühmann, Peter Schlupp, Dominic Reinhardt, Holger von Wenckstern, and Marius Grundmann — Universität Leipzig, Felix-Bloch Institute for Solid State Physics, Germany

The nitrogen vacancy (NV) center is a color center in diamond. In its negative charge state, it has a relatively long spin coherence time at room temperature and a spin-dependent photoluminescence that enables optical spin polarization. Because of these properties, the NV center was proposed as a platform for room-temperature quantum computing. For this application the NV centers must be located close to the diamond surface. This can present new challenges due to surface effects resulting in, e.g. charge state instabilities of the shallow NV centers. Various surface treatments can be used to mitigate these effects, such as thermal oxidation, plasma surface treatments or the deposition of a thin passivation layer on the diamond surface.

We present a titanium dioxide thin film as the passivation layer. Titanium dioxide is a wide-bandgap semiconductor with a high refractive index of 2.5. In a first step, we investigate the growth of titanium dioxide layers by pulsed laser deposition and long-throw sputtering under different conditions. We then study the effect of optimized titanium dioxide layers on the luminescence properties of NV centers at implantation depths between 7 nm and 67 nm. Through spectroscopic analysis, we observe a significant increase in charge stabilization of shallow NV centers.

HL 29.41 Tue 18:00 P1

Secondary electron spectrometer for deterministic single ion implantation — •Priyal Dadhich, Nico Klingner, and Gregor Hlawacek — Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf(HZDR), Dresden, Germany

The deterministic placement of single ions is essential for programmable quantum computers based on the nuclear spin of the donor atom to serve as a spin qubit.

Spatially revolved single ion implantation requires the reliable detection of implantation events. Our approach utilizes SEs generated during ion impact. To optimize the detection we use a windowless silicon drift detector (SDD) biased up to +10 kV. The SDD measures the electron energy through electron-hole pair generation, enabling quantifying the number of electrons by counting pile-up pulses [1]. Given the low average SE yield per single-ion impact, optimizing the extraction geometry is crucial for achieving the maximum possible success rate.

We use the open-source three-dimensional ion optical C++ library, IBSIMU[2], to simulate a realistic extraction design for efficient SE collection on the detector's active area. For the highest detection efficiency, we must also consider the unlikely event of backscattering of the electrons from the SDD. The extraction geometry is designed to recapture these electrons and re-accelerate them into the detector's active area.

[1] F. Aumayr et. al., Applied Surface science,47(2):139*147, 1991.

[2] Taneli Kalvas et. al., Review of Scientific Instruments, 81(2), 2010.

HL 29.42 Tue 18:00 P1

Emission properties of electron irradiated hBN — •Annkathrin Köhler, Jan Böhmer, Christian T. Plass, and Carsten Ronning — Friedrich Schiller Universität, Jena, Deutschland

Defect centers in solid state materials have emerged as promising candidates for quantum emitters. In particular, hexagonal boron nitride (hBN) has attracted significant attention due to its ability to host single-photon emitters (SPEs) at room temperature. Here, we systematically examined the luminescence properties of exfoliated hBN flakes as well as hBN nano-powders dispersed in various solutions and drop-casted onto a substrate. The effects of local electron irradiation and thermal annealing on the hBN samples were analyzed, providing insights into the conditions necessary for tuning their emission characteristics. Photoluminescence (PL) spectra were recorded using a micro-PL setup to compare the spectral distribution of the emission under different treatments. To further understand the quantum nature of the emitters, we conducted second-order correlation measurements as a function of the preparation parameters.

HL 29.43 Tue 18:00 P1

Germanium MOSFETs for Quantum Computation — •Thembelihle Dlamini and Mónica Benito — Institute of Physics, University of Augsburg

The project focuses on studying hole dynamics and spin properties in Germanium (Ge) metal-oxide-semiconductor (MOS) nanostructures to achieve high-fidelity single-qubit operations. Leveraging MOSFETs superior compatibility with industrial manufacturing techniques, holes' unique properties such as strong spin-orbit coupling, and Ge advantages over Si, GeMOS hole-spin qubits addresses some of the limitations of state-of-the-art spin quantum processors. The device-design phases will be assisted by three-dimensional structural simulations of the device. Moreover we will develop custom analytical models for holes in low-dimensional GeMOS geometries and the Ge/oxide interface by using symmetry analysis and $k \cdot p$ theory. Finally, we will investigate the effect of the multiband character of holes and their spin-orbit coupling in the effective spin representation of systems with a few holes in realistic quantum-dot potentials.

HL 29.44 Tue 18:00 P1

Crystal Growth and Influence of Fe^{3+} Doping on the Structural, Optical, and Magnetic Properties of Lead-Free Double Perovskites — •Volodymyr Vasylkovskyi[1,2], Anastasiia Kultaeva[1], Olga Trukhina[1], Patrick Dörflinger[1], Daniele Ludwig[1], Mykola Slipchenko[1,2], and Vladimir Dyakonov[1] — [1]Experimental Physics 6, University of Würzburg, 97074 Würzburg, Germany — [2]Institute for Scintillation Materials, NAS of Ukraine, 61072 Kharkiv, Ukraine

Semiconducting perovskite materials have attracted significant attention for their photovoltaic and light-emitting applications, yet their magnetic properties are largely unexplored. Doping perovskites with transition metal ions, such as Fe^{3+}, introduces novel properties, broadening their potential for spintronic and quantum applications.
In this study, Fe-doped $Cs_2AgBiBr_6$ and $Cs_2AgBiCl_6$ single crystals were synthesized using a controlled cooling crystallization technique with varying Fe^{3+} doping concentrations. Despite low Fe^{3+} incorporation (<0.01%), doping significantly affected defect density, optical properties, and magnetic behavior. Electron paramagnetic resonance revealed complex spin properties of the intrinsic spin centers and their interactions, which depend on both temperature and the orientation of single crystals with respect to the magnetic field.
Our findings highlight Fe-doped lead-free perovskites as promising materials for spintronic applications, emphasizing the importance of precise doping and defect manipulation to optimize their performance.

HL 29.45 Tue 18:00 P1

Multi-Frequency ODMR applied to Boron Vacancy Spin Defects of hBN — •Lucas Schreiber, Selin Steinicke, Paul Konrad, Andreas Sperlich, and Vladimir Dyakonov — Experimental Physics 6, University of Würzburg, 97074 Würzburg, Germany

Spin defects in hexagonal boron nitride (hBN) present a multitude of potential applications in the fields of quantum sensing and quantum information technology. Especially, the negatively charged boron vacancy defect can interact with the nuclear spins of its surrounding nitrogen atoms, thereby giving rise to hyperfine interactions. In this study, the spin defect was analyzed using optically detected magnetic resonance (ODMR) spectroscopy, wherein the spin sublevels are controlled by microwave pulses. In contrast to previous studies, the coherent microwave pulses employed in this work simultaneously utilize the multiple resonance frequencies of the hyperfine splitting. We therefore implement a multi-resonance technique for enhanced contrast and exploitation of the spin system. For an accurate and quantitative comparison with conventional ODMR, we derived a value for the contrast, allowing for a direct comparison of the hyperfine interaction on the spin defect. This approach aims at enhancing the optical detection of resonant excitation of the spin defect and facilitating coherent control experiments in future studies.

HL 29.46 Tue 18:00 P1

Temperature-dependent Studies of Boron-Vacancy Spin Defects in hexagonal Boron Nitride — •Selin Steinicke, Paul Konrad, Andreas Sperlich, and Vladimir Dyakonov — Experimental Physics 6, University of Würzburg, 97074 Würzburg, Germany

Optically addressable spin-carrying defects in solid-state materials are promising candidates in the field of quantum information technology and sensing applications. The recently discovered negatively charged Boron vacancies (V_B^-) in hexagonal Boron Nitride (hBN) raised the prospect of quantum sensing in a two-dimensional material. Although numerous studies on hBN emerged in the last years, the optical pump cycle has not yet been fully researched. Temperature-dependent spectroscopy on V_B^- ensembles shows broad photoluminescence around 850 nm and an increase in intensity at cryogenic temperatures. Using temperature-dependent transient photoluminescence measurements, we investigate the non-radiative relaxation path from the triplet excited state into the triplet ground state via the metastable intermediate state. The dependence of the intermediate state's lifetime on temperature is examined. These results shed light into the dark processes of V_B^- and can be used to optimize coherent control of V_B^-, which leads to a higher sensitivity in quantum sensing.

HL 29.47 Tue 18:00 P1

Investigating the optical pumping of silicon vacancies in 4H-SiC to increase the maser output — •Emilian Eisermann, Vladimir Dyakonov, and Andreas Sperlich — Experimental Physics 6, University of Würzburg, 97074 Würzburg, Germany

A major breakthrough in the realization of a continuous-wave maser at room temperature was achieved with the utilization of nitrogen vacancies in diamond. However, diamond is a comparatively expensive material. For this reason, silicon carbide (SiC), a material used commercially in electrical systems, has received attention in recent years. Only recently, our group has demonstrated the first room temperature continuous-wave SiC maser. Despite innovative microwave feedback loop engineering, only a low output could be achieved. In an effort to boost the maser output, we investigate the fundamental pumping behavior of silicon vacancy defects in SiC in dependence of the optical pump wavelength, the temperature and their density. Using electron paramagnetic resonance spectroscopy, we resolve microwave absorption and emission signals due to the optical polarisation of Zeeman-split states. By analyzing these features, we calculate the population inversion in the gain material. This crucial parameter allows us to quantitatively evaluate the pump efficiency. It turns out that an excitation with an energy of the zero-phonon line of the silicon vacancy is particularly efficient. Furthermore, we examine to what extent excitation with an energy lower than that of the zero-phonon line is possible if thermally driven phonons are used to compensate the missing energy. First results are presented on the poster, which we are discussing here.

HL 29.48 Tue 18:00 P1

UV Photolithographic Fabrication of Photonic Structures on Diamond — •Nidhin Varghese, Oleg Peter, and Wolfgang Harneit — Institute of Physics,University of Osnabrück,Germany

The NV center in diamond is a point defect with promising quantum applications at room temperature, combining long spin relaxation times with optical excitation and state readout. Photonic structures such as micron-sized pillars help to increase the photon collection efficiency, improving the SNR ratio and enhancing sensitivity. NV centers in photonic structures can also be used to read out and control other spins, e.g., molecular qubits The top-down approach to fabricating photonic structures is straightforward and based on reactive ion etching of diamond. The process first requires a patterned etching mask, which is usually defined using electron beam lithography (EBL). Although EBL allows to make very small patterns, it is quite expensive and time-consuming. Using photolithographic processes could enhance industry adoption and increase accessibility to diamond quantum technology for research labs that do not have access to EBL. Here, we present a novel approach to nano-pillar fabrication based on direct (UV) laser writing lithography. An easy-to-use epoxy stage was developed for spin coating of photoresists on very small substrates, which largely supresses the formation of edge beads. The photonic pillar structures were fabricated by lithography and ion etching, and characterized. Confocal fluorescence scans demonstrated the increased photon output performance. CW-ODMR measurements confirmed the presence and accessibility of NV centers.

HL 29.49 Tue 18:00 P1

Birefringence effects in crystalline AlGaAs/GaAs mirror coatings from 4 K to room temperature — •Mona Kempkes, Chun Yu Ma, Thomas Legero, Uwe Sterr, and Daniele Nicolodi — Physikalisch-Technische Bundesanstalt, Braunschweig

Coating thermal noise limits the performance of high precision interferometry experiments, including ultra-stable optical oscillators used for interrogating atomic clocks and gravitational wave detectors. Due to their low mechanical losses, Bragg-reflectors from crystalline $Al_{0.92}Ga_{0.08}As/GaAs$ heterostructures emerged as a lower thermal noise alternative to traditional dielectric mirror coatings. Mirrors realized with this material exhibit still poorly understood birefringence that can be modified by temperature and incident optical power. Furthermore, experiments at 4 K, 16 K and 124 K revealed spontaneous fluctuations of the birefringence, as well as an additional and yet unidentified noise source that limits the performance well above the expected thermal noise floor [J. Yu et al., Phys. Rev. X 13, 041002 (2023)]. Reconciling these observations from different samples is challenging and hinders a common interpretation. Thus we have set up one system where the temperature can be swept continuously across a wide range. We will present our setup based on a low-vibration closed-cycle cryostat, and measurements of the birefringence of crystalline AlGaAs/GaAs mirror coatings from 4 K to room temperature and as function of optical power.

HL 29.50 Tue 18:00 P1

Stark Effect of color centers studied from a- and m-face 4H-SiC — •Fabio Candolfi, Johannes A. F. Lehmeyer, Michael

Krieger, and Heiko B. Weber — Friedrich-Alexander Universität Erlangen-Nürnberg, Lehrstuhl für Angewandte Physik, Staudtstr. 7 91058 Erlangen, Germany

Color centers in silicon carbide (SiC) can operate as single photon sources and are well suited for photonic quantum technology. As compared to the intensively studied diamond platform, SiC provides both mature semiconductor functionality and process technology.

We investigated the Stark effect response of two different color centers in 4H-SiC; the established silicon vacancy defect and the less known TS defect. Both were studied from the c-face, but the photon emission occurs predominantly in the basal plane. This is why in this work low-temperature photoluminescence across the a- and m-faces were studied with Stark effect along three principal crystallographic axes. From the emission polarization of shifted and split photoluminescence lines we obtain the orientation of the dipole moment.

HL 29.51 Tue 18:00 P1

InGaAs quantum dots grown by local droplet etching — •Selma Delić[1,2], Xuelin Jin[1,2], Nils von den Driesch[1], Elias Kersting[3], Arne Ludwig[3], Alexander Pawlis[1], Detlev Grützmacher[1,2], and Beata Kardynał[1,2] — [1]Peter Grünberg Institut, Forschungszentrum Jülich, 52428 Jülich, Germany — [2]Department of Physics, RWTH, 52074 Aachen, Germany — [3]Lehrstuhl für angewandte Festkörperphysik, Ruhr-Universität Bochum, 44780 Bochum, Germany

Gallium arsenide quantum dots (QDs) grown using local droplet etching epitaxy (LDE) have been shown to be excellent single photon emitters. Integrated into GaAs heterostructures with two-dimensional electron gases (2DEG), the LDE QDs could facilitate spin-photon interface to spin-qubits in gated QDs, provided that photon absorption in the 2DEG in eliminated.

In this contribution, we demonstrate that the wavelength of LDE quantum dots can be effectively tuned by filling the holes edged in Al0.33Ga0.67As with InxGa1-xAs with x=10-20%. At such compositions, two-dimensional growth is expected and quantum dot formation should follow the same mechanism as that of GaAs QDs. We characterise the QDs using atomic force microscopy, low-temperature photoluminescence (PL), and microPL and analyse the effects of the growth temperature, etching step parameters, and filling material on the wavelength of QD emission. Furthermore, we show how the wetting layer emission wavelength can be used to evaluate the thickness and composition of the deposited InxGa1-xAs.

HL 29.52 Tue 18:00 P1

Tuning InGaAs quantum dots for quantum interface for heterogeneous quantum network — •Xuelin Jin[1,2], Selma Delic[1,2], Zheng Zeng[1,2], Nils von den Driesch[1,3], Alexander Pawlis[1,3], Detlev Grützmacher[1,2,3], and Beata Kardynal[1,2] — [1]Peter Grünberg Institute 9, Forschungszentrum Jülich, 52425 Jülich, Germany — [2]Department of Physics, RWTH Aachen, 52074 Aachen, Germany — [3]Peter Grünberg Institute 10, Forschungszentrum Jülich, 52425 Jülich, Germany

Abstract. Connecting different spin qubits using photonic qubits could facilitate building networks that would benefit from the inherent advantage of the individual subsystems. An efficient transfer of a qubit from a photon to the spin qubit requires matching of the energies and the bandwidths of the photon wave packet and the spin qubit optical transitions.

We discuss the design of an epitaxial quantum dot device that aim to use electrostatic gates to manipulate the bandwidth of the photons emitted from InAs QDs to improve the match to the spin qubits realized in trapped ions. We show that application of electrostatic fields can change the overlap of the e-h wavefunctions. We will discuss the conditions that the heterostructure has to fulfill for the device operation and will show the status of fabrication, which has centered on optimizing the epitaxial growth of the material. Finally, we will show the results of its characterisation aiming to show how the electronic states in these quantum dots evolve with voltages applied to the surface gates.

HL 29.53 Tue 18:00 P1

Spin-Dependent Processes Involving Defects Caused by Lithography — •Henry Stock[1,3], Michael Göldl[1,3], Niklas Bruckmoser[2,3], Leon Koch[2,3], Stefan Filipp[2,3], and Martin S. Brandt[1,3] — [1]Walter Schottky Institut, Technische Universität München, Am Coulombwall 4, 85748 Garching, Germany — [2]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Walther-Meißner-Straße 8, 85748 Garching, Germany — [3]School of Natural Sciences, Technische Universität München, James-Franck-Straße 1, 85748 Garching, Germany

A precise knowledge of the paramagnetic defects present in quantum devices and their contribution to magnetic noise can be crucial for the optimization of such devices. However, conventional electron spin resonance experiments are often not sensitive enough to observe the defects. Using spin selection rules governing, e.g., recombination, the sensitivity of magnetic resonance experiments can be improved significantly. In its pulsed form, this so-called electrically detected magnetic resonance (EDMR) even enables the time-resolved study of the spin dynamics of the defects, allowing for measurements of the formation and recombination of spin pairs, as well as of the spin relaxation times T_1 and spin decoherence times T_2. Here, we present a study where we investigate paramagnetic P_{b0} defects and lithographically induced fluorine defects in Si substrates used for the manufacturing of superconducting transmon qubits. Our results are important to illuminate the role these defects play in flux noise and their influence on qubit coherence.

HL 29.54 Tue 18:00 P1

Progress on fully gate-defined optical interfaces to spin qubits — •Maxim Reznikov[1], Sebastian Kindel[1], Kui Wu[2], Nikolai Spitzer[3], Andreas D. Wieck[3], Arne Ludwig[3], Jeremy Witzens[2], and Hendrik Bluhm[1] — [1]JARA-FIT Institute for Quantum Information, Forschungszentrum Jülich GmbH and RWTH Aachen University, Germany — [2]Institute of Integrated Photonics, RWTH Aachen University, Germany — [3]Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, Germany

Advancing quantum networks beyond proof-of-concept applications requires an approach for fabricating quantum repeater nodes with multiple qubits and optical interfaces in a controlled manner. Semiconductor spin qubits in gate-defined quantum dots address these needs in terms of established high-fidelity qubit operations and compatibility with industrial semiconductor technology. By employing electrostatic gating on either side of a submicron-thick heterostructure, excitons can be precisely localized at deterministic positions, thus also realizing an optical interface. These exciton trapping devices overcome the fabrication randomness associated with self-assembled quantum dots and enabling fine-tuning of operational wavelengths.

In this work, we demonstrate the successful integration of exciton trapping devices based on GaAs quantum wells into photonic crystal cavities. Additionally, we show the same confinement mechanism can be transferred to the Ge/SiGe platform, which is more compatible with industrial processing and telecom wavelength.

HL 29.55 Tue 18:00 P1

RPCVD growth of nuclear spin-free 70Ge/28Si70Ge heterostructures on industrial SiGe wafers — •Patrick Daoust, Simone Assali, Anis Attiaoui, Gérard Daligou, Patrick Del Vecchio, Sebastian Koelling, Lu Luo, Nicolas Rotaru, Oussama Moutanabbir, and Éloise Rahier — Department of Engineering Physics, École Polytechnique de Montréal, C.P. 6079, Succ. Centre-Ville, Montréal, Québec, Canada H3C 3A7

The coherence and operation of hole spin qubits in planar Ge heterostructures are both very sensitive to the nuclear spin bath. Therefore, developing nuclear spin-depleted materials is critical to control the performance of these quits. To this end, it is important to eliminate the nuclear spin-full 29Si and 73Ge in the epitaxial Ge/SiGe heterostructures. Our group has recently demonstrated highly crystalline, defect free, isotopically purified (>99.9 at.% 70Ge) nuclear spin-depleted 70Ge quantum well (QW) heterostructures grown in a reduced pressure CVD using purified precursors (>99.9 at.% 70GeH4 and >99.99 at.% 28SiH4) on in situ grown reversed graded SiGe buffers [1]. However, this growth protocol is not efficient and consumes significantly these purified precursors. Herein, we show that the growth of 70Ge QW can be achieved on industrial SiGe wafers thus optimizing the usage of precursors, preventing any background contamination from natural precursors, and yielding highly purified 70Ge/28Si70Ge heterostructures.

HL 29.56 Tue 18:00 P1

Time resolved electron imaging of a high-Q nonlinear nanomechanical oscillator — •Kai Nettersheim[1], Alexander Schröder[1], and Sascha Schäfer[1,2] — [1]Department of Physics, University of Regensburg, Regensburg, Germany — [2]Regensburg Center for Ultrafast Nanoscopy (RUN), Regensburg, Germany

While micro-electromechanical systems are well adapted for probing nonlinear dynamics in nanomechanical systems, they are often limited in their spatial resolution. Recent advances in ultrafast electron microscopy (UTEM) [1] enable the highly localized probing of nanoscale oscillator dynamics as well as their atomic structure and material defects.

Here, we present the characterization of non-linear free-standing silicon membranes by UTEM imaging techniques using an event-based electron detector with nanosecond temporal resolution. By exiting the sample with a modulated continuous wave laser the sample is driven into the nonlinear regime, resulting in Duffing resonances with high quality factors of up to 10^5. We experimentally characterized the temperature and fluence dependencies of the resonance as well as the mode shapes involved and compare these to finite-element simulations.

[1] A. Schröder et al., arXiv:2410.23961v1 (2024)

HL 29.57 Tue 18:00 P1

Quantum Particles on Strongly Bent Curves — •Tim Bergmann, Benjamin Schwager, and Jamal Berakdar — Martin-Luther-Universität Halle-Wittenberg

Quantum systems under geometrical restrictions appear both in research and applied fields such as materials design, for example in the context of quantum wires. In the case of a curve these lead to a one-dimensional Schrödinger equation with its curvature appearing as a potential like term. Up to this point, there existed no ansatz for the treatment of singulary bent curves because the curvature diverges. We provide a solution to this problem for a subclass of such curves, employing a useful mathematical tool for the convergence of eigenvalue equations. This desingularization renders the approximation of the eigenspectrum and corresponding wave functions of systems with singular Hamilton operators possible.

HL 29.58 Tue 18:00 P1

Shutter synchronized deposition in molecular epitaxy for wafer scale homogeneous quantum emitter growth — •Elias Kersting, Hans Georg Babin, Nikolai Spitzer, Andreas Wieck, and Arne Ludwig — Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, Deutschland

Most quantum dot (QD) based single photon emitters today are based on random position nucleated QDs with spectrally broad emission properties. Deterministic QD growth in position and emitter wavelength would be highly appreciated for large-scale and good turnabout chip manufacturing. Local droplet etching during molecular beam epitaxy is an all-in-situ method to predetermine the nucleation site of quantum dots. As recently demonstrated, this method can produce strain-free GaAs QDs with excellent photonic and spin properties. We use random position droplet nucleation and hole filling demonstrating enhanced emitter wavelength homogeneity on a wafer scale. By shutter synchronized rotation and ideal growth parameters, we grow QDs with a peak emission wavelength spread of no more than 2 nm on a full 2" diameter area with a narrow inhomogeneous ensemble broadening. While the emission wavelength of these QDs is < 800 nm, we can use this random local droplet nucleation, nanohole drilling and InAs infilling to produce QDs emitting in the telecom optical fibre transparency window around 1.3 μm, the so-called O-band. For this approach, we demonstrate 2" wafer scale control of the emission wavelength and excellent uniformity. We discuss our methodology, structural and optical properties.

HL 29.59 Tue 18:00 P1

Integration of quantum dot-based single-photon sources onto silicon photonic platform using micro-transfer printing — •Simon Oberle, Ponraj Vijayan, Simone Luca Portalupi, Michael Jetter, and Peter Michler — Institut für Halbleiteroptik und Funktionelle Grenzflächen, Universität Stuttgart, Germany

Silicon photonics for telecommunications applications has garnered much attention recently. The optical transparency and the large refractive index contrast of silicon in the telecommunication wavelengths allow the implementation of high-density photonic integrated circuits. One disadvantage of silicon photonics is the lack of a native light source due to the indirect band-gap nature of silicon. One potential solution is the integration of III-V material, which offers outstanding optical emission properties, on a silicon platform. The direct growth of III-V materials on silicon is economically favourable and therefore the most desired approach. However, it is challenging because of the large lattice mismatch between the III-V materials and silicon. An alternate approach for large-scale integration is through hybrid integration of III-V structures using micro-transfer printing. Our group has previously developed In(Ga)As quantum dots on GaAs emitting in the telecom C-band. Here, we report our approach to designing and fabricating structures for the hybrid integration of these QDs onto a silicon platform using micro-transfer printing.

HL 29.60 Tue 18:00 P1

enhancing the emission Intensity of Mn2+ by doping with Ln3+ ions in ZnSe QDs and heavy metal ions detection — •Iram Gul[1], Zahid U. Khan[2], Latif U. Khan[3], Hermi F. Brito[4], and Muhammad Abdullah Khan[5] — [1]Department of Environmental Sciences, Quaid-i-Azam University (QAU), 15320, Islamabad, Pakistan — [2]Research Centre for Greenhouse Gas Innovation, University of Sao Paulo (USP), 05508-030, São Paulo * SP, Brazil — [3]Synchrotron-light for Experimental Science and Applications in the Middle East (SESAME) P.O. Box 7, Allan 19252, Jordan — [4]Institute of Chemistry, University of São Paulo (USP), 05508-000, São Paulo-SP, Brazil — [5]Department of Environmental Sciences, Quaid-i-Azam University (QAU), 15320, Islamabad, Pakistan

This study enhances the photoluminescence of ZnSe:Mn2+ quantum dots (QDs) by doping with Ln3+ ions (Sm3+, Gd3+, La3+, Y3+, Nd3+, Yb3+, Tm3+, Lu3+). Sm3+ and Gd** exhibited the strongest emissions due to efficient energy transfer to Mn2+, while other ions showed quenching at higher concentrations. These QDs, with uniform morphology, were applied to detect heavy metals (Pb2+, Cr3+, Hg2+, Cu2+, Fe2+), which quenched photoluminescence. Pb2+ showed the highest sensitivity (LoD: 4.648.10-3 mol/L), and Fe2+ the lowest (LoD: 5.257.10 -3 mol/L). ZnSe:Ln3+,Mn2+ QDs demonstrate potential for advanced photoluminescent applications and environmental monitoring of pollutants

HL 29.61 Tue 18:00 P1

enhancing the emission Intensity of Mn2+ by doping with Ln3+ ions in ZnSe QDs and heavy metal ions detection — •Iram Gul[1], Zahid U. Khan[2], Latif U. Khan[3], Hermi F. Brito[4], and Muhammad Abdullah Khan[5] — [1]Department of Environmental Sciences, Quaid-i-Azam University (QAU), 15320, Islamabad, Pakistan — [2]Research Centre for Greenhouse Gas Innovation, University of Sao Paulo (USP), 05508-030, São Paulo SP, Brazil — [3]Synchrotron-light for Experimental Science and Applications in the Middle East (SESAME) P.O. Box 7, Allan 19252, Jordan — [4]Institute of Chemistry, University of São Paulo (USP), 05508-000, São Paulo-SP, Brazil — [5]Department of Environmental Sciences, Quaid-i-Azam University (QAU), 15320, Islamabad, Pakistan

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HL 29.62 Tue 18:00 P1

Towards Efficient Entangled Photon Pair Sources by Semiconductor Quantum Dots in Planar Cavities — •Aditi Javali[1], Raphael Joos[1], Ponraj Vijayan[1], Lena Engel[1], Tobias Huber-Loyola[2], Sven Höfling[2], Michael Jetter[1], Simone Luca Portalupi[1], and Peter Michler[1] — [1]Institut für Halbleiteroptik und Funktionelle Grenzflächen (IHFG), Center for Integrated Quantum Science and Technology (IQST) and SCoPE, Universität Stuttgart, Allmandring 3, 70569 Stuttgart, Germany — [2]Lehrstuhl für Technische Physik, Physikalisches Institut, Julius-Maximilians-Universität Würzburg, 97074 Würzburg, Germany

Since the EPR violation, entangled photons have become key protagonists in quantum technology, serving as communication carriers via polarization qubits. Photon pairs entangled in telecom C-band are particularly advantageous, as this wavelength range minimizes dispersion and loss in standard optical fibers, enabling long-distance communication with reduced signal degradation. In this work, we demonstrate the generation of entangled photon pairs in the telecom C-band using InAs quantum dots integrated with a planar photonic cavity. The cavity enhances photon emission rates and collection efficiency with high entanglement fidelity. The biexciton state, emitting the entangled pair, is prepared using a two-photon excitation scheme. The entanglement is verified through state tomography, confirming the strong quantum correlations between the photons. This work highlights telecom C-band quantum dots' potential as efficient entangled-photon sources for high-performance quantum communication.

HL 29.63 Tue 18:00 P1

Influence of Short-Wavelength Irradiation on Self-Assembled Quantum Dots — •Julia Avdeev[1], Jan Lange[1], Lukas Berg[1], Laurin Schnorr[1], Thomas Heinzel[1], Charlotte Rothfuchs-Engels[2], Sven Scholz[2], Arne Ludwig[2], and Andreas Wieck[2] — [1]Condensed Matter Physics Laboratory, Heinrich Heine University, Düsseldorf, Germany — [2]Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität, Bochum, Germany

Using Deep Level Transient Spectroscopy (DLTS) the charge transfer to and from Self-Assembled Quantum Dots (SAQDs) at large distance from the reservoir can be observed. Measurements are performed at a temperature of 77 K studying the influence of short-wavelength infrared irradiation. With wavelengths larger than 1.5 μm photons are not capable to induce charge emission from neutral Quantum Dots in ground state but can cause free charge carriers from electronic states in SAQDs.

HL 29.64 Tue 18:00 P1

Quantum Mechanics on Periodically Deformed Manifolds — •Theresa Appel, Benjamin Schwager, and Jamal Berakdar — Martin-Luther-Universität Halle-Wittenberg, Halle (Saale), Deutschland

Quantum systems confined to low-dimensional geometries exhibit unique physical behavior due to curvature-induced potentials. The poster presents results on the dynamics of particles confined to periodically curved manifolds, which we term “deformation crystals”. The periodic spatial deformations directly influence the particle dynamics resulting in a band structure similar to other crystalline systems. We examine the transition from a free electron gas to a one-dimensional deformation crystal while analyzing the energy dispersion relation and symmetry-breaking effects. Furthermore, the behavior of different deformations is compared. The results reveal that the specific geometric deformations significantly influence the effective potential landscape and the band structure, thus opening up new opportunities for applications via deformation modulation of the underlying space.

HL 29.65 Tue 18:00 P1

Single-electron charging events on quantum dots in InSb nanowires — •Marcus Liebmann[1], Kanji Furuta[1], Sasa Gazibegovic[2], Diana Car[2], Erik Bakkers[2], and Markus Morgenstern[1] — [1]II. Phys. Inst. B, RWTH Aachen Univ., Germany — [2]Dept. of Appl. Phys., Eindhoven Univ., The Netherlands

As a first step to realize a single-electron counting tip for a scanning tunneling microscope, we investigate the charge state of a quantum dot (QD) by recording the current through a floating-gate-coupled sensor dot. InSb nanowires are placed mechanically onto bottom gates with hexagonal boron nitride (h-BN) as a dielectric to define two quantum dots capacitively coupled via a floating gate. At zero source-drain voltage and high barriers, charge stability diagrams are acquired, and time series of the QD charge state reveal single-electron charging events. These are analyzed with respect to full counting statistics. The Fano factor and factorial cumulants [1] are extracted to search for correlation effects.

[1] P. Stegmann *et al.*, Phys. Rev. B **92**, 155413 (2015).

HL 29.66 Tue 18:00 P1

Spin relaxation dynamics of the excited triplet state in self-assembeld quantum dots — •Carl Nelson Creutzburg[1], Jens Kerski[1], Arne Ludwig[2], Andreas D. Wieck[2], Martin Geller[1], and Axel Lorke[1] — [1]Faculty of Physics and CENIDE, University of Duisburg-Essen, Germany — [2]Chair of Applied Solid State Physics, Ruhr-University Bochum, Germany

The two-electron triplet state in a self-assembled quantum dot (QD) can pair with the singlet ground state to form a spin qubit. This state is electrically addressable, making it a promising candidate for quantum information processing. Achieving this requires a long coherence time (T_2), which is limited by the spin relaxation time (T_1). While T_1 has been previously studied using optical techniques, we employ an all-electrical measurement approach. The dots are embedded in an inverted high electron mobility transistor (HEMT) to selectively charge and discharge their many-particle states with electrons from a tunnel-coupled electron reservoir (2DEG). The 2DEG also acts as a sensitive detector for the charge in the QD layer. By employing time-resolved transconductance spectroscopy [1] and varying the charging intervals, we observe the relaxation process from the excited triplet state to the singlet ground state. Using a rate equation model, we extract the spin relaxation time T_1. While there are already first results for T_1 [2], an improved temporal resolution provides new insights that could help to refine assumptions in previous studies.

[1] B. Marquardt. et al., Nature Commun. 2, 209 (2011)
[2] K. Eltrudis. et al., Appl. Phys. Lett. 111, 092103 (2017)

HL 29.67 Tue 18:00 P1

Multiphoton Emission of Quantum Dots with Different Excitation Schemes — •Patricia Kallert, Nicolás Claro-Rodríguez, Francesco Salusti, Sonja Barkhofen, Santiago Bermúdez Feijóo, Lukas Hanschke, Normen Auler, Dirk Reuter, and Klaus D. Jöns — PhoQS Institute, CeOPP, and Department of Physics, Paderborn University, Paderborn, Germany

High efficiency, single-photon purity, high indistinguishability, and good qualities as entangled-photon pair emitters are key properties of ideal sources for photon-based quantum technologies. Accordingly, semiconductor quantum dots (QDs) are promising candidates. If a multi-level system is excited coherently with optical pulses of different pulse areas, such as 1π, 2π and higher, the system experiences Rabi rotations of the according rotation and the respective population inversions. For each pulse area, the probability of emitting different photon numbers for different pulse areas varies, which is recognizable in the second correlation function. [1] Since various excitation schemes are interesting for different qualities of QDs, we analyze the multiphoton emission characteristics with different excitation schemes. We anticipate that this gives a deeper insight into the structure of the emitted states and possible applications to generate customised quantum light states and required modifications to generate them.

[1] Fischer, K., Hanschke, et al. Signatures of two-photon pulses from a quantum two-level system. Nature Phys 13, 649-654 (2017).

HL 29.68 Tue 18:00 P1

Investigating Photo-Physical Properties of Ag-In-S Core and Core-shell Quantum Dots — •Johannes Kunze, Julian Mann, Sushant Ghimire, and Jochen Feldmann — Chair for Photonics and Optoelectronics, Nano-Institute Munich and Department of Physics, Ludwig-Maximilians-Universität (LMU), Königinstr. 10, 80539 Munich, Germany

Non-toxic I-III-VI quantum dots (QDs) are promising candidates for next-generation light-emitting and energy-harvesting devices. However, the optical properties in these QDs are governed by subgap defects which limit their applications. Here, we synthesize AgInS2 QDs, and study them using various steady-state and time-resolved spectroscopy. Photoluminescence spectroscopy reveals that these QDs exhibit a narrow free-exciton emission and a more dominant, broad, red-shifted emission. The observed dominance arises from defects in the QDs, which introduce donor and acceptor states within the bandgap, effectively trapping electrons and holes from the band edge. A femtosecond differential transmission spectroscopy reveals an ultrafast carrier trapping time in these QDs. Additionally, a broad absorption onset with a defect-related Urbach tail is observed. We coated AgInS2 QDs with gallium sulfide, forming core/shell QDs, which significantly enhanced the intensity of the narrow free-exciton emission, reduced defect emissions, and sharpened the absorption onset by lowering the Urbach energy. These results show that the defects in these QDs are located on their surface, and Ga-S coating effectively passivates them, improving the excitonic characteristics.

HL 29.69 Tue 18:00 P1

Effects of vacancies in a bilayer graphene quantum dot — •Ivan Verstraeten, Robin Smeyers, François Peeters, and Lucian Covaci — University of Antwerp, Antwerp, Belgium

Confining the motion of an electron to the nanoscale in all three dimensions, i.e. a quantum dot (QD), sees the emergence of interesting physics and useful applications, such as single electron control or qubits. Bilayer graphene in particular, is a suitable and promising material for quantum dots owing to the many exotic properties of graphene, as well as the possibility to create and tune electronic confinement simply by applying a (position dependent) perpendicular electric field. In this work, the electronic spectrum of an electrostatically defined QD in a finite bilayer graphene flake is numerically calculated using the tight-binding model, which is compared to existing results in the literature where a low-energy continuum theory was used. The tight-binding approach allows for a straightforward implementation of vacancies in the lattice, of which the effects on the spectrum and its valley character are studied. The results show a generally good agreement between the continuum and tight-binding theory, with some interesting discrepancies. We find that vacancies enhance the inter-valley scattering, as in the magnetic field dependence of the spectrum we observe a widening of the avoided crossings between energy levels of a different valley character. Furthermore, vacancies are found to be able to significantly shift energy levels, alter the shape of the wavefunction density and make a state retain its valley mixed character even in the presence of perpendicular magnetic field

HL 29.70 Tue 18:00 P1

Towards scalable quantum circuits based on microlaser-pumped quantum emitters — •Maximilian Klonz, Aris Koulas-Simos, Léo Roche, Imad Limame, Sven Rodt, and Stephan Reitzenstein — Institut für Festkörperphysik, Technische Universität Berlin, Hardenbergstraße 36, 10623 Berlin, Germany

We report on activities towards the development of a scalable technology platform for integrated quantum photonic circuits (IQPCs) based on semiconductor quantum dots, which are deterministically integrated into photonic waveguides by in-situ electron beam lithography [1], acting as single-photon emitters. Photons, generated by these on-demand quantum emitters, serve as flying qubits in quantum communication systems and as input states for photonic quantum computing [2, 3]. Here, we present innovative technological approaches for a two-step epitaxial growth method to achieve areas with low and high density of quantum dots to further fabricate lasers and single-photon sources monolithically integrated on the same wafer. We show simulations towards a scheme for optical on-chip pumping of these single-photon emitters and first experimental results.

References
[1] P. Schnauber et al., Nano Letters 18, 2336 (2019)
[2] T. Heindel et al., Advances in Optics and Photonics 15, 613 (2023)
[3] S. Rodt and S. Reitzenstein., APL Photonics 6, 010901 (2021)

HL 29.71 Tue 18:00 P1

Duration of scattering processes on curved quantum wires — •Adrian Henrik Starke, Benjamin Schwager, and Jamal Berakdar — Martin-Luther-Universität Halle-Wittenberg, Institut für Physik

Over the last decade, the duration of quantum processes has become experimentally accessible via measurement of e.g. the Wigner time delay [1]. However, these measurements have so far only been performed in flat space. This study extends the concept of scattering time to curved, one-dimensional quantum wires. Wigner time delay and other parameters are examined for plane waves as well as wave packets constraint to propagate through these structures. The results demonstrate that the geometry-induced potentials significantly affect the scattering time, particularly at low energies, with the classical behavior emerging at higher energies. These findings offer insights into the interplay between curvature and quantum dynamics, paving the way for further analysis of scattering phenomena in complex geometries.

[1] Schulze et al., 'Delay in Photoemission'. In: Science 328 (2010), DOI: 10.1126/science.1189401

HL 29.72 Tue 18:00 P1

Towards a Quantitative Framework for Capacitance-Voltage Spectroscopy in Quantum Dot Ensembles — •Phil Julien Badura[1], Nico Frédéric Brosda[1], Ismail Bölükbaşi[1], Ibrahim Engin[1], Patrick Lindner[1], Sascha René Valentin[1], Andreas Dirk Wieck[1], Björn Sothmann[2], and Arne Ludwig[1] — [1]Lehrstuhl für angewandte Festkörperphysik, Ruhr-Universität Bochum, D-44780 Bochum, Germany — [2]Fakultät für Physik and CENIDE, Universität Duisburg-Essen, Lotharstraße 1, D-47048 Duisburg, Germany

This study investigates an inhomogeneous ensemble of quantum dots coupled to a charge reservoir using capacitance-voltage spectroscopy. Experimental measurements reveal shifts in capacitance peak positions influenced by AC frequency and temperature, with frequency-dependent shifts remaining unexplained by existing models. To address this, we develop a master equation-based theoretical model incorporating energy-dependent tunneling effects, which successfully reproduces the experimental data. Our findings emphasize the role of energy-dependent tunneling in distinct regimes: at low temperatures, energy level dispersion dominates, while at high temperatures and frequencies, shifts arise from optimized sequences of in- and out-tunneling events.

HL 29.73 Tue 18:00 P1

Experimental time-bin encoding quantum key distribution with telecom semiconductor quantum dot — •Jipeng Wang[1], Jingzhong Yang[1], Joscha Hanel[1], Zenghui Jiang[1], Vincent Rehlinger[1], Raphael Joos[2], Stephanie Bauer[2], Sascha Kolatschek[2], Eddy Rugeramigabo[1], Michael Jetter[2], Simone Portalupi[2], Michael Zopf[1,3], Peter Michler[2], and Fei Ding[1,3] — [1]Leibniz Universität Hannover, Institut für Festkörperphysik, Appelstraße 2, 30167 Hannover — [2]Institut für Halbleiteroptik und Funktionelle Grenzflächen, Center for Integrated Quantum Science and Technology (IQST) and SCoPE, University of Stuttgart, Stuttgart, Germany. — [3]Laboratorium für Nano-und Quantenengineering, Leibniz Universität Hannover, Schneiderberg 39, 30167 Hannover, Germany

Quantum Key Distribution (QKD) enables secure data transmission via quantum-generated secret keys. Semiconductor quantum dots (QDs) are promising light sources for high-speed quantum networks due to their deterministic single-photon emission. However, polarisation stability in fibre networks is often disrupted by environmental factors. Here, we demonstrate a stable QKD scheme using time-bin qubits derived from polarised photons emitted by a QD in the telecommunication C-band. A 16-bit pseudo-random sequence is encoded via a Sagnac-loop interferometer and decoded using an unbalanced Mach-Zehnder interferometer after transmission through 80 km of fibre. This study highlights QDs' potential for scalable, robust quantum networks.

HL 29.74 Tue 18:00 P1

Experimental time-bin encoding quantum key distribution with telecom semiconductor quantum dot — •Jipeng Wang[1], Jingzhong Yang[1], Joscha Hanel[1], Zenghui Jiang[1], Vincent Rehlinger[1], Raphael Joos[2], Stephanie Bauer[2], Sascha Kolatschek[2], Eddy Rugeramigabo[1], Michael Jetter[2], Simone Portalupi[2], Michael Zopf[1,3], Peter Michler[2], and Fei Ding[1,3] — [1]Leibniz Universität Hannover, Institut für Festkörperphysik, Appelstraße 2, 30167 Hannover — [2]Institut für Halbleiteroptik und Funktionelle Grenzflächen, Center for Integrated Quantum Science and Technology (IQST) and SCoPE, University of Stuttgart, Stuttgart, Germany. — [3]Laboratorium für Nano-und Quantenengineering, Leibniz Universität Hannover, Schneiderberg 39, 30167 Hannover, Germany

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HL 29.75 Tue 18:00 P1

Cyclic Growth of InAs Quantum Dots: Exploring Structure-Property Relations for Telecom O-Band Applications — •Lennart Anderson[1,2], Danial Kohminaei[1], Severin Krüger[1,3], Marcel Schmidt[1], Nikolai Spitzer[1], Peter Zajac[1,4], Andreas Wieck[1], and Arne Ludwig[1] — [1]Angewandte Festkörperphysik, Ruhr-Universität Bochum — [2]ICAMS, Ruhr-Universität Bochum — [3]Sparrow Quantum ApS, Copenhagen — [4]Gesellschaft für Gerätebau mbH, Dortmund

Quantum dots (QDs) are promising single-photon emitters that could transform long-range quantum communication within telecom optical fiber transparency windows. In this study, we grow self-assembled InAs QDs using the Stranski-Krastanov growth mode, enhanced by a strain reduction layer to achieve emission at 1.3 μm in the telecom O-band. By employing cyclic sub-monolayer deposition, we observe periodic modulations in QD density, emission wavelength, and geometric properties, driven by nucleation waves, i.e. a new generation of QDs is formed each time a critical material amount for nucleation is reached. We explore the correlations between the structural characteristics and opto-electronic properties by atomic force microscopy and photoluminescence as well as capacitance-voltage spectroscopy. Our results identify optimal regions for QD density and emission wavelength across 3-inch wafers and propose a modified deposition scheme to enhance the usable area of the wafers.

HL 29.76 Tue 18:00 P1

Statistical spectroscopy of perovskite quantum dots — •Christopher Borchers[1], Frederik Benthin[1], Tom Rakow[1], Pengji Li[1], Maximilian Heller[1], Chenglian Zhu[2,3], Ihor Cherniukh[2,3], Gabriele Rainò[2,3], Maksym Kovalenko[2,3], Michael Zopf[1,4], and Fei Ding[1,4] — [1]Leibniz Universität Hannover, Institut für Festkörperphysik, Appelstraße 2, 30167 Hannover — [2]Institute of Inorganic Chemistry, Department of Chemistry and Applied Biosciences, ETH Zürich, CH-8093 Zürich, Switzerland — [3]Laboratory for Thin Films and Photovoltaics, Empa - Swiss Federal Laboratories for Materials Science and Technology, CH-8600 Dübendorf, Switzerland — [4]Laboratory of Nano and Quantum Engineering, Leibniz University Hannover, Schneiderberg 39, D-30167 Hannover, Germany

The ability to perform fast and automated photoluminescence (PL) spectroscopy measurements greatly improves the efficient development of quantum light emitters and their optimization in quantum technologies.

We adopt and semi-automate standard low temperature optical characterization measurements for lead halide perovskite colloidal quantum dots. Here, PL spectroscopy on CsPbBr3 samples is used to characterize the emission spectrum, polarization properties, and fine structure, and to perform corresponding automated statistical analyses of these measurements. For these analyses, we have developed a program that processes PL spectral data, automatically detecting and fitting emission peaks for subsequent evaluation.

HL 29.77 Tue 18:00 P1

SUPER drived quantum dot at telecom wavelength — •Zenghui Jiang[1], Vikas Remesh[2], Frederik Benthin[1], Michael Zopf[1], and Fei Ding[1] — [1]Leibniz Universität Hannover, Institut für Festkörperphysik, Appelstraße 2, 30167 Hannover — [2]Department of Experimental Physics University of Innsbruck Technikerstr. 25d, Office 01/503 6020 Innsbruck, Austria

To obtain the best photon properties from quantum dots (QDs),a direct drive between the S-shell and ground state (resonance excitation) is required. However, since the excitation laser and the emitted wavelength are very close to each other, filtering out the laser becomes highly challenging. A theoretical study conducted in 2021 by Prof. Doris Reiter's group predicted that with two relatively detuned laser pulses, full population inversion can still be achieved without interacting with other energy levels. Consequently, photon properties comparable to those achieved through resonance excitation can be expected.

To efficiently drive QDs, two temporally overlapping laser pulses with different frequencies are needed. Compared to using two separate lasers for "SUPER" excitation, employing a single laser with a pulse shaper eliminates the need for synchronization between two lasers. However, until now, no experiment using a single laser with a pulse shaper has been performed on telecom-wavelength QDs. In our work, we constructed a pulse shaper using a spatial light modulator to generate two sharply defined laser pulses from a single broadband laser pulse,and successfully *SUPER* excited QD at telecom wavelength.

HL 29.78 Tue 18:00 P1

Fabrication of Ohmic contact for Electrical tuning of GaAs quantum dots — •Krupali Dobariya[1], Tom Fandrich[1], Yiteng Zhang[1], Johann Dzeik[1], Arijit Chakraborty[1], Tom Rakow[1], Sulabh Shrestha[1], Doaa Abdelbarey[1], Eddy P. Rugeramigabo[1], Michael Zopf[1,2], and Fei Ding[1,2] — [1]Leibniz Universität Hannover, Institut for Solid State Physics, Hannover, Germany — [2]Leibniz Universität Hannover, Laboratorium for Nano and Quantum Engineering, Hannover, Germany

Semiconductor quantum dots have shown unique properties as deterministic single photon and entangled photon pair sources. Their outstanding optical properties have the potential for use in quantum applications like quantum communication, quantum key distribution and quantum computing. Nevertheless, due to the stochastic nature of the self-assembly growth process, quantum dots typically emit photons with a broad wavelength distribution across the entire chip, posing challenges for applications requiring specific wavelengths. To address this issue, various tuning techniques have been developed. Electrical tuning, in particular, has emerged as an effective method for adjusting the wavelength and mitigating charge noise in semiconductor quantum dots. Our research focuses on the impact of contact fabrication on the emission properties of GaAs quantum dots. We aim to optimize the process of forming ohmic contacts to n- and p-doped GaAs, placing special emphasis on the selection of materials and the reduction of contact resistance. The quality and performance of the electrical contacts are evaluated through the photoluminescence characterization.

HL 29.79 Tue 18:00 P1

Marker-based deterministic EBL integration of GaAs quantum dots (QDs) into electrically tunable Circular Bragg Gratings (eCBGs) at a wavelength of 780 nm — •Dinara Basharova[1], Mudi Priyabrata[1], Avijit Barua[1], Setthanat Wijitpatima[1], Andreas D. Wieck[2], Sven Rodt[1], Arne Ludwig[2], Richard Warburton[3], and Stephan Reitzenstein[1] — [1]Institute of Solid State Physics, Technische Universität Berlin, D-10623 Berlin, Germany — [2]Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, DE-44780 Bochum, Germany — [3]Department of Physics, University of Basel, Klingelbergstrasse 82, CH-4056 Basel, Switzerland

Integration of high-quality quantum emitters with photonic structures is essential for advancing quantum information technologies. We present a marker-based deterministic electron beam lithography (EBL) technique to integrate Gallium Arsenide (GaAs) quantum dots (QDs) into electrically contacted Circular Bragg Gratings (eCBGs) at an emission wavelength of 780 nm, combined with a PIN-diode structure. eCBG devices not only enhance the photon extraction efficiency through a circularly symmetric cavity design but also provide precise electrical control over the QD emission. This enables fine-tuning of the wavelength, addressing spectral mismatches, and stabilizing the charge environment around the QD, critical for high-performance quantum light sources. Therefore, combining the eCBG design with deterministic fabrication techniques ensures that the QDs are precisely positioned at the cavity center, maximizing light-matter interaction.

HL 29.80 Tue 18:00 P1

Laboratory management software: Plexy : Python Library for EXperimental Physics — •Frederik Benthin, Christopher Borchers, Nico Eggeling, Tom Fandrich, Dolores García de Viedma, Joscha Hanel, Maximilian Heller, Martin Hesse, Kai Hühn, Johannes Knollmann, Marcel Pölking, Tom Rakow, Eduard Sauter, Pavel Sterin, Fei Ding, Jens Hübner, and Michael Zopf — Leibniz Universität Hannover, Institute of Solid-State Physics, Appelstraße 2, 30167 Hannover

Measurements often involve complex protocols requiring the coordination of many different devices. Laboratory management or measurement software such as Qudi and NOMAD-CAMELS assist in performing these tasks. It provides a framework for easier collaboration and sharing of resources. It often includes a standalone graphical user interface (GUI). This GUI controls new compound instruments consisting of several devices and can be used to coordinate the measurement. Different projects often improve an additional aspect, such as NOMAD-CAMELS with metadata collection or MAHOS with messaging between distributed devices. Here we present Python Library for EXperimental Physics (Plexy), which is a highly modular repository of Python modules. Among the main design goals are automatic metadata recording, distributed device coordination, modular and flexible but standardized code organization as well as independent and common GUIs. An analyzer GUI performs common analyses specific to photoluminescence spectroscopy and time-correlated single-photon counting of quantum dot single-photon sources.

HL 29.81 Tue 18:00 P1

Signatures of the quantum skyrmion Hall effect in the Bernevig-Hughes-Zhang model — •Reyhan Ay, Adipta Pal, and Ashley M. Cook — Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Strasse 38, 01187 Dresden, Germany

Given the recent discovery of the quantum skyrmion Hall effect (QSkHE) revealing that the 2+1 D SU(2) gauge theory should be generalized to include terms from an underlying 4+1 D SU(2) gauge theory subjected to generalized fuzzification, we re-examine the canonical Bernevig-Hughes-Zhang (BHZ) model for the quantum spin Hall insulator (QSHI). Considering that the isospin degrees of freedom in the tight-binding model Hamiltonian effectively encode two additional spatial dimensions, we identify signatures of topological states within the QSkHE framework related to intrinsically 4+1 D topological phases revealed by breaking time-reversal symmetry through a weak Zeeman field. We identify distinctive real-space boundary orbital angular momentum textures due to the QSkHE, as well as gapless boundary modes that are robust against magnetic disorder, which is unexpected for a QSHI but predictable for compactified boundary 3D Weyl nodes in a topological skyrmion phase. Revisiting experimental work on robust edge conduction in HgTe quantum wells under Zeeman and orbital magnetic fields, we find these results consistent with theoretical predictions of compactified boundary 3D Weyl nodes to such external fields. These experiments are thus potentially the first-known experimental observation of the quantum skyrmion Hall effect.

HL 29.82 Tue 18:00 P1

Side-contacted narrow superconducting finger on quantum anomalous Hall insulator — •Bibek Bhujel, Anjana Uday, Gertjan Lippertz, Alexey A. Taskin, and Yoichi Ando — Physics Institute II, University of Cologne, Zülpicher Str. 77, 50937 Köln, Germany

Recently, the evidence for superconducting pair correlation is obtained in the chiral edge states of a vanadium-doped $(Bi_xSb_{1-x})_2Te_3$ thin film, tuned to the quantum anomalous Hall insulator phase by observing the negative nonlocal resistance downstream from a narrow superconducting (grounded) Nb finger electrode fabricated on the top [1]. This negative downstream resistance is due to the crossed Andreev reflection (CAR) process, which creates superconducting correlations in the chiral edge. To investigate this observation further, we are currently fabricating side-contacted Al and Nb finger electrodes on the etched QAHI. One of the main advantages of fabricating the side-contacted electrodes is their low contact resistance, which has high reproducibility. We will report on our progress on this project so far.

[1] Uday, A., Lippertz, G., Moors, K. et al. Induced superconducting correlations in a quantum anomalous Hall insulator. Nat. Phys. 20, 1589*1595 (2024). https://doi.org/10.1038/s41567-024-02574-1

HL 29.83 Tue 18:00 P1

Anomalous Hall effect in a two-dimensional disordered Lorentz gas — •Frederik Bartels[1], Zakaria Harroud[1], Beate Horn-Cosfeld[1], Mihai Cerchez[1], Jürgen Horbach[2], and Thomas Heinzel[1] — [1]Condensed Matter Physics Laboratory, Heinrich Heine University, Düsseldorf, Germany — [2]Theoretical Physics II: Soft Matter, Heinrich Heine University, Düsseldorf, Germany

Using a combination of experiment and simulation, it was studied the magnetotransport in a two-dimensional disordered Lorentz gas with cross-shaped obstacles. Our focus is on the investigation of the Hall effect for obstacle densities beyond the low-density limit. From previous studies, we know that for lower obstacle densities, the magnetotransport properties, as obtained from the simulation and the experiment of a pristine sample, can be well described in terms of the Drude-Boltzmann model. At higher obstacle densities, deviations from the normal Hall effect are observed, depending on both obstacle density and magnetic field. These results extend previous studies on circular obstacles, where similar deviations were observed and the Hall coefficient does not accurately reflect the electron density because of the presence of memory effects. [1]

[1] B. Sanvee *et al.* Phys. Rev. B **108**, 035301 (2023)

HL 29.84 Tue 18:00 P1

Accelerated Electrical Transport Predictions of the Non-Perturbative ab initio Kubo-Greenwood Method via a Deep-learned Hamiltonian technique: Strongly Anharmonic Material Cases — •Juan Zhang, Jingkai Quan, Matthias Scheffler, and Kisung Kang — The NOMAD Laboratory at the FHI of the Max Planck Society, Berlin, Germany

High-performance thermoelectric materials are characterized by low thermal and high electrical conductivities. Thermal insulators with ultra-low thermal conductivity feature strong anharmonicity, also significantly affecting electronic transport [1]. Strong anharmonicity impedes the application of perturbative methods due to the breakdown of the quasi-particle picture. This challenge can be overcome by the non-perturbative ab initio Kubo-Greenwood approach (aiKG)[1]. However, the aiKG method requires substantial computational cost due to its extensive supercell electronic structure evaluations at each step during ab initio Molecular Dynamics (aiMD). A recent deep neural network technique to train and predict the Kohn-Sham Hamiltonian, implemented by DeepH[2], can provide an efficient bypass to extract the electronic structure of each MD step with nearing ab initio accuracy. This work introduces an AI-assisted aiKG formalism with accelerated carrier mobility evaluations, exemplified by its application to strongly anharmonic materials. We thoroughly examine DeepH's capability for electronic property predictions with its spatial scalability.

[1] J. Quan et al., Phys. Rev. B, accepted (arXiv:2408.12908).
[2] X. Gong, et al., Nat Commun. 14, 2848 (2023).

HL 29.85 Tue 18:00 P1

Magnetotransport in the correlated metal $CaVO_3$ — •Olivio Chiatti[1], Mahni Müller[1], Maria Espinosa[1], Tatiana Kuznetsova[2], Roman Engel-Herbert[2,3], and Saskia F. Fischer[1,4] — [1]Novel Materials Group, Humboldt-Universität zu Berlin, 10099 Berlin, Germany — [2]Department of Materials Science and Engineering, The Pennsylvania State University, University Park, PA 16802, USA — [3]Paul-Drude-Institut für Festkörperelektronik, 10117 Berlin, Germany — [4]Center for the Science of Materials Berlin, Humboldt-Universität zu Berlin, 12489 Berlin, Germany

Transparent conductive materials are in great demand in the optoelectronic industry for their high-performance and cost-effectiveness. Enhancing the carrier effective mass through strong electron-electron interactions in correlated metals is a promising approach to achieve both high-optical transparency and high-electrical conductivity [1]. Here, we study the electric transport properties of thin $CaVO_3$ films grown on $LaAlO_3$ substrates by hybrid molecular beam epitaxy, with residual resistivity ratio (RRR) up to 98 [2]. Magnetoresistance and Hall measurements were performed between 50 mK and 300 K. Films with high RRR show nonlinear Hall resistivities and linear magnetoresistance below 40 K. Shubnikov-de Haas oscillations are also observed for magnetic fields above 6 T. The application of a multi-carrier model and the complex Fermi surface of $CaVO_3$ are discussed.

[1] Zhang *et al.*, Nature Materials **15**, 204 (2016)
[2] Kuznetsova *et al.*, APL Materials **11**, 041120 (2023)

HL 29.86 Tue 18:00 P1

Selenium, Silicon and SiC power diodes as temperature sensors, operated in different voltage regimes and under extreme conditions — •Heinz-Christoph Neitzert, Arpana Singh, and Vincenzo Carrano — Dept. of Industrial Engineering (DIIn), Salerno University, Via Giovanni Paolo II 132, 84084 Fisciano (SA), Italy

Commercial semiconductor temperature sensors are nowadays mostly based on silicon diodes and transistors, operated under constant forward current conditions. We compared the temperature sensing capabilities of a series of different power diodes from different materials not only in the forward, but also in the reverse bias and in one example also in the breakdown voltage regime. All investigated devices, including the historical Se rectifiers, showed stable temperature sensing capabilities in the forward bias regime under moderate temperature changes. Some of them have been tested under extreme conditions like extreme temperatures and particle irradiation. In particular it is shown in the case of the SiC Schottky diodes, that the excellent temperature sensing properties are also maintained after irradiation with high energy ions. In the case of Silicon pn diodes the sensitivity as sensor in the forward voltage and avalanche breakdown regime has been determined. In both regimes the sensors showed very good linear characteristics, when biased under constant current conditions. For Silicon diodes, also the temperature limit, where no irreversible device changes are observed has been determined and the defect creation for higher temperatures has been monitored.

HL 29.87 Tue 18:00 P1

Structural Dynamics of Excimer Formation in single crystalline α-Perylene — •Helena Hollstein[1], Simon Versmissen[2], Bram Spijkerman[2], Heinrich Schwoerer[2], and Sebastian Hammer[1] — [1]University of Würzburg, 97074 Würzburg, Germany — [2]Max-Planck-Institut für Struktur und Dynamik der Materie, 22761 Hamburg, Germany

In the field of organic semiconductors an exact understanding of the formation of multi-molecular excited states, such as excimers, and geometric inter-molecular changes caused thereby, is crucial but challenging. Quantum chemical methods are in principle able to capture all structural changes during excimer formation but are hardly feasible due to the complexity of organic crystals. Experimentally on the other hand, the molecular motion can be detected by ultra-fast electron diffraction (UED) on a femtosecond timescale [1], and by using structural modeling the molecular movement can be reconstructed from changes in the diffraction pattern [2].

In this contribution we examine the structural reorganization during the formation of the low lying excimer state in single crystalline perylene in its crystallographic α-phase by means of UED. We are able to reveal the pathways of the geometric relaxation during the excimer formation on a fs timescale and find that the formation happens on a 5 ps timescale.

HL 29.88 Tue 18:00 P1

All-optical spin injection in silicon investigated by element-specific time-resolved Kerr effect — Simone Laterza[1,2], Antonio Caretta[1], •Richa Bhardwaj[1,3], Roberto Flammini[4], Paolo Moras[5], Matteo Jugovac[5], Piu Rajak[6], Mahabul Islam[6], Regina Ciancio[6], Valentina Bonanni[1], Barbara Casarin[2], Alberto Simoncig[1], Marco Zangrando[1,6], Primož R. Ribič[1], Giuseppe Penco[1], Giovanni De Ninno[1], Luca Giannessi[1], Alexander Demidovich[1], Miltcho Danailov[1], Fulvio Parmigiani[1], and Marco Malvestuto[1,6] — [1]Elettra Sincrotrone Trieste, Italy — [2]University of Trieste, Italy — [3]Institute of Physics and Center for Nanotechnology (CeNTech), University of Münster, 48149 Münster, Germany — [4]Istituto di Struttura della Materia-CNR (ISM-CNR), Roma, Italy — [5]Istituto di Struttura della Materia-CNR (ISM-CNR), Trieste, Italy — [6]Istituto Officina dei Materiali (CNR-IOM), Trieste, Italy

Understanding how a spin current flows across metal-semiconductor interfaces at pico- and femtosecond time scales is of paramount importance for ultrafast spintronics, storage applications etc. However, the possibility to directly access the propagation of spin currents, within such time scales, has been hampered by the simultaneous lack of both ultrafast element-specific magnetic sensitive probes and tailored well-built and characterized metal-semiconductor interfaces. Here, by means of a novel free-electron laser-based element-sensitive ultrafast time-resolved Kerr spectroscopy, we reveal different magnetodynamics for the Ni $M_{2,3}$ and Si $L_{2,3}$ absorption edges.

HL 29.89 Tue 18:00 P1

Implementation and operation of a fiber-coupled CMOS detector for time-resolved photoemission electron microscopy — •Philipp Kessler[1], Johanna Kinder[1], Victor Lisinetskii[1], Torsten Franz[2], Florian Schütz[2], Matthias Hensen[1], and Tobias Brixner[1] — [1]Institut für Physikalische und Theoretische Chemie, Universität Würzburg, Am Hubland, 97074 Würzburg — [2]ELMITEC Elektronenmikroskopie GmbH, 38678 Clausthal-Zellerfeld

Since their invention, low-energy electron microscopy (LEEM) and photoemission electron microscopy (PEEM) have predominantly relied on microchannel plates for electron detection and image generation. Recent developments in detector technology allow the LEEM-PEEM community to use pixel- [1] and fiber-based [2] detectors that have a small detection pixel size, avoid blooming effects, and have an extended dynamic range. These advancements are particularly beneficial for ultrafast time-resolved experiments with weak signals. Here, we present the integration of the fiber-coupled CMOS detector XF416 (TVIPS GmbH, Germany) into an Elmitec AC-LEEM III system. This includes a structural solution to address the detector's inability to undergo bake-out, a critical step for achieving ultrahigh vacuum conditions. The first-time operation of the new detector unit is demonstrated through time- and energy-resolved PEEM measurements on terrylene bisimide-based molecular thin films, enabling the study of exciton dynamics at the nanoscale.

[1] G. Tinti et al., J. Synchrotron Rad. 24, 963 (2017).
[2] D. Janoschka et al., Ultramicroscopy 221, 113180 (2021).

HL 29.90 Tue 18:00 P1

Experimental scheme for high-order fluorescence-detected pump–probe micro-spectroscopy on monolayer MoS_2 — •Ruidan Zhu, Patrick Grenzer, Simon Büttner, Matthias Hensen, Tobias Hertel, and Tobias Brixner — Institut für Physikalische und Theoretische Chemie, Universität Würzburg, Am Hubland, 97074 Würzburg, Germany

Monolayers of transition metal dichalcogenides (TMDCs) are two-dimensional (2D) semiconductors with fascinating optoelectronic properties. However, exciton–exciton interaction (EEI) sets a fundamental limit to optimizing the quantum efficiency of 2D materials under high exciton densities. In particular, EEI processes are frequently mixed with single-exciton dynamics, thereby complicating the elucidation of their underlying mechanisms. Here, we apply fluorescence-detected pump–probe spectroscopy [1] in a cryomicroscope to detect the exciton dynamics of monolayer MoS_2. By incorporating the high-order separation methods that we recently developed [2], we aim to isolate EEI dynamics from the single-exciton dynamics, other higher-order signal contributions, and non-resonant substrate responses. We present the fundamental concept, the experimental setup, and the first data.

[1] P. Malý and T. Brixner, Angew. Chem. Int. Ed. 2021, 60, 18867.
[2] P. Malý et al., Nature 2023, 616, 280.

HL 29.91 Tue 18:00 P1

Detection Strategies for Highspeed Impulsive Stimulated Raman Scattering — •Laura Hüllmandel, Julia Lang, and Georg Herink — Universität Bayreuth

Impulsive stimulated Raman scattering is an established method for resolving transient coherent superpositions of optical phonons in matter. Inside a laser cavity, however, this nonlinear interaction between multiple ultrashort temporal solitons can accumulate and determine their trajectories [1]. In this contribution, we study different regimes of the coupling between solitons via optical phonons. Based on extra-cavity spectroscopic experiments on crystalline media, we compare interferometric and spectrally-resolved sampling modes and, in particular, we discuss practical aspects in enhancing Raman signal quality. These new insights contribute to the understanding of phonon-driven soliton coupling and the development of time-domain intra-cavity Raman spectroscopy.

[1] A. Völkel et al., "Intracavity Raman Scattering Couples Soliton Molecules with Terahertz Phonons.", Nature Communications 13.1 (2022).

HL 29.92 Tue 18:00 P1

Two-dimensional spectroscopy setup for the investigation of excitons and polaritons in 2D materials — •Trideep Kawde, Pavel Trofimov, Matteo Russo, Anton Trenczek, David Koch, and Hélène Seiler — Freie Universität Berlin, 14195, Berlin, Germany

Coherent two-dimensional (2D) electronic spectroscopy is a powerful tool for probing interactions between electronically excited states and map their evolution in both energy and time domains. Here we introduce a coherent two-dimensional spectrometer tunable over the 460-950 nm spectral range to investigate the exciton and polariton dynamics in 2D materials. We employ a hollow-core fiber setup for broadband visible continuum generation. Pulse shapers are used to produce phase-locked sequences of pulses. A custom sample area has been designed specifically for 2D materials, typically featuring high degrees of spatial inhomogeneity and small sizes (few tens of micrometers). Linear spectroscopies can be performed at the same position as the 2D spectroscopy experiments, including angle-resolved spectroscopy to investigate polariton dispersion. With our setup we will be able to reveal insights into excitonic and polaritonic properties in 2D materials.

HL 29.93 Tue 18:00 P1

Measurement of ultrashort electron pulse durations using a transient electric field — •Lukas Nöding, Arne Ungeheuer, Ahmed Hassanien, Mashood Tariq Mir, Thomas Baumert, and Arne Senftleben — University of Kassel, Institute of Physics, Kassel, Germany

Ultrafast electron diffraction is a well-known method for conducting time-resolved measurements on molecules and condensed matter. In this approach, electron diffraction is performed with an electron pulse at a variable time after optical excitation of the sample. The duration of the electron pulse directly determines the temporal resolution. A streaking setup utilizing free electrons is implemented to measure the duration of the electron pulse. Therefore, a transient electron deflector, was designed. Its main feature is a metal surface parallel to the path of the electron pulse. A femtosecond laser pulse is focused from the side onto this metal surface. As the beam incides, electrons are released from the metal. Due to their momentum, they separate from the surface, create an electric field perpendicular to the surface and then recombine. The build-up and the subsequent fading of this transient electric field is used to streak the electron pulse, because different electrons in the pulse experience different field strengths. By that, the duration of the pulse is mapped into a spatial broadening of the pulse. The broadening is captured by the detector as a streak. We will show results measured with different numbers of electrons per pulse and compare them with simulations. Moreover, the evaluation process and the fitting algorithms for the electron streak will be explained.

HL 29.94 Tue 18:00 P1

Ultrafast dynamics reveal proximity induced changes in Graphite — •Mashood Tariq Mir, Ahmed Hassanien, Arne

Ungeheuer, Lukas Nöding, Arne Senftleben, and Thomas Baumert — University of Kassel, Institute of Physics, D-34132 Kassel, Germany

Layered transition metal dichalcogenides (TMDs) are at the forefront of materials research due to their diverse electronic and structural properties. Among these materials, 1T-TaS2 exhibits a complex temperature-dependent phase diagram characterized by charge density waves (CDWs) of varying commensurabilities. When integrated into heterostructures, novel interfacial phenomena emerge, enabling the study of proximity effects in atomically thin materials. This work investigates the light-induced dynamics of a van der Waals heterostructure composed of 1T-TaS2 and graphene using ultrafast electron diffraction (UED). Femtosecond laser pulses induce rapid structural changes, revealing a proximity-induced CDW in graphene. This observation demonstrates how interfacial coupling can imprint the characteristic periodic lattice modulation of CDWs onto an otherwise non-CDW material. By controlling lattice heating, we probe the reversible phase transition of 1T-TaS2 from the nearly commensurate to the incommensurate phase and its influence on the interfacial properties of the heterostructure.

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Determination of Arrival Time in Ultrafast Electron Diffraction in Specimen Close Proximity with High Accuracy — •Ahmed Hassanien, Mashood Tariq Mir, Arne Ungeheuer, Lukas Nöding, Arne Senftleben, and Thomas Baumert — University of Kassel, Institute of Physics, 34132 Kassel, Germany

The ability to determine time zero in a pump-probe experiment qualitatively indicates its ability to capture dynamics and quantitatively serves as a measure of its temporal resolution. There are only a few methods for determining the time zero in ultrafast electron diffraction (UED) [1,2]. Here, we propose a robust and easy-to-implement method to determine time zero in the immediate vicinity of the sample with sub-picosecond accuracy using Fourier-transformed electron micrography (FT-EM). In the same analogy as the Debye-Weller effect in crystalline solids, the attenuation of the peak amplitude in FT-EM patterns for a metal grid blurred by femtosecond optically-induced transient electrostatic lensing (TEL) allowed us to determine time zero to better than 500 fs. To demonstrate our method, we measured the time zero in the vicinity of a graphite flake, for which we also performed a routine UED measurement by exciting with the same optical pump fluence, well below the damage threshold for either material. Using the accurately determined time zero, we were able to identify the earlier onset of the out-of-plane coherent optical phonon mode in graphite. References: [1] Olshin, Pavel K., et al. APL 120.10 (2022). [2] Dwyer, Jason R., et al. Philos. Trans. of the Royal Society A: Math., Phys. and Eng. Sci. 364.1840 (2006): 741-778.

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Investigation of dynamics and character of excitons in WSe_2 multilayers — •Anna Weindl[1], Matthias Brem[1], Jennifer Lehner[1], Kenji Watanabe[2], Takashi Taniguchi[3], and Christian Schüller[1] — [1]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, 93053 Regensburg — [2]Research Center for Functional Materials, National Institute for Materials Science, Tsukuba Ibaraki 305-0044, Japan — [3]International Center for Materials Nanoarchitectonics, National Institute for Materials Science, Tsukuba Ibaraki 305-0044, Japan

We report about our time-resolved Faraday ellipticity (TRFE) experiments on multilayers of the transition metal dichalcogenide WSe_2. In a continuation of our recent work by Raiber et al. [1], we aim to investigate the nature of the temporal dynamics in WSe2 multilayers. These previous results have shown that pseudospin oscillations appear in the TRFE signal when we apply an in-plane magnetic field to our multilayer samples. Current results show that the oscillations have two different frequencies, a shorter one earlier in time and a longer one later in time. In differential transmission measurements, the lifetimes show a fast and slow decay on the same time scales. This suggests two different exciton dynamics or species. Now we try to characterize and manipulate these oscillations by playing with different experimental parameters. Varying the angle of the magnetic field, adding an electric field or investigating the layer dependence are examples for our toolbox of parameters to gain further insights in the dynamics of the multilayers. [1] Raiber et al., Nat Commun 13, 4997 (2022).