XXXVIIIth International Winterschool on Electronic Properties of Novel Materials

Molecular Nanostructures

Program

IWEPNM 2026

Hotel Sonnalp
Kirchberg/Tirol
Austria

28 Feb - 06 Mar, 2026

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This year's logo of the IWEPNM shows a Moiré pattern on a bilayer graphene.

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Financial assistance from the sponsors and supporters is greatly acknowledged.

Dear Friend:

Welcome to the 38th International Winterschool on:

Electronic Properties of Novel Materials!

This Winterschool is a sequel of thirty-seven previous meetings held in Kirchberg in the last decades on problems related to the electronic structure of novel materials. The idea of the meeting is to bring together experienced scientists from universities and industry with advanced students working in the selected field and thus create a fruitful and prosperous community for the exchange of scientific information and personal experience. It is a tradition of the Winterschools in Kirchberg that this exchange is not restricted to the lectures and poster sessions but occurs throughout the whole week.

The Winterschool is dedicated to molecular nanostructures as a new class of materials. Like the previous Winterschools it runs on an informal level.

If you have any questions concerning the organization and the program, come and see one of us or one of the colleagues involved in the preparation of the meeting. These persons are:

Program	Stephanie Reich
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Daily Information Poster	Elena Stroici & Jose Andres Arcos Pareja
Conference Publications	Antonio Setaro
Visa	Angelin See

Also the manager of the hotel, Stefan Leppert, and his staff promised to help us wherever they can. We want to acknowledge their help.

We wish you an interesting, successful, and pleasant week in Kirchberg. We are very much looking forward to your contributions at the event.

Sincerely yours,
Stephanie, Sebastian, Janina, Andreas, and Christoph

Chairpersons

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S. Heeg (Berlin)
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Scope

This winterschool will provide a platform for reviewing and discussing new developments in the field of electronic properties of molecular nanostructures and their applications. The scope of the winterschool covers experimental and theoretical work in the following fields:

- Materials science of graphene, nanographene, and carbon nanotubes
- Novel two-dimensional materials
- Optics, electronics, growth, and selection of carbon nanotubes and graphene
- Theory of novel materials
- Applications of novel materials
- Nanostructure spintronics
- Topological materials
- Plasmonic nanostructures
- Single-molecule experiments

INFORMATION FOR PARTICIPANTS

Time and location
The IWEPNM 2026 starts on Saturday, 28 February, evening, at the hotel Sonnalp in Kirchberg/Tirol, Austria and extends to Friday, 6 March, breakfast. The welcome reception takes place in the Sonnalp hotel lobby on Saturday evening at 9.00 pm. On the last evening (Thursday) we will have a farewell dinner in the seminar hall at 7.30 pm.

Transport
The hotel Sonnalp can be reached by private car from downtown Kirchberg by driving about one kilometer towards Aschau. Participants arriving at the railway station in Kirchberg or Kitzbühel should hire a taxi to get to the hotel.

Addresses
The address of the Winterschool is:
IWEPNM 2026 Hotel Sonnalp, A-6365 Kirchberg/Tirol, Austria
e-mail: info@hotelsonnalp.info, web: `www.hotelsonnalp.info`

All questions concerning the IWEPNM 2026 should be directed to:

Prof. Dr. Stephanie Reich,
Fachbereich Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany
email: iwepnm@posteo.de, web: `https://iwepnm.org/event/2026/`

Participation
Participation at the IWEPNM 2026 is possible for students and scientists working in the field covered by the scope of the meeting. Because of the limited space the participation requires prearranged acceptance by the organizers.

Contributions
All oral contributions will be presented in the big seminar room of the Hotel Sonnalp. All participants are invited to contribute comments to research and tutorial lectures, where 10 minutes for discussion are reserved within each lecture. Video projection will be available for presentations. Invited speakers please test the video projection with the technical staff at the latest a few minutes before your session begins. Posters will be presented in the hall of the seminar room. **We kindly ask you NOT to take any pictures or videos of the presentations.**

Childcare
Childcare is provided by Michaela Kisch (michaela@kitzkids.com). If you need childcare during the winterschool, please contact us at the registration desk.

Ski pass and internet connection
If you wish to buy a ticket for the ski lifts, please ask at the hotel reception.
Internet connection through WLAN is available for all participants, even if they are not accommodated at the Hotel Sonnalp. Please check at the front desk.

Poster awards
There will be a poster award for the best poster presentation in each poster session on Sunday, Monday, and Wednesday. Poster awards are kindly provided by Wiley VCH.

Conference Publication
IWEPNM presenters are cordially invited to contribute to the **Special Collection "Electronic Properties of Novel Materials"** that traditionally resides on the homepage of the journal *physica status solidi (b)* and is extended every year.

The collection encompasses articles in the journals *physica status solidi (b)*, *physica status solidi (RRL) – Rapid Research Letters*, and *Advanced Electronic Materials*. These three journals feature a designated special section "Electronic Properties of Novel Materials" to select in the manuscript submission process. Papers published in other journals of Wiley´s Advanced journal group may also be added to the collection.

The journals publish Research Articles and Reviews. Accepted manuscripts will fulfill the standards and requirements of the journal and are peer-reviewed in the same way as regular submissions. Acceptance of a contribution for presentation at the winterschool does not automatically include acceptance for publication in the special issue. Each article will be published on an individual timescale without delay and be added to the Special Collection once it is online in the regular journal content.

Presenters will receive an individual invitation launched from the editorial system of *physica status solidi (b)* with a direct upload link. Please notify the editorial office at pssb@wiley-vch.de if you choose another journal to ensure inclusion in the special collection. **Note that the journals have transitioned to a new editorial system on the Research Exchange platform that requires a one-time registration for a Connect profile!**

Manuscript submission is due on May 31st.

Please reach out to the staff editors at pssb@wiley-vch.de and the guest editors at iwepnm-publication@physik.fu-berlin.de.

IWEPNM 2026
CHAIRPERSONS FOR THE ORAL SESSIONS

The following participants are asked to support the program of the Winterschool by serving as chairperson:

Sunday, 01.03.	morning	Janina Maultzsch
	morning, after coffee break	Ralph Krupke
	evening	Claudia Backes
Monday, 02.03.	morning	Kin Fai Mak
	morning, after coffee break	Anna Seiler
	evening	Hui-Ming Cheng
Tuesday, 03.03.	morning	Andreas Hirsch
	morning, after coffee break	Viera Skakalova
	evening	Sofie Cambre
Wednesday, 04.03.	morning	Eduardo Barros
	morning, after coffee break	Sebastian Heeg
	evening	Roman Gorbachev
Thursday, 05.03.	morning	Christoph Stampfer
	morning, after coffee break	Astrid Weston
	evening	Stephanie Reich

Chairpersons are asked to start the sessions in time and **to terminate the lectures according to schedule**. The discussions may be extended up to 5 minutes beyond the schedule.

Chairpersons please remember:
You have to ask for questions from the sideroom (bar)!

For questions from the main room please ask the speaker to repeat the question. The chairperson's microphone should only be passed on to questions from the first row.

If there are any objections to the suggested list of chairpersons, please let us know at the beginning of the Winterschool.

We acknowledge your support. The Organizers

DAILY PROGRAM

AND

ABSTRACTS

08:30 – 09:30	Jie Shan *Bandwidth-tuned Mott transition and superconductivity in twisted WSe_2*
09:30 – 10:00	Cory Dean *Superconductivity in twisted bilayer WSe_2*
10:00 – 10:30	Coffee Break
10:30 – 11:00	Irina Grigorieva *Revealing an unconventional superconducting state in layered $PdBi_2$*
11:00 – 11:30	Long Ju *Chiral Superconductivity and Fractional Quantum Anomalous Hall Effect in Graphene*
11:30 – 12:00	Francesco Mauri *Raman fingerprint of high-temperature superconductivity in compressed hydrides*
12:00 – 17:00	Mini Workshops
17:00 – 18:30	Dinner
18:30 – 19:00	Hui-Ming Cheng *Exploration of 2D Material Membranes with High Ion Conductivities*
19:00 – 19:30	Birgit Esser *Design and application of conjugated nanohoops displaying antiaromaticity, chirality or redox activity*
19:30 – 20:00	Jean-Sébastien Lauret *Nanographenes as single quantum emitters*
20:00	Poster I

08:30

Bandwidth-tuned Mott transition and superconductivity in twisted WSe_2

Jie Shan[1].

[1]Max Planck Institute for the Structure and Dynamics of Matter

Moiré materials built on transition metal dichalcogenide semiconductors have emerged as a programmable Hubbard model system. A natural question then arises: can such a system yield high-temperature superconductivity? In this talk, I will discuss the emergence of effectively high-temperature superconductivity near Mott transitions in twisted WSe_2 with intermediate interaction strength. Remarkably, the emergent doping-temperature phase diagram resembles that in copper oxide superconductors. I will also discuss the evolution of the phase diagram as a function of gate-tuned displacement field that modifies the electronic band structure. The results could provide a new angle for understanding the phenomenon of high-temperature superconductivity in strongly correlated materials.

09:30
Superconductivity in twisted bilayer WSe_2
Cory Dean[1].
[1]Columbia University

Superconductivity in twisted bilayer and twisted trilayer graphene results from an interplay between interlayer coupling and a Moiré superlattice that gives rise to low-energy flat bands with strong correlations. Similar flat bands have been explored in lattice-mismatched and/or twisted heterostructures of other two-dimensional materials beyond graphene such as transition metal dichalcogenides (TMDs). However, despite a wide range of correlated phenomenon robust demonstration of superconductivity in the TMDs remained absent and its possibility an open question. In my talk, I will present our recent observation of superconductivity in twisted bilayer WSe_2, appearing adjacent to a magnetic ordering state. The ability to vary the twist angle provides a unique capability to modulate the interacting strength in this system and in recent experiments we observe a systematic evolution of the magnetic and superconducting phases. I will discuss our current understanding of the phase space of correlated states in this Moiré system, and how this relates to conventional examples of unconventional superconductors.

10:30
Revealing an unconventional superconducting state in layered $PdBi_2$
Irina Grigorieva[1].

[1]University of Manchester, UK

I will present our recent results on the layered superconductor β-$PdBi_2$, where tunneling spectroscopy under in-plane magnetic fields reveals a transition from conventional s-wave pairing to a nodal p-wave superconducting state. This sharp transition, marked by a discontinuous change in the tunneling spectra, occurs at a well-defined threshold field and originates from spin polarization and spin–momentum locking induced by locally broken inversion symmetry, which renders p-wave pairing energetically favorable at high fields. Remarkably, signatures of this transition also appear in magnetization, indicating the formation of a novel domain structure consisting of coexisting p-wave superconducting and normal regions. These findings offer a new experimental window into how spin textures, symmetry breaking, and strong spin–orbit coupling can stabilize unconventional superconductivity and generate emergent magnetic responses in layered materials.

11:00

Chiral Superconductivity and Fractional Quantum Anomalous Hall Effect in Graphene

Long Ju[1].

[1]Massachusetts Institute of Technology

Fractional quantum Hall effect and superconductivity are two famous examples of emergent quantum phenomena driven by electron topology and correlations. They usually happen in very different materials and experimental settings. In this talk, I will discuss how they can be unified in one crystalline material, known as rhombohedral graphene. More than being hosted by the same material, the settings challenge the conventional understanding of these phenomena: the fractional quantum Hall effect happens at zero magnetic field, while the superconductor behaves as a spin and orbital magnet. I will also discuss the implications of these phenomena in the context of non-Abelian quasiparticles and topological quantum computation.

11:30

Raman fingerprint of high-temperature superconductivity in compressed hydrides

Francesco Mauri[1], Philip Dalladay-Simpson[2], Guglielmo Marchese[1], Zi-Yu Cao[3], Paolo Barone[4], Lara Benfatto[1], Gaston Garbarino[5], Federico Aiace Gorelli[2].

[1]Università di Roma La Sapienza, Roma, Italy
[2]Center for High Pressure Science and Technology Advanced Research (HPSTAR), Shanghai, China
[3]School of Physics Science and Information Technology, Liaocheng University, Liaocheng, China
[4]Consiglio Nazionale delle Ricerche (CNR)-SPIN, Roma, Italy
[5]European Synchrotron Radiation Facility, Grenoble, France

The discovery of high-temperature superconductivity in hydrogen-rich compounds under extreme pressures has prompted great excitement, intense research, but also debate over the past decade. In this study, we acquired unprecedented high-quality Raman spectra of hexagonal LaH10 at approximately 145 GPa and low temperatures, in conjunction with electrical transport measurements. Upon cooling, we observe a drop of resistivity and simultaneous remarkable variations of phonon frequencies and linewidths. These effects are interpreted and perfectly reproduced by the Migdal–Eliashberg theory, providing a definitive proof of phonon-mediated superconductivity and enabling a quantitative determination of the superconducting energy gap. Our results establish Raman spectroscopy as a robust, contact-free probe with micrometric resolution for studying high temperature superconductivity, opening a powerful route to its discovery and characterization.

We acknowledge financial support from the European Union ERC-SYN MORE-TEM no. 951215 (F.M., L.B., P.B. and G.M.).

18:30
Exploration of 2D Material Membranes with High Ion Conductivities
Hui-Ming Cheng[1].

[1]Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences

Solid electrolytes are promising candidates for safe, high-energy power systems. Composite electrolytes hold the potential to combine high ionic conductivity with stable electrode interfaces. However, a fundamental trade-off often exists between ion conduction and mechanical properties. First, we found that 2D materials show excellent ionic conductivity along 2D channels. Second, we introduce a composite electrolyte design that decouples ion conduction from mechanical flexibility, achieving a high ionic conductivity of 10.2 mS cm^{-1} at room temperature. The architecture features alternating layers of perpendicularly aligned 2D $Li_{0.3}Cd_{0.85}PS_3$ (PA-LiCdPS) to create continuous superionic conduction pathways and polyethylene oxide (PEO) for flexibility and improved interfacial compatibility. This PA-LiCdPS/PEO electrolyte enables Li||$LiNi_{0.8}Co_{0.1}Mn_{0.1}O_2$ coin cells (stack pressure <0.5 MPa) to have high electrochemical performance. Finally, we have designed and synthesized a sieving 2D solid state organic electrolytes with mixed planes and vertical nanochannels, which can be scaled up and shows high environmental tolerance and temperature stability, for practical solid-state batteries.

19:00

Design and application of conjugated nanohoops displaying antiaromaticity, chirality or redox activity

Birgit Esser[1].

[1]Ulm University

With their bent π-system and radially oriented p-orbitals, conjugated nanohoops are intriguing compounds, both from the synthetic point of view as well as for electronics applications. In this talk, I will present on the design and synthesis of conjugated nanohoops incorporating antiaromatic panels, of chiral and redox-active nanohoops as well as on their optoelectronic properties, supramolecular host-guest studies and application for energy storage in batteries.

19:30

Nanographenes as single quantum emitters

Thanh Trung Huynh[1], Suman Sarkar[1], Océane Capelle[1], Sébastien Quistrebert[1], Cynthia Banga-Kpakao[2], Nikos Fayard[1], Elsa Cassette[1], Stéphane Campidelli[2], Jean-Sébastien Lauret[1].

[1]Université Paris-Saclay, ENS Paris-Saclay, CentraleSupélec, CNRS, LuMIn, Orsay, FR

[2]LICSEN, NIMBE, CEA, Université Paris-Saclay, Gif-sur-Yvette, FR

Nanographenes synthesized by bottom-up chemistry are tunable emitters with promises in optoelectronic and quantum technologies. Recent investigations have classified them as stable and bright single-photon sources [1-4]. The next step towards using nanographenes as quantum emitters is to reach a lifetime-limited linewidth. Inspired by pioneering works on small organic molecules [6], we designed a new guest-host system to decouple the nanographene from its local environment [7].

In addition, we also test hBN as a substrate for nanographenes. This presentation will showcase our recent results on the low-temperature spectroscopy of new nanographenes [5], either embedded in a novel molecular crystal host [7] or deposited on hBN [8].

References

[1] Levy-Falk, Hugo, et al. physica status solidi (b) (2023).
[2] S. Zhao et al, Nature Communications, 9, 3470 (2018)
[3] T. Liu et al, Nanoscale, 14, 3826 – 3833 (2022)
[4] T. Liu et al, Journal of Chemical Physics 156, 104302 (2022)
[5] D. Medina-Lopez et al, Nature Communications 14, 4728 (2023)
[6] WP. Ambrose et al J. Chem. Phys. 95 (10), 7150–7163 (1991)
[7] Huynh Thanh Trung et al, in preparation
[8] S. Sarkar et al, in preparation

POSTER I

SUN 1
Solving the electrostatics of bilayer graphene devices

Şiyar Duman[1], Florian Libisch[1].

[1]TU Wien

Bilayer graphene (BLG) has become a popular platform for various experiments investigating quantum dots, moiré superstructures, highly correlated physics such as superconductivity, and devices for manipulating individual charges with the eventual goal of BLG qubits. The electrostatically tunable bandgap allows precise experimental control, yet also causes significant theoretical challenges when simulating such experiments. In particular, the smaller number of available states compared to bulk materials and the sensitive dependence of the gap on the local electric field requires simultaneously solving the Poisson equation and the redistribution of charge due to the electrostatic potential. Here we solve the resulting non-linear Poisson equation in the local density of states approximation to explain observations in a recent experiment and demonstrate qualitative agreement [1]. We also suggest how to enable current solution strategies to obtain not only qualitative but also quantitative agreement and discuss future challenges.

[1] Katrin Hecker and Samuel Möller et al.
doi: https://doi.org/10.48550/arXiv.2509.12061.

SUN 2
Excitonic Resonances in Anisotropic CrSBr Probed by Polarization-Resolved Magneto-Reflectance

Jan-Hendrik Larusch[1], Pierre-Maurice Piel[1], Aleksandra Łopion[1], Zdeněk Sofer[2], 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

CrSBr is an air-stable magnetic vdW semiconductor with a direct bandgap; its anisotropic spin, lattice, and charge, drive anisotropic light–matter interaction $\epsilon(\omega)$. We directly determine the full dielectric tensor of exfoliated CrSBr by spectroscopic imaging ellipsometry (SIE). In the paramagnetic phase, SIE verifies $\epsilon_{xx} \neq \epsilon_{yy} \neq \epsilon_{zz}$ and resolves in-plane ϵ_{xx},ϵ_{yy} [1]. Room-temperature comparison of Mueller-matrix and generalized ellipsometry guides cryogenic SIE, enabling us to track changes across the Curie and Néel temperatures as the system evolves from intralayer ferromagnetism to A-type antiferromagnetism. In the AFM phase, polarization-resolved magneto-reflectance with fields along c (hard), b (easy), and a (intermediate) axis yields critical fields of 2.2, 1.05, and 0.3 T, with field-induced optical changes. Together, these measurements quantify the anisotropic light-matter interaction and its dependence on magnetic order, linking exciton-dominated emission/absorption

to the full dielectric tensor [1,2].

[1] P.M. Piel, S. Schaper, A. Łopion, J.H. Larusch, M. Duwe, Z. Sofer, U. Wurstbauer, in preparation.
[2] J. Klein et al. ACS Nano 17, 5316–5328 (2023).

SUN 3
Characterization of carbon nanotubes doped by endohedral filling

Cristian Borja-Peña[1,2], Martin Magg[3], Benjamin S. Flavel[3], Salomé Forel[4], Wim Wenseleers[2], Sofie Cambré[1].

[1]University of Antwerp, TSM2 group
[2]University of Antwerp, NANOrOPT group
[3]Karlsruhe Institute of Technology
[4]Claude Bernard University Lyon 1

Filling carbon nanotubes with electron-donor or -acceptor molecules is a promising way to tune their electronic properties in a controlled and stable manner. This stability arises from the encapsulation of the dopants, protecting them from environmental interactions. Although both p- and n-type doping have been reported, a consistent spectroscopic characterization of these nanohybrids remains elusive. Interpretation of doping effects is complicated by competing factors such as bundling, strain, and interactions with oxygen and solvents. To address these issues, we compare samples prepared by gas- and liquid-phase filling methods, followed by thorough rinsing to remove externally adsorbed dopants, ensuring that the observed effects arise from encapsulated material. We then characterize the doped CNTs using Raman and absorption spectroscopy, as well as thermogravimetric analysis. Doped samples are benchmarked against an undoped reference to establish a consistent framework for correlating spectroscopic signatures with doping levels. These efforts aim to clarify the spectroscopic response of endohedrally doped CNTs and provide a robust basis for their preparation and characterization.

SUN 4
Controllable Doping of Single-Walled Carbon Nanotubes via Covalent Charge-Transfer Engineering

Alphonse Fiebor[1], Mohsen Adeli[1], Stephanie Reich[1], Antonio Setaro[1].

[1]Physics Department, Freie Universität Berlin

Precisely controlling the doping level of single-walled carbon nanotubes at the individual scale unlocks new applications. Electrochemical gating finely tunes the Fermi level but is typically applied to nanotube ensembles, while charge-transfer by filling the tubes with molecules enable single-nanotube doping but lacks precise charge regulation. We propose an alternative approach using covalently attached, custom-synthesized charge-transfer compounds. This preserves π-conjugation

and optoelectronic properties while enabling systematic charge transfer control by adjusting functional group attachment. Our rational ambipolar design employs the same molecular building blocks [1] —methoxy-substituted aniline rings—to achieve either electron donation or withdrawal, depending on the assembly configuration [2].

References:
[1] A Fiebor et al., J. Phys. Chem. C125, 19925 (2021).
[2] A Fiebor et al., Small Structure 6, 2500168 (2025).

SUN 5
Intensity analysis of higher order Raman modes in confined carbyne

Johannes Lechner[1], Pietro Marabotti[1], Getúlio Silva e Souza Júnior[1], Pablo Hernández López[1], Lei Shi[2], Thomas Pichler[3], Carlo S. Casari[4], Sebastian Heeg[1].

[1]Institut für Physik & Center for the Science of Materials Berlin, Humboldt Universität zu Berlin, Germany
[2]Sun Yat-Sen University, Guangzhou, China
[3]University of Vienna, Austria
[4]Dipartimento di Energia, Politecnico di Milano, Milano, Italy

Carbyne, an infinite linear chain of carbon atoms, is the truly one-dimensional allotrope of carbon. While ideal carbyne and its fundamental properties have remained elusive, carbyne-like materials like confined carbyne, consisting long linear carbon chains (>100 atoms) inside carbon nanotubes, are available for study. Here we investigate the overtones of the Raman active C mode of single confined carbyne chains by confocal resonant Raman spectroscopy. We analyze the Raman resonance profiles of the C mode and its overtones, which indicate a complex electronic structure. Surprisingly, the relative intensities of different Raman mode orders also change with the frequency of the C mode, implying that the strength of electron-phonon coupling in confined carbyne varies. These new discoveries enable further insight into the structural and electronic properties of confined carbyne as a material system.

SUN 6
Impact of Ion-Irradiation-Induced Defects on the Optical and Vibrational Properties of Transition Metal Dichalcogenides

Philipp Kraus[1], Stefan Wolff[1], Eileen Schneider[1], Yuri Koval[1], Janina Maultzsch[1].

[1]Friedrich-Alexander-Universität Erlangen-Nürnberg

We present the controlled creation of vacancies in transition metal dichalcogenides (TMDCs), in particular molybdenum disulfide (MoS_2), by low-energy ion irradiation. We prepared TMDC mono- and bilayers by mechanical exfoliation and via chemical vapor deposition (CVD). These were irradiated consecutively with different Ar^+ ion

doses. We discuss the impact of the ion-induced defects on Raman and photoluminescence (PL) spectra and compare our results with density functional theory (DFT) calculations of the phonon modes of MoS_2 with S-vacancy and Mo-vacancy defects. We show that the Raman spectra of Ar^+-irradiated MoS_2 can be well understood assuming S vacancies, whereas Mo vacancies appear less likely.

SUN 7
Ubiquitous Antiparallel Domains in 2D Hexagonal Boron Nitride Uncovered by Interferometric Nonlinear Optical Imaging

Yeri Lee[1], Sunmin Ryu[1], Juseung Oh[1].

[1]POSTECH, South Korea

Hexagonal boron nitride (hBN) supports a wide range of two-dimensional (2D) technologies, yet assessing its crystalline quality over large areas remains a fundamental challenge. Both antiparallel domains, an intrinsic outcome of epitaxy on high-symmetry substrates, and associated structural defects have long evaded optical detection. Here, we show that interferometric second-harmonic generation (SHG) imaging provides a powerful, non-destructive probe of lattice orientation and structural integrity in chemical vapor deposition-grown hBN. This approach reveals the ubiquitous formation of antiparallel domains and quantifies their impact on crystalline order. SHG intensity also emerges as a direct optical metric of domain disorder, spanning three orders of magnitude across films produced by ten different growth routes. Correlation with Raman spectroscopy establishes a unified framework for evaluating crystalline quality. Beyond hBN, this method offers a high-throughput route to wide-area structural imaging in various non-centrosymmetric materials, advancing their deployment in electronics, photonics, and quantum technologies.

SUN 8
High-throughput correlated microscopy and automated device integration of 1D and 2D materials

Teja Potocnik[1], Ibtisam Abbasi[1], Greg Chu[1], Zeinab Tirandaz[1], Hark Hoe Tan[2], Chennupati Jagadish[2], Stephan Hofmann[1], Hannah Joyce[1], Jack Alexander-Webber[1].

[1]University of Cambridge
[2]Australia National University

Low-dimensional materials are promising candidates for low-power (opto)electronics, but development is hindered by slow characterisation. We address this bottleneck using high-throughput multi-modal correlated microscopy (optical & SEM). We automate material identification, characterisation and device integration to demonstrate the statistical diameter-dependent properties of thousands of individual InAs nanowires. Using automated device fabrication of hundreds of single-nanowire devices [Potočnik et al. ACS Nano 16, 18009, 2022], we link growth conditions

and channel geometry to device properties. This process enables the fabrication of NMOS logic inverters from InAs nanowires [Abbasi et al. Nanotech. 36, 245202, 2025]. We control the threshold voltage by tuning the nanowire diameter and optimise the inverter's voltage transfer characteristics by controlling channel geometries. We apply these techniques to 2D materials, including lateral $MoSe_2$–WSe_2 photodiodes [Potočnik et al. 10.1002/smtd.202500437, 2025]. Our approach enables rapid nanoscale prototyping and characterisation to accelerate the feedback loop between synthesis, characterisation, and device performance.

SUN 9
Programmable Phase and Exciton Engineering in Monolayer MoS_2

Zhuting Hao[1], Siegfried Eigler[1].

[1]Freie Universität Berlin

Phase engineering and interfacial carrier modulation offer powerful routes to tailor the properties of two-dimensional transition metal dichalcogenides (TMDs), yet achieving spatial precision and simultaneous excitonic control remains challenging. Here, we present two complementary strategies that enable programmable phase transitions and tunable photoluminescence (PL) in monolayer MoS_2. First, laser irradiation in the presence of silver trifluoroacetate generates silver nanoparticles in situ, whose hot-electron injection triggers a localized 2H-to-1T phase transition, while CF_3 radicals concurrently induce spatially confined covalent functionalization. This one-step approach achieves lithography-compatible phase patterning. Second, a MoS_2/GO/Au heterostructure employs Au nanoparticles as electron extraction layers to modulate interfacial carrier density, driving MoS_2 toward charge neutrality and yielding a ~9.7-fold PL enhancement. Together, these results establish a versatile platform for deterministically programming phase states and excitonic responses in TMD monolayers.

SUN 10
Hexacyano-Trimethyl-Cyclopropane as a Raman Probe for Quantifying Charge Transfer in mol/2D Material Heterostructures

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Hexacyano-trimethyl-cyclopropane (CN6-CP) is an organic molecule with a high electron affinity (-5.94 eV) making it an ideal benchmark for studying charge transfer (CT) in hybrid systems. Upon accepting an electron, CN6-CP forms a radical anion that displays a distinct Raman shift from 1770 to 1850 cm^{-1} providing a clear marker of its reduction. By combining the CN6-CP with graphene - a well characterized electron donor - CT is simultaneously monitored through the changes in the

Raman responses of molecular and graphene spectra. The integrated intensity of the radical anion peak scales with the G band shift allowing a quantitative correlation between the two. The G-peak shifts by 13 cm^{-1}, corresponding to a CT density of approximately 0.75×10^{13} cm^{-2} consistent with the high electron affinity of CN6-CP. Comparison with F4TCNQ (-5.20 eV) yields a slightly lower CT density of 0.65×10^{13} cm^{-2}. This correlation establishes the CN6-CP radical anion Raman signature as a reliable tool for quantifying CT, offering a powerful method for studying the CT in more complex molecule/2D material heterostructures.

SUN 11
Moiré fractional Chern insulators from topological bosons and trivial fermions

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Recent realizations of fermionic fractional Chern insulators (FCIs) and anomalous Hall crystals have established Moiré systems as a powerful platform for exploring correlated topological phases. Here, we predict the emergence of robust bosonic topological order arising from long-lived interlayer excitons consisting of holes in twisted bilayer WSe_2 and electrons in an additional $MoSe_2$ layer. In particular, exact diagonalization reveals that realistic long-range interactions stabilize Laughlin and non-Abelian Moore–Read states at filling factors 1/2 and 1 of the exciton Chern band present in this system. In parallel, we uncover Laughlin-like fermionic FCIs in topologically trivial bands of twisted multilayer graphene, where a strongly inhomogeneous quantum geometry drives topological order independent of band topology. Together, these results highlight the extraordinarily rich landscape of Moiré quantum matter, encompassing both bosonic and fermionic topological order shaped by quantum geometry.

SUN 12
SpectraFormer: AI tool for spectroscopy unmixing

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2D materials have attracted research interest as candidates for next-generation semiconductor industry due to their excellent properties. The key technological issues to realize large scale device production include reliable large scale uniform growth of 2D materials. For several materials, such as buffer layer graphene (or

zero layer, ZLG) – identifying optimized growth recipes remains challenging when relying on standard trial-and-error approaches.

To overcome such obstacles, we focus on:
- adopting classical and machine learning guided approaches to realize Raman spectroscopy unmixing to provide feedback on the quality of the synthesized ZLG;
- integrating the latter into the growth protocol by unravelling ZLG features from SiC strong signal using AI.

Here, we present a transformer architecture based AI model that can unleash surface material's features with an example of buffer layer graphene. This progress not only offers major gains in 2D material characterization, but paves the way for innovations in material science, empowering AI-driven techniques to unlock and refine different synthetic procedures.

SUN 13

Circular polarization selective terahertz photothermoelectric effect in carbon nanotube fiber p-n junction

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Terahertz (THz) frequency region of electromagnetic waves is promising for diverse areas such as sensing and telecommunication. However, the THz technologies are still under development because of the difficulty for generation and detection [1]. Carbon nanotubes (CNTs) have great attraction as materials for THz photothermoelectric (PTE) detectors due to their excellent absorption properties spanning from the visible to the THz range, large thermoelectric power arising from their one-dimensionality, and strong optical anisotropy induced by alignment [2]. In this study, we fabricated a *p*–*n* junction by twisting *p*-type and *n*-type CNT fibers together and investigated its PTE response under THz irradiation. Interestingly, we observed clear circular polarization selective signals with extinction ratio of ~4, whose helicity depends on the chirality of the twisted fibers. We report the details of the linear and circular polarization selection rules in the twisted CNT fibers and their application to polarization-resolved imaging.

[1] M. Asada *et al.*, Sensors 21, 1384 (2021)
[2] X. He *et al.*, Nano Lett. 14, 3953 (2014)

SUN 14
Stabilizing the 0.21° magic-angle graphene superlattice

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Correlated quantum states emerge in bilayer graphene when the two sheets are rotated to specific “magic” angles, giving rise to flat electronic bands. Until now, only the first (largest) magic angle of ~1.1° has been accessible experimetnally. Smaller magic angles require the stabilization of huge moiré superlattices that are extremely fragile against structural reconstructions and disorder. Here we present the first experimental realization of a giant (~65 nm) unreconstructed graphene superlattice, corresponding to the 0.21° magic angle. This was achieved by inserting a molecular spacer layer between graphene sheets, preventing reconstructions, but preserving sufficient electronic coupling for flat-band formation. The resulting flat band is remarkably robust, persisting even in the presence of susbtantial substrate-induced (SiO_2) disorder.

SUN 15
Optical Probing of Interfacial Magnetic Properties of the CrSBr- $MnPS_3$ heterointerface

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CrSBr and $MnPS_3$ are both 2D antiferromagnetic semiconductors with different magnetic and optical properties. $MnPS_3$ has out-of-plane spin alignment while CrSBr’s spins are aligned in-plane [1,2]. Interfacing these two materials is expected to result in complex interfacial spin-alignment, presumably with the stabilization of a non-collinear magnetic phase at the interface. CrSBr exhibits strong excitonic features coupled to the magnetic order [3]. This is used as a probe for the magnetic state of the $MnPS_3$-CrSBr interface. The interfacial magnetic properties are probed by low-temperature magneto-photoluminescence and reflectance spectroscopies. We observed a peculiar influence of $MnPS_3$ on the optical response of CrSBr. A proximity-induced modification of the magnetic properties of CrSBr interfaced with $MnPS_3$ seems to induce long-range order, since the impact is observable on the CrSBr flake more than 10 µm away from the interfaced region. Our observations might be connected to the stabilization of an intermediate ordered magnetic state in CrSBr.

[1] Wilson, et al. Nat. Mat. 20.12 (2021)
[2] Kobets, et al. Low Temp. Phys. 35.12 (2009)
[3] Heißenbüttel, et al. Phys. Rev. B 111.7 (2025)

SUN 16
Dual Proximity Engineering of Spin-Orbit and Magnetic Effects in Graphene Heterostructures

Christoph Kastl[1], Alexander Holleitner[1], Alexandre Bernard[1], Ernst Knöckl[1], Marko Burghard[2], Matthias Klein[1], Sayooj Satheesh[2].

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[2]Max Planck Institute - FKF

The coexistence of induced spin–orbit coupling (SOC) and magnetic exchange fields is predicted to drive graphene into topological phases such as the quantum anomalous Hall state. We study monolayer graphene heterostructures that combine dual proximity effects from WSe_2 (SOC) and $Cr_2Ge_2Te_6$ (magnetic exchange). Low-temperature magnetotransport reveals a large anomalous Hall effect persisting at zero magnetic field, signaling an intrinsic Berry curvature arising from the interplay of SOC and magnetism. Although not quantized, the effect indicates strong coupling between both interactions. Landau fan analysis shows Landau-level anticrossings as direct signatures of spin–orbit splitting, enabling quantification of the induced SOC strength. Complementary photogalvanic measurements on graphene/WSe_2 heterostructures provide an optoelectronic fingerprint of SOC. These results highlight the tunable coexistence of spin–orbit and magnetic proximity effects in van der Waals heterostructures and establish a route toward topological graphene phases.

SUN 17
Electronic Doorway States in Layered Materials

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We investigate the coupling between surface states and the vacuum in layered materials. Experimental data on secondary low-energy electron emission show that properties of the density of states alone are insufficient to explain the measured energy distribution of secondary electrons. The coupling from the above-threshold conduction band states to vacuum states must also be accounted for. We discuss how coupling elements between these resonances and vacuum states can be extracted from standard density functional theory calculations. Comparing experimental and theoretical data for single-, and bilayer graphene as well as graphite, we find specific resonances acting as “doorway states” that dominate secondary electron emission. This framework can explain the differences observed in secondary electron emission as a function of layer number.

SUN 18
Phase and microstructure evolution of SnO_x:Ta thin films as a function of the oxygen partial pressure during deposition

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Recent research on SnO_2-based TCOs has focused on Ta-doped SnO_2 (TTO) since it surpasses In_2O_3:Sn and ZnO:Al in thermal stability under vacuum and in air [1,2]. This work presents a detailed Raman spectroscopy, DFT, and XRD study on the phase and microstructure evolution of SnO_x:Ta thin films as a function of the oxygen partial pressure during thin film deposition by reactive direct current magnetron sputtering. At low O_2 flow rates a phase structure comprising metallic β-Sn, SnO, and Sn_3O_4 without incorporated Ta is found. Higher O_2 flow rates yield the formation of rutile-type SnO_2:Ta, where Ta replaces Sn as Ta_{Sn} and transfers free charge carriers into the Sn 5s* conduction band [3]. A resistivity minimum of 1.3 × 10^{-3} Ω cm, a maximum mobility of 16 $cm^2(Vs)^{-1}$, and a distinct NIR reflectivity edge were found for the best films, which also showed a noticable texture in XRD measurements and a slight excess of oxygen.

[1] F. Lungwitz et al., Sol. Ener. Mater. Solar Cells 196, 84-93 (2019),
[2] M. Krause et al., J. Mat. Chem. A 11, 17686-17698 (2023),
[3] M. Krause et al., J. Mat. Chem. A 13, 15128-15139 (2025).

SUN 19
Epitaxial Growth of Bernal Stacked Multi Layered Graphite on C-face Silicon Carbide

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[1]Paul-Drude-Institut für Festkörperelektronik

Epitaxial growth of few-layer graphene (FLG) on the $(000\bar{1})$-face of SiC (C-face) is widely assumed to yield films that are turbostratic or only partially aligned, in contrast to the well-ordered Bernal (2H) stacking typically associated with (0001)-face (Si-face) growth.
In this work, we show that molecular-beam-epitaxy growth on the C-face can, in fact, produce FLG with genuine 2H stacking and remarkably low mosaic spread. Using detailed Raman spectroscopy, supported by complementary structural characterization, we identify clear spectral signatures of Bernal ordering, including a well-defined 2D-band lineshape. These findings demonstrate that ordered stacking is achievable on the C-face under appropriately controlled MBE conditions. We will present our full

spectroscopic analysis and discuss its implications for the structural and electronic properties of the grown FLG.

SUN 20
Intrinsic Contrast in Near-Field Raman Enhancement Between MoS_2 and WS_2

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Tip-enhanced Raman spectroscopy (TERS) of lateral MoS_2/WS_2 heterostructures reveals a systematically higher signal enhancement in WS_2 compared to MoS_2, despite their similar crystal structures and phonon symmetries. This contrast suggests that Raman amplification in transition metal dichalcogenides is governed by intrinsic vibrational and electrodynamic properties rather than purely by geometric near-field confinement. To investigate the origin of this difference, we employ a staircase MoS_2 sample with controlled layer numbers as a model system to isolate the roles of vibrational symmetry and dimensionality. By extracting relative enhancement factors of the in-plane E_2g and out-of-plane A_1g modes under high-NA excitation, we observe a pronounced symmetry-dependent response, with stronger amplification of out-of-plane vibrations. These results demonstrate that Raman enhancement in TMDs arises from the interplay between electromagnetic field confinement, vibrational symmetry, and layer-dependent polarizability, providing insight into mode-selective light matter interaction at the nanoscale.

SUN 21
Three-dimensional imaging of local atomic reconstruction at bulk interfaces

Nicholas Clark[1], Roman Gorbachev[1].

[1]University of Manchester

Atomic reconstruction of twisted two-dimensional interfaces offers a unique way of controlling optical, electronic and mechanical properties at the atomic level. Despite substantial recent progress in understanding both the structure and properties of twisted bilayers, the behaviour of thicker twisted heterostructures remains largely unexplored. Here we employ multi-slice electron ptychography to perform the first high-resolution depth sectioning of a twisted multilayer transition metal dichalcogenide reconstructed interface. We achieve a record 1.2 nm slice thickness, tracking >40,000 atomic locations individually across 20 layers. Position tracking with ~
6 pm uncertainty allows us to describe how the lattice reconstruction effects evolve as a function of distance from the twisted interface - both in homo- and hetero-multilayers. Coupled with bespoke theoretical modelling, this work creates a foundation for future experimental and computational discoveries in multi-layer

heterostructures across several disciplines from nanoscale tribology to quantum science.

SUN 22
Mapping Nanoscale Buckling in Atomically Thin $Cr_2Ge_2Te_6$

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Magnetic two-dimensional materials are a promising platform for novel nanoelectronic device architectures, such as the ferromagnetic semiconductor chromium germanium telluride ($Cr_2Ge_2Te_6$), which has potential for spintronics and memory applications. We investigate its structural properties using atomic resolution Scanning Transmission Electron Microscopy (STEM) and present the first atomic resolution images down to its monolayer limit. We develop a novel technique that allows one to map the local tilt with unprecedented spatial resolution using only high-resolution images, enabling mapping of the topography and morphological variation of atomically thin crystals. Using it, we show that the $Cr_2Ge_2Te_6$ monolayer has an unusually large out-of-plane rippling, with local tilts reaching 20° over a few nm length scales. We hypothesize that such a strongly buckled structure originates from both point and extended lattice defects which are more prevalent in monolayer crystals. Additionally, we correlate the structural observations with the band structure measurements using Angle-Resolved Photoemission Spectroscopy (ARPES).

SUN 23
Direct Fabrication of WO_{3-x}-WS_2 Core-Shell Nanotubes (CSNT) Electronic Devices on Si Substrate via a Close-space Sublimation Approach

Hao Yu[1], Xiaofan Lin[1], Greg Chu[1], Jack Alexander-Webber[1], Stephan Hofmann[1].

[1]University of Cambridge

Tungsten (sub)oxide and sulfide nanostructures are promising for next-generation optoelectronic, sensing, and neuromorphic systems. Conventional powder-based CVD synthesis of WS_2 nanotubes typically requires multistep processing and nanowire transfer, which constrain uniformity, throughput, and device scalability. We present a close-space sublimation (CSS) approach enabling direct, wafer-compatible fabrication of WO_{3-x}–WS_2 core–shell nanotubes (CSNTs) on SiO_2/Si substrates. Using a sputtered WO_3 thin film as precursor and a sublimation-limited model to guide growth kinetics, WO_{3-x} nanowhiskers are first deposited via CSS and subsequently sulphurised in a hot-wall CVD process. The resulting CSNTs,

exceeding 10 μm in length and ~100 nm in diameter, form spatially isolated and aligned networks. The as-grown CSNTs can be integrated with high-throughput fabrication techniques to realise multiple nanowire electronic devices per chip. The fabricated devices exhibit excellent photoresponse current, and selective lithography of the shell/core enables formation of single-nanowire FETs for scalable nanoelectronic integration.optoelectronic applications.

SUN 24
Optical and Vibrational Properties of TMDCs: From Resonant Raman to Near-Field Imaging

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Light–matter interactions govern the optical and vibrational behaviour of crystals, mediating the formation of excitons—bound electron–hole pairs—and their coupling to phonons. Their optical response reveals how electronic and vibrational properties depend on the local dielectric environment. Transition-metal dichalcogenides (TMDCs) provide an ideal platform for exploring excitonic physics: they host stable excitons at room temperature with strong resonances and rich vibrational structure. Their atomic thickness makes them ideal for studying how optical and lattice excitations interact across momentum and spatial regimes.
We combine far- and near-field spectroscopies to explore these regimes in TMDCs. Resonant Raman spectroscopy reveals interlayer exciton–phonon coupling in $MoSe_2/WSe_2$ heterostructures, while visible-range scattering-type near-field optical microscopy (s-SNOM) accesses high-momentum excitations, enabling nanoscale imaging of dielectric variations in WS_2/Au and of interlayer excitons in $MoSe_2/WSe_2$. Finite-dipole modelling links the near-field amplitude and phase to the local dielectric function, providing quantitative insight into excitonic and vibrational coupling.

SUN 25
Programmable phonon-assisted resonant energy transfer between moiré cells in charge-tunable $MoSe_2$-WS_2 heterobilayers

Alexander Högele[1,2], Caique Serati de Brito[3], Christian Schüller[4], Daniel Erkensten[5], Ermin Malic[5], Giuseppe Maneghini[5], Jonas Göser[1,2], Julian Trapp[1,2], Kenji Watanabe[6], Nicolas Paulik[4], Philipp Parzefall[4], Takashi Taniguchi[6], Yara Galvão Gobato[3].

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We report on resonant photoluminescence (PL) studies on charge-tunable moiré superlattices in $MoSe_2$-WS_2 moiré heterobilayers. We tune a Ti:Sapphire laser into close resonance with excitonic moiré transitions of $MoSe_2$ and compare the resulting PL spectra to off-resonant PL and white light reflectance contrast experiments of this type-I heterostructure (HS). We identify multiple resonant energy transfers (RET) in the samples: When exciting resonantly with the moiré quasi-particles, a one- or two-phonon relaxation into a lower-energy moiré quasi-particle can be observed. We interpret our results as follows: The moiré exciton (M_1) and, in the case of charging, the electron are strongly localized in a moiré cell. When exciting M_1 resonantly, a phonon-assisted RET from a localized M_1 state to a neighboring charged moiré cell results in a localized M_1^*, which recombines radiatively and can be confirmed via electrostatic doping.. Furthermore, temperature-dependent measurements indicate phonon-assisted tunneling between moiré cells as the primary energy-transfer mechanism. Thus, we report on signatures of lateral transport in a charge-tunable moiré HS.

SUN 26

Layer number dependent intrinsic splitting of the G-mode in the Raman spectrum of perfect rhombohedral graphite

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In recent years, rhombohedral or ABC-graphite (RG) has gained prominence as a multitude of strongly correlated phenomena was discovered in this simple crystal, including the fractional quantum anomalous Hall effect, unconventional superconductivity, and insulating states driven by correlations. Despite the intense experimental and theoretical work, the underlying physics governing these electronic states, including the strength and stacking dependence of the electron-phonon coupling, is

still to be understood. Based on our recent results in Electronic Raman Scattering, we were able to prepare, identify, and analyze stacking defect-free RG samples in the complete sequence from 3 to 20+ layers. Here we show that the simplest phonon-related peak, the G mode, is split in perfect RG of 6-13 layer thickness, hinting at more peculiar electron-phonon coupling. The evident explanations of the observed splitting (strain, electric field, doping, dielectric environment, etc.) were excluded. These findings imply intrinsic electron-phonon scattering processes to control the observed phenomena, which are still to be understood.

SUN 27
Highly Efficient Laser Writing of Graphene via Sulphonium Reagents

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Laser writing is a versatile strategy for covalent two-dimensional (2D) patterning of graphene, whose development critically relies on suitable reagents. Herein, we report a series of sulphonium compounds that enable highly efficient laser writing of graphene, significantly expanding the reagent library. Upon laser irradiation, sulfur-centered bonds are cleaved to generate radicals in situ, which react with graphene and induce local rehybridization of carbon atoms from sp^2 to sp^3.
Among these reagents, two enable highly efficient trifluoromethylation of graphene with a tunable degree of functionalization. The incorporation of strongly electron-withdrawing trifluoromethyl groups results in pronounced and tunable surface potential modulation, as characterized by Kelvin probe force microscopy (KPFM). Notably, the achievable functionalization degree reaches the second regime of the Cançado curve. In addition, another sulphonium reagent enables spatially resolved vinyl functionalization of graphene, which is unprecedented. All reported functionalizations are fully reversible upon thermal annealing, enabling a cycle of writing, reading, and erasing chemical information on graphene.

SUN 28
Pressure induced large angle twisted bilayer graphene

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Twisted bilayer graphene hosts strongly correlated phases at the magic angle, but these effects are suppressed at larger, more experimentally accessible twist angles where the electronic bands are typically dispersive. We demonstrate that perpendicular pressure can restore this flatband physics in large-angle TBG by systematically enhancing interlayer coupling. These pressure induced flatbands exhibit strong electronic localization in AA-stacked regions, mimicking the magic angle case. In a magnetic field, these flatbands give rise to an integer quantum Hall effect with a characteristic zero-energy plateau. At higher twist angles, this behaviour evolves, and

additional asymmetric plateaus emerge due to broken particle-hole symmetry. This topological correspondence is confirmed by the Hofstadter butterfly spectrum, which reveals the requisite low-energy gaps that align with the Hall conductivity plateaus. Our results establish a fundamental limit to this effect: while pressure extends magic-angle behaviour to moderate twists, moiré correlations weaken beyond a critical angle of $\sim 6^{\circ}$.

SUN 29
Highly Tunable Quantum Light Sources from a Reconfigurable Straintronic Platform

Oğuzhan Yücel[1], Kirill Bolotin[1].

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We present a platform that applies local, strong, non-uniform tensile strain to monolayer transition metals dichalcogenides (TMDs), creating a funnel-shaped potential that deterministically traps excitons and yields a series of narrow-line, addressable quantum emitters. Electrostatic gating mechanically actuates the membrane, enabling continuous ≈300 meV tuning of the emission energy with active control over brightness and charge state. Cryogenic PL maps with line-tracking confirm localized excitonic emission and the emergence of localized emission centers; emission energies follow the strain gradient with sub-µm precision. Using a coupled multiphysics model, we reconstruct isotropic and anisotropic strain fields and disentangle contributions from piezoelectricity, band-edge/exciton shifts, the Stark effect, and other field-induced interactions, quantitatively linking them to the resulting trap size. These results establish a wafer-compatible straintronic building block for on-chip, wavelength-programmable single-photon sources, scalable emitter arrays, and reconfigurable confinement compatible with integrated photonics

SUN 30
Multi-wavelength Raman spectroscopy of interlayer Raman modes in twisted bilayer transition metal dichalcogenides

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Twisting two layers of transition metal dichalcogenides (TMDCs) on top of each other introduces an additional degree of freedom to tune their physical properties, such as modifications in band structure. The functionality of twisted TMDC devices relies on the interlayer coupling between the constituent layers. In this work, we investigate the interlayer coupling using excitation-energy dependent Raman spectroscopy. By exciting the system near the C exciton resonance, interlayer Raman

modes are activated that are not observable in a single layer [1]. These modes become Raman active in bilayers due to symmetry changes. In addition, because the C exciton wavefunction - in contrast to A and B excitons - expands over both layers, it couples strongly to the interlayer Raman modes. In twisted bilayer TMDCs, we observe that different interlayer Raman modes show a different dependence on twist angle and excitation wavelength. This behavior is further examined using multi-wavelength Raman spectroscopy with a tunable laser on twisted bilayer MoS_2 and $MoSe_2$.

[1] Eileen Schneider, Kenji Watanabe, Takashi Taniguchi, Janina Maultzsch, Phys. Rev. B 110, 125431 (2024)

SUN 31
Prolonged Valley Lifetime In $MoSe_2$/CrSBr van der Waals Heterostructure with Orthogonal Spin Texture

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Van der Waals (vdW) heterostructures comprising transition metal dichalcogenides (TMDCs) and magnetic materials present a promising platform to functionalize valley and excitonic properties in non-magnetic TMDCs. Here, we report a comprehensive optical study of a monolayer (ML) $MoSe_2$ on the layered A-type antiferromagnetic semiconductor CrSBr.
Time-resolved Kerr ellipticity (TRKE) measurements provide insights into the spin-valley dynamics of the system. A power-dependent TRKE study reveals a mono-exponential increase in valley lifetimes—from 4 ps to 176 ps—attributable to strong p-type doping and power-dependent spin stabilization mechanisms, representing a three-orders-of-magnitude enhancement relative to pristine monolayer $MoSe_2$. Notably, the TRKE traces display asymmetries in decay times, signal amplitudes, and offsets, which likely arise from asymmetric excitation or decay pathways of excited electrons, providing further evidence for spin splitting between the K and K' valleys.

SUN 32
Domain Formation in Twisted Monolayer-Bilayer Graphene studied with Machine-Learned Force Fields

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The stacking arrangement of graphene layers critically shapes the material's physical properties. In trilayer graphene featuring a twisted middle layer, lateral stacking shifts play an important role in the layer properties [1]. By contrast, combining a Bernal-stacked bilayer with a twisted monolayer eliminates this problem despite pronounced lattice relaxation at twist angles below 1 degree. The system reconstructs to minimize high-energy stacking sites and generates alternating triangular domains of ABC and ABA stacking, which are in contrast to twisted bilayer graphene distinguished by the third layer. These structural changes are central to the unique electronic and optical phenomena observed in a twisted monolayer-bilayer graphene heterostructure. We have trained machine-learned force fields to determine the precise reconstruction geometry for supercell configurations of up to 50 nm in size. In this way, we achieve near-DFT accuracy in a cost-effective manner. We quantitatively discuss the emerging ABA - ABC transitions, and extract tight-binding parameters to calculate electronic properties of the emerging superstructures.

[1] Physical Review B 104, 035139 (2021)

SUN 33
Near-field terahertz investigation of ABC-stacked rhombohedral graphite

Krisztián Márity[1], Konrád Kandrai[1], Peter Nemes-Incze[2], Susanne C. Kehr[2], Jacob Wetzel[1].

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The exploration of correlation effects in topological flat bands, exemplified by Landau levels and 'magic-angle' bilayer graphene, remains a central topic in condensed matter physics. Rhombohedral graphite (RG) stands out as a unique system hosting a symmetry-protected flat band without requiring a moiré superlattice, thereby providing an ideal platform for studying many-body interactions, particularly in thicker samples. In this work, we performed terahertz scattering-type scanning near-field optical microscopy (THz-sSNOM) measurements to probe the fine structure of the flat band in rhombohedral graphite. This technique provides nanoscale spatial resolution, granting access to the local optical and electronic response beyond the diffraction limit. Here we compare the complex optical response of ABC-stacked

(rhombohedral) and AB-stacked (hexagonal) graphite, to elucidate how their distinct stacking orders influences their low-energy optical response. We systematically analyze the THz contrast of both stacking sequences as a function of layer number, ranging from 8 to 31 layers. The results show a remarkably strong contrast for the ABC structure compared to the AB one

SUN 34
Surface-dependent phonon dynamics in 9-atom-wide graphene nanoribbons arrays

Ángel Labordet[1], Roman Fasel[1], Gabriela Borin Barin[1], Michel Calame[1], Mirjana Dimitrievska[1].

[1]EMPA

Graphene nanoribbons (GNRs) are promising candidates for the next-generation, low-dimensional, semiconductor materials, especially for use in electronic, optoelectronic, and photonic devices. Due to lateral quantum confinement effects, GNRs feature remarkable physical properties that are critically determined by their width and edge structure.
In this work, we combine temperature-dependent (70–295K) and polarization-resolved Raman spectroscopy to track phonons in 9-atom graphene nanoribbons. Peak shifts follow substrate thermal-expansion, while linewidths reveal intrinsic anharmonic damping plus an inter-ribbon coupling component that strengthens with coverage and alignment. This enables tuning of GNR properties by simply controlling inter-ribbon distance and alignment.

SUN 35
Optical Readout of Triplet States in sp^3-defects in Carbon Nanotubes: a Path towards Quantum Sensing

J. Alejandro de Sousa[1], Jana Nikolic[1], Ilias Vandevenne[1], Etienne Goovaerts[1], Sofie Cambré[1].

[1]University of Antwerp

Controlled sp^3-functionalization of single-wall carbon nanotubes (SWCNTs) has become a common route to enhance their emission efficiency [1], indispensable for their integration in various applications.[2] While research focused on the effect of the functionalization on the bright singlet excitons, the fate of the triplet states is largely unknown. Here we investigate the triplet excitons by optically detected magnetic resonance, a technique combining the sensitivity of emission spectroscopy with magnetic resonance transitions between the triplet sublevels in an external applied magnetic field.[3] We perform ODMR experiments on a series of samples with different functionalization density and functional groups, and find significant differences in zero-field splitting, ODMR intensity and triplet spin density distribution.[4] Experimental results are corroborated by theoretical DFT calculations. Finally, by

tuning the functional group, we address readout of triplet states at room temperature.
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[4] J.A. de Sousa ACS Nano 2025, doi: 10.1021/acsnano.5c09734

SUN 36
Exploration of 2D Material Membranes with High Ion Conductivities

Hui-Ming Cheng[1].

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Solid electrolytes are promising candidates for safe, high-energy power systems. Composite electrolytes hold the potential to combine high ionic conductivity with stable electrode interfaces. However, a fundamental trade-off often exists between ion conduction and mechanical properties. First, we found that 2D materials show excellent ionic conductivity along 2D channels. Second, we introduce a composite electrolyte design that decouples ion conduction from mechanical flexibility, achieving a high ionic conductivity of 10.2 mS cm^{-1} at room temperature. The architecture features alternating layers of perpendicularly aligned 2D $Li_{0.3}Cd_{0.85}PS_3$ (PA-LiCdPS) to create continuous superionic conduction pathways and polyethylene oxide (PEO) for flexibility and improved interfacial compatibility. This PA-LiCdPS/PEO electrolyte enables Li||$LiNi_{0.8}Co_{0.1}Mn_{0.1}O_2$ coin cells (stack pressure <0.5 MPa) to have high electrochemical performance. Finally, we have designed and synthesized a sieving 2D solid state organic electrolytes with mixed planes and vertical nanochannels, which can be scaled up and shows high environmental tolerance and temperature stability, for practical solid-state batteries.

SUN 37
Strain-Tunable Charge Density Wave Transitions in 1T-TaS_2

Rafael Luque Merino[1], Andrés Castellanos-Gomez[1], Eudomar Henríquez-Guerra[2], Félix Carrascoso[1], M. Reyes Calvo Urbina[2], Riccardo Frisenda[1].

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[2]BC Materials
[3]Università di Roma La Sapienza

Strain is a powerful control parameter in correlated and low-dimensional materials, enabling tunable electronic phases such as charge density waves (CDWs). We study the strain dependence of the CDW phase transition in thin 1T-TaS_2 flakes using a flexible, device-compatible platform that applies controlled uniaxial tensile and compressive strain at room temperature. Electrical transport measurements reveal reversible modulation of both the nearly commensurate-to-incommensurate transition threshold voltage and the resistance of the NC phase. A quadratic rela-

tion between strain-induced resistance change and threshold voltage confirms that piezoresistive modulation governs the strain tunability of the transition. This coupling modifies the Joule-heating conditions required to drive phase switching, providing a route for mechanical control of collective electronic order. Leveraging this mechanism, we demonstrate a compact strain and displacement detector with a threshold-like response, highlighting the potential of CDW materials for strain-programmable electronic devices.

SUN 38
Dynamic screening of excitons by interfacial water-layer

Ayan Halder[1], Sviat Kovalchuk[1], Maximilian Becker[1], Maksim Degoev[1], Yinan Liu[1], Adrian Dewambrechies[1], Kirill Bolotin[1], Roland Netz[1].

[1]Physics Department, Freie Universität Berlin

Our aim is to investigate both frequency dependent dynamic screening of excitons [1] induced by surrounding dielectric environment and sensing the interfacial effect of dielectric response of few nanometers thick spurious water molecules [2] using excitons as localized nano probes. To achieve this, we perform optical reflectivity measurement on WSe2 monolayer, brought in contact with liquid water and extract 1s, 2s excitonic resonance positions for the same device across three distinct dielectric configurations (various water environments). Followed by extracting effective dielectric constant of liquid water screened by 1s and 2s excitons distinctly. By comparing these extracted ϵ values with reported dielectric functions of Bulk and interfacial water, we establish that the strongly confined 1s exciton predominantly "probes" the interfacial dielectric properties, on the other hand more delocalized 2s excitons "probe" the bulk-dielectric effect around frequencies corresponding to their respective excitonic binding energies.

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SUN 39
On-surface synthesis of triangulene chains on a proximitized superconductor.

Katerina Vaxevani[1], Dongfei Wang[2], Georg Monninger[1], Jon Ortuzar[3], Jose Ignacio Pascual[1], Stefano Trivini[1].

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[2]Institute of Physics, University of Chinese Academy of Sciences
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Bridging magnetism and superconductivity is of great interest, particularly in molecular systems where interactions can be tuned through molecular design. However, most elemental superconductors have reactive surfaces that cause molecular

degradation upon adsorption. To overcome this limitation, we develop a metallic proximitized superconducting platform that supports molecular on-surface-synthesis while maintaining a robust superconducting gap. We first grow and characterize Au films on Ag/Nb(110), adjusting thickness and annealing to reproduce Au(111)-like surface morphology and electronic structure. On this optimized surface, we successfully synthesize triangulene chains, previously realized only on bulk Au(111), and resolve their electronic and structural properties with high-energy-resolution spectroscopy and bond-resolved imaging. This platform enables complex molecular architectures to be integrated with superconducting correlations, offering new opportunities for studying molecular magnetism in a superconducting environment.

Refs:
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SUN 40
Phonon Modes in 2D Metal Halides: Raman Spectroscopy and DFT Analysis of Zr/Hf–Cl/Br Systems

Charlotte Berrezueta Palacios[1], Ernesto Joselevich[2], Sabrina Jürgensen[1], Shiyi Gao[2], Stephanie Reich[1], Tamir Forsht[2], Vincent Meunier[3].

[1]Freie Universität Berlin
[2]Department of Molecular Chemistry and Materials Science, Weizmann Institute of Science
[3]Department of Engineering Science and Mechanics, Pennsylvania State University

Two-dimensional metal halides have recently emerged as a new class of layered materials with tunable electronic and vibrational properties. While their structural and electronic characteristics have been explored theoretically, their phonon behavior remains largely uncharted experimentally. Here, we present a combined Raman spectroscopy and density functional theory (DFT) study of monolayer and bulk metal halide systems based on ZrCl, ZrBr, HfCl, and HfBr encapsulated in hexagonal boron nitride. Raman measurements reveal four distinct peaks corresponding to the Raman-active phonon modes expected for a monolayer, in excellent agreement with the phonon eigenmodes obtained from DFT calculations. Comparison with bulk phonon calculations shows a closer match for the two lower-frequency modes, reflecting the layered nature and interlayer coupling of the encapsulated crystals. by systematically varying the metal (Zr vs Hf) and halide (Cl vs Br), we highlight clear trends in phonon frequencies and mode characteristics, elucidating the interplay between chemical composition and vibrational properties in this family of 2D materials.

SUN 41

Tunable Topological and Electronic Properties in Two-Dimensional Bismuthene and Antimonene Bilayers

Marko Petric[1], Stefan Wolff[1], Alexander Grüneis[2], Florian Libisch[2], Janina Maultzsch[1], Roland Gillen[3].

[1]Friedrich-Alexander-Universität Erlangen-Nürnberg
[2]TU Wien
[3]Swansea University

We investigate strong interlayer interactions in two-dimensional pnictogen-based homo- and heterobilayers. These materials exhibit high carrier mobilities and strong spin-orbit coupling. In contrast to monolayers, few-layer systems show markedly altered electronic and optical properties due to interlayer coupling. We present recent results on two systems: (i) multilayer bismuthene and (ii) bilayer antimonene. For bismuthene, tight-binding calculations reveal that spin-polarized surface states emerge beyond a critical slab thickness. Moreover, an asymmetric electric field applied perpendicular to the plane inverts the surface bands, potentially inducing a topological phase transition and highlighting their promise for topological spintronics. Using first-principles calculations, we analyze in bilayer antimonene the evolution of the electronic structure as a function of interlayer distance and twist angle, demonstrating how these parameters govern hybridization of electronic bands, band-gap evolution and indirect-to-direct band-gap transitions.

SUN 42

Raman spectra of $Mo_{(1-x)}W_xS_2$ alloys: the role of disorder

Max Sinner[1], Ludger Wirtz[1], Martin Keller, Miguel Marques[2], Tsachi Livneh[3], Henry Fried[1], Muralidhar Nalabothula[1].

[1]University of Luxembourg
[2]Ruhr Universität Bochum
[3]NRCN, Israel

Machine learning force-fields have revolutionized the field of simulations of large systems that are reliant on inter-atomic potentials, now giving access to simulations that were previously unfeasible with ab initio methods. Recent applications in phonon calculations [1] successfully reproduce the eigenmodes for TMDC alloy supercells at PBEsol precision. Subsequent Raman spectra are calculated through use of DFT Raman tensors from the pure TMDC systems with the alloy supercell eigenmodes via the projection method.
We propose a different approach for simulating the Raman spectra: The trained force-field from [1] was leveraged to simulate Raman spectra through use of the bond polarizability model [2]. By fitting the bond-polarizability parameters to a reference ab initio spectrum for the constituent materials of the alloy system, features of experimental spectra are recovered. We discuss possible extensions and further

applications for single-photon emitters in layered semiconductors [3].

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[2] P. Umari, A. Pasquarello, A. Dal Corso, Phys. Rev. B, 63, 094305 (2001).
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SUN 43
Electronic, optical and catalytic properties of pristine and defective $MnPX_3$ (X: S and Se) monolayers

Jiajun Dai[1], Elena Voloshina[2], Yuriy Dedkov[3], Kangli Wang[4], Beate Paulus[1].

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[3]Center for Advanced Laser Techniques
[4]Institute for Physical Chemistry, Justus-Liebig-Universität Gießen

$MnPX_3$ (X=S,Se) is a new 2D material with tunable electronic properties. We investigate structural properties for pristine and defective MnPX3 with state-of-the-art DFT methods and apply a GW-BSE approach to accurately determine the electronic and optical band gaps. Pristine $MnPS_3$ demonstrates a higher optical band gap (2.68 eV) and stronger exciton binding energy (0.72 eV) compared to $MnPSe_3$ (2.38 eV, 0.31 eV), attributed to reduced dielectric screening in sulfur-based systems. Defects, especially multi-atom vacancies, significantly lower optical band gaps and alter exciton stability. These findings underscore the tunability via defect engineering, highlighting their potential for optoelectronic and photocatalytic applications. Therefore we investigated the water splitting and the materials applications for hydrogen evolution reaction. The adsorption behavior of H_2O on a pristine $MnPX_3$ is of physisorption nature, whereas the adsorption energy is significantly increased for the defective structures. At the same time, the water dissociation process is more energetically favorable, and the reactivity of $MnPX_3$ is determined by the vacancy configuration.

SUN 44
First-principles and Raman investigation of antimony-based layered crystals

Stefan Wolff[1], Michael Hüttenkofer[1], Tobias Dierke[1], Janina Maultzsch[1].

[1]Friedrich-Alexander-Universität Erlangen-Nürnberg

Antimony-based two-dimensional (2D) structures are promising for novel material design. Antimony (Sb) forms layered crystals that can be exfoliated into 2D antimonene sheets, which are reactive under ambient conditions and form stable oxidized structures with stoichiometries Sb_2O_2 and Sb_2O_3 [1,2]. Besides these layered derivatives, Sb_2S_3 forms quasi-layered bulk crystals composed of one-dimensional (1D)-like units [3], which can be prepared as thin films and potentially isolated into 1D-like nanoribbons. We present density functional theory calculations of the vibrational and electronic properties of 2D Sb_2S_3 layers and bulk structures,

discuss Raman selection rules, and compare them with polarization-dependent Raman measurements of Sb_2S_3 thin films.

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SUN 45
Architecting Novel Properties in 2D Materials: A Synergy of Growth Control and Strain Engineering

Shengnan Li[1], Bilu Liu;[1].

[1]Tsinghua University

Strain engineering offers a potent methodology for tailoring the physical properties of 2D materials through both intrinsic and extrinsic approaches. Our investigation into intrinsic strain engineering is exemplified by the synthesis of a novel 2D ferrimagnet Cr1-xSe, a pivotal material for flexible spintronics. We developed an aged-precursor-assisted chemical vapor deposition (CVD) method to introduce intrinsic chromium (Cr) vacancies into the crystal lattice. These atomic-scale vacancies function as endogenous microscopic stress concentrators, governing the material's mechanical response. Consequently, the material exhibits anomalous elasticity, with a Young's modulus of ~52 GPa—among the lowest for 2D systems. In parallel, extrinsic strain engineering was explored by inducing biaxial strain in 2D In2Se3, significantly enhancing its nonlinear optical response. Collectively, these findings highlight the versatility of strain engineering as a powerful strategy for designing novel properties in 2D materials.

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SUN 46
Uncovering the atomic structure of substitutional platinum dopants in MoS_2 with single-sideband ptychography

David Lamprecht[1], Manuel Längle[2], Anna Benzer[1], Mate Capin[1], Clemens Mangler[2], Toma Susi[2], Lado Filipovic[1], Jani Kotakoski[2].

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[2]Faculty of Physics, University of Vienna

Although heteroatom replacement of Mo and S atoms in monolayer MoS_2 has been explored for various elements, many studies lack unambiguous atomic-scale evidence due to surface recontamination between modification and imaging. Owing to

the unique layout of our UHV system, we can introduce defects in monolayer MoS_2 via helium plasma irradiation, repopulate defective sites with heteroatoms by evaporation, and analyze the resulting structures with scanning transmission electron microscopy (STEM) without air exposure. For structural analysis, we employ high-angle annular dark field (HAADF) imaging and single-side-band (SSB) ptychography. HAADF reveals elemental composition but is limited by the beam sensitivity of defective MoS_2, while SSB reconstruction of 4D-STEM data enables atomic-resolution imaging at lower doses and simultaneous visualization of high and low Z elements. Using these techniques, we investigate defect structures produced by He ion irradiation and the local structure of Pt atoms substituting Mo and S. SSB reliably distinguishes Pt atoms in S mono- or divacancies, Mo vacancies, and adatoms. Quantitative phase analysis and DFT calculations support these results.

SUN 47
Modulated Elemental Reactants Growth of Two-Dimensional MoS-CoS Heterostructures

Donghun Lee[1], Vincent Peheliwa[1], Marie H. Kratochvílová[1], Olha Vinnik[1], Tim Verhagen[1].

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Despite experimental success in controlling magnetism and polarization for the oxide-based multiferroics, such as $BiFeO_3$ and $YMnO_3$, they are limited by low magnetoelectric coupling (ME) coefficient and are multiferroic typically at temperatures well below room temperature. Two-dimensional (2D) heterostructures composed of transition metal chalcogenides, which exhibit unique electrical and magnetic properties driven by strong d-p orbital interactions, are considered promising alternatives to overcome these limitations. In particular, ME coupling can be enhanced through interfacial effects between layered TMDs with different properties, such as the sliding ferroelectric Mo-S and magnetic Co-S structures proposed in this study. Here, we employed the modulated elemental reagents method in an MBE system to prepare MoS-CoS 2D heterostructures with various stacking configurations. This approach provides high controllability at the atomic scale, allowing us to precisely explore the synthesis of MoS-CoS heterostructures. The structural and surface properties of the layered materials were characterized by in-situ RHEED and ex-situ XRD, XRR, XRF, Raman spectroscopy, and AFM.

SUN 48
Quasi-free-standing carbyne chains in boron nitride nanotubes

Pietro Marabotti[1], Getúlio Silva e Souza Júnior[1], Benjamin S. Flavel[2], Sebastian Heeg[1].

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zu Berlin, Germany
[2]Karlsruhe Institute of Technology

Carbyne, the one-dimensional sp-hybridized carbon allotrope, remains unrealized in bulk form, while extended chains appear only when confined in carbon nanotubes (CNTs) [1]. While CNTs enable bottom-up growth and stabilization of carbyne chains, they strongly electronically interact with the guest, renormalizing carbyne vibrational and electronic properties and masking intrinsic behavior. An ideal host should provide one-dimensional confinement without strong interaction. Here, we isolated ultrathin single-walled boron nitride nanotubes (BNNTs) with diameters of 0.5–1 nm and used them as nanoreactors for carbyne growth. Encapsulated short carbon wires ($HC_{10}H$) are converted into extended carbyne chains by controlled vacuum annealing. Raman spectroscopy reveals intense C mode features at frequencies exceeding those reported for carbyne in CNTs and approaching values extrapolated for ideal carbyne. These results demonstrate that carbyne in BNNTs provides the closest experimental realization of ideal carbyne to date.

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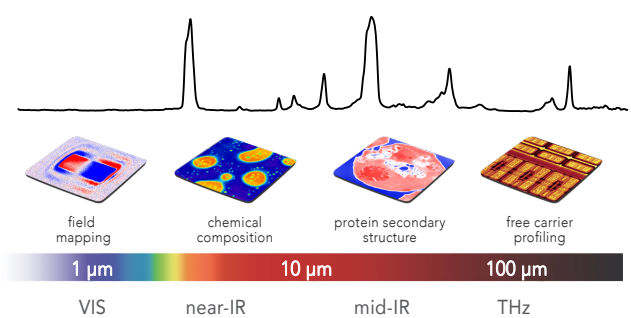

08:30 – 09:00	Xavier Marie *Exciton Formation in 2D Semiconductors*
09:00 – 09:30	Y. K. Kato *Exciton dynamics in 1D-2D mixed-dimensional heterostructure*
09:30 – 10:00	Feng Wang *Electron-hole fluid in van der Waals heterostructures*
10:00 – 10:30	Coffee Break
10:30 – 11:00	Xiaoqin Elaine Li *Emergent Trion Resonance Driven by Lattice Reconstruction in a Moire Superlattice*
11:00 – 11:30	Nadine Leisgang *Optical signatures of interlayer electron coherence in a bilayer semiconductor*
11:30 – 12:00	Junichiro Shiomi *Phonon Engineering and Thermal Transport in 2D Heterostructures*
12:00 – 17:00	Mini Workshops
17:00 – 18:30	Dinner
18:30 – 19:00	Georg Duesberg *Functional devices with not-so-perfect 2D materials*
19:00 – 19:30	Jong-Hyun Ahn *Scalable 2D TMD active-matrix platforms for electronic applications*
19:30 – 20:00	Szabolcs Csonka *Pressure tuning of van der Waal crystal based devices*
20:00	Poster II

08:30
Exciton Formation in 2D Semiconductors
Xavier Marie[1].
[1]INSA Toulouse - CNRS

Robust excitons dominate the optical properties of atomically thin semiconductors based on transition-metal dichalcogenides. However, a crucial question persists: What is the exciton formation mechanism?
This study addresses this fundamental problem through polarization-dependent micro-PL studies on WSe_2 and MoS_2 monolayers close to the neutrality point. The results of our experiments clarify the role played by the two potential formation mechanisms: a) geminate and b) bimolecular. The geminate formation process corresponds to the monomolecular annihilation of the photogenerated correlated electron-hole pair. In contrast the non-geminate formation results from the random bimolecular binding of two free charges, losing all correlation between the excitation photon and the electron-hole pair of the exciton.
For a laser excitation energy below the band gap, we show that the geminate mechanism prevails as expected, whereas above the band gap, both geminate and bimolecular process coexist[1]. This means that we must go beyond the simple description used until now of either a totally geminate or totally bimolecular formation process.

[1] Mourzidis et al, PRX 15 , 031078 (2025)

09:00
Exciton dynamics in 1D-2D mixed-dimensional heterostructure
N. Fang[1], Y.R. Chang[1], S. Fujii[1,2], D. Yamashita[1,3], M. Maruyama[4], Y. Gao[4], C. F. Fong[1,3], D. Kozawa[1,5], K. Otsuka[1,6], K. Nagashio[1,6], S. Okada[4], Y. K. Kato[1].

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[2]Keio University
[3]AIST
[4]Tsukuba University
[5]NIMS
[6]The University of Tokyo

Two-dimensional van der Waals heterostructures have revealed unconventional phenomena at atomically precise interfaces, and further advances are expected in mixed-dimensional systems. Here we discuss exciton physics in free-standing 1D–2D heterostructures of carbon nanotubes and tungsten diselenide [1,2]. Chirality and layer number are identified to study band alignment effects, and the heterostructures are assembled using anthracene-assisted transfer [3]. For small-gap nanotubes with type I alignment, exciton transfer is observed [1]. For large-gap tubes forming type II alignment, we find that localized interface excitons exhibit quantum emission at room temperature [2]. With mixed-dimensional van der Waals heterostructures where band alignment can be engineered, new opportunities for quantum photonics are envisioned.

Work supported in part by JSPS, JST, and MEXT.

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09:30
Electron-hole fluid in van der Waals heterostructures
Feng Wang[1].

[1]University of California-Berkeley

Atomically thin two-dimensional heterostructure provides an exciting platform to realize strongly interacting electron and hole fluid in the ground state. With the combination of both repulsive and attractive Coulomb interactions, the quantum electron-hole fluid can host a variety of novel correlated phenomena of multiparticle charge complexes. I will discuss the rich phase diagram of the electron-hole fluid, including bosonic exciton fluid, fermionic trion fluid, electron-hole plasma, and different mixture phases. I will also show that optical spectroscopy provides a powerful way to probe the phase diagram as well as transport of the electrons, holes, and excitons in the electron-hole fluid.

10:30
Emergent Trion Resonance Driven by Lattice Reconstruction in a Moiré Superlattice

Xiaoqin Elaine Li[1].

[1]University of Texas at Austin

In this talk, I will discuss how new many-electron excited states emerge in $MoSe_2$ homobilayers when the lattice reconstructions evolve. Notably, we identify a new trion resonance that arises in the transition regime of lattice reconstruction, where gradual changes in atomic alignment between the layers occur. Magnetic field–dependent measurements, supported by first-principles calculations, indicate that the exciton forms at the K valley while the doped hole resides in the Γ-valley. First-principles calculations further indicate that two nearly degenerate exciton resonances can arise, localized at different sites within the Moiré supercell. We propose that the new trion resonance is a “charge-transfer" trion, in which the electron–hole pair is spatially separated from the doped hole. These novel trions offer promising opportunities for the optical control of spin arrays embedded in the Moiré superlattice.

11:00

Optical signatures of interlayer electron coherence in a bilayer semiconductor

Nadine Leisgang[1], Alexander A. Zibrov[2], Hongkun Park[2], Jiho Sung[3], Jue Wang[4], Kenji Watanabe[5], Mikhail D. Lukin[2], Pavel E. Dolgirev[2], Philip Kim[2], Takashi Taniguchi[5], Valentin Walther[6], Xiaoling Liu[2].

[1]Philipps-Universität Marburg
[2]Harvard University
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[6]Purdue University

Emergent strongly correlated electronic phenomena in atomically thin transition-metal dichalcogenides represent an exciting frontier in condensed matter physics, with examples ranging from bilayer superconductivity and electronic Wigner crystals to the ongoing search for exciton condensation.
Here, we report experimental signatures of unconventional coupling of interlayer excitons consistent with coherence between electrons in different layers of a naturally grown MoS_2 homobilayer. When the bilayer is electron-doped under conditions where tunnelling between layers is negligible, we observe that two interlayer excitons – which normally should not interact – hybridize in a way distinct from both conventional level crossing and anti-crossing. We show that these observations can be explained by quasi-static random coupling between the excitons, which increases with electron density and decreases with temperature. We argue that this phenomenon is indicative of a spatially fluctuating order parameter in the form of interlayer electron coherence – a theoretically predicted many-body state that has yet to be unambiguously established experimentally outside the quantum Hall regime.

11:30
Phonon Engineering and Thermal Transport in 2D Heterostructures
Junichiro Shiomi[1].

[1]The University of Tokyo

Two dimensional (2D) van der Waals heterostructures offer an unprecedented platform to engineer heat flow by design. Weak interlayer coupling, strong elastic anisotropy, and highly structured phonon dispersions produce thermal transport that is fundamentally different from 3D crystals. In this talk, I will outline a phonon engineering framework for 2D stacks that link atomic structure to spectral energy transfer. I will first clarify the governing mechanisms for in plane and cross plane thermal transport in layered materials, emphasizing the roles various phonon modes and classification between coherent and incoherent phonon propagation. Building on this foundation, I will show how heterostructure design knobs—layer sequence and thickness, twist angle and Moiré periodicity, strain and intercalation—permit selective filtering and blocking of phonons. A spectral perspective, using modal-resolved thermal conductivity and wavevector-resolved interfacial thermal conductance, will be used to illustrate phonon band engineering. Finally, I will discuss the challenges and opportunities for thermal management in next the generation electronics with particular focus on cryo-CMOS devices.

18:30
Functional devices with not-so-perfect 2D materials

Georg Duesberg[1], Cormac Ó Coileáin[1], Florian Herdl[2], Janos Papp[1], Martin Gerlei[1], Natalie Galfe[1,3], Nikolaus Dominik[1,3], Paul Seifert[1], Sebastian Klenk[1], Simon Schlosser[1], Stefan Heiserer[1].

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Two-dimensional (2D) layered materials are explored for next-generation hybrid devices such as micro- and nano-electro-mechanical systems (MEMS/NEMS), sensors and electron emitters.
This talk discusses hybrid devices of 2D materials integrated with silicon by scalable techniques. The vapour phase grown 2D materials typically deviate from perfect crystallinity, exhibiting domain sizes ranging from a few nano- to several micrometers. Thus, these structural imperfections remain to be of the mayor challenges for 2D materials-based devices, however, also bear new functionalities, compromising opportunities for novel devices functionalities. The chemical and morphological properties of the layers and functional stacks are characterized using a range of complementary techniques, including Raman X-ray photoelectron spectroscopy (XPS). Finally, the electrical performance of devices based on these not-so-perfect 2D materials will be discussed.

19:00
Scalable 2D TMD active-matrix platforms for electronic applications
Jong-Hyun Ahn[1].
[1]Yonsei University

The rapid evolution of electronics has spurred the exploration of two-dimensional (2D) materials to transcend the limitations of conventional rigid platforms. In this talk, I will present recent advancements in molybdenum disulfide (MoS_2)-based devices, unlocking diverse applications ranging from traditional electronics to bio-integrated systems.
In parallel, MoS_2 thin-film transistor (TFT) arrays have been optimized for backplane circuits, which are critical for driving flexible OLED and microLED displays as well as X-ray detectors. These arrays demonstrate exceptional uniformity and operational stability, supporting high-resolution visual outputs.
Additionally, MoS_2 transistor arrays have been engineered for electrocorticogram (ECoG) signal detection, opening new frontiers in neural interfacing and brain–machine integration. By harnessing the complementary properties of graphene and MoS_2, this research lays the foundation for a new era of bio-integrated electronics—enhancing human-device interaction, expanding biomedical capabilities, and transforming wearable sensor technologies.

19:30

Pressure tuning of van der Waals crystal based devices

Albin Marffy[1], Bálint Szentpéteri[1], Zoltan Kovacs-Krausz[1], Margarita Rahimkulov[1], Roland Tóth[1], Bálint Fülöp[1], Endre Tóvári[1], Péter Makk[1], Szabolcs Csonka[1].

[1]Department of Physics, Budapest University of Technology and Economics

Van der Waals heterostructures offer unprecedented control in materials science by enabling atomic-scale stacking of metals, insulators, superconductors, and magnetic materials—optionally with tailored twist angles. The electronic properties of these systems are highly sensitive to interlayer tunnel coupling, which can be tuned by modifying the layer spacing using hydrostatic pressure. In this talk, I will present transport measurements performed with a unique pressure-cell platform capable of probing wire-bonded devices up to 2.5 GPa. I will discuss how pressure enhances proximity-induced spin–orbit coupling in TMDC–graphene heterostructures, modifies the band structure in twisted graphene, alters colossal magnetoresistance in the antiferromagnet CrSBr, and affects topological phases in 2D crystals such as $MnBi_2Te_4$. These results highlight pressure as a powerful tool for engineering electronic states in van der Waals materials.

POSTER II

MON 1

Dynamics of phonon-assisted resonant energy transfer between Moiré cells in charge-tunable $MoSe_2$/WS_2 heterobilayers

Michael Lorenz[1], Philipp Parzefall[1], Nicolas Paulik[1], Jonas Göser[2], Julian Trapp[2], Kenji Watanabe[3], Takashi Taniguchi[3], Daniel Erkensten[4], Yara Galvão Gobato[5], Ermin Malic[4], Alexander Högele[2], Christian Schüller[1].

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[5]Universidade Federal de São Carlos, Brazil

We report further insight into the recently discovered deterministic resonant energy transfer between Moiré cells in charge-tunable $\mathrm{MoSe_2}$-$\mathrm{WS_2}$ by investigating the dynamics of the process.
When exciting resonantly with the Moiré exciton (M_1), a phonon-assisted (E^1_{2g}) relaxation into the Moiré trion (M_1^*) state is observed [1]. In real space this transfer is associated with a strongly localized exciton [2] going from an empty cell to an adjacent cell, which is filled with one electron. The maximum transfer rate of this process is reached when every second Moiré cell is filled with an electron.
We performed time-resolved reflectance measurements by pumping the M_1 resonantly while probing both the M_1 itself and the M_1^*. A distinct difference between the rise time of the M_1 (instantly) and the rise time of the M_1^* can be observed. The latter is identified with the time of the energy transfer to take place, further supporting our interpretation of lateral transport in a charge-tunable Moiré heterostructure.

[1] P. Parzefall et al., npj 2D Mater. Appl. **9**, 84 (2025)
[2] B. Polovnikov et al., Phys. Rev. Lett. **132**, 076902 (2024).

MON 2

Localized phonons at defect-induced single-photon emitters in monolayer TMDCs

Sebastian Kindl[1], Max Sinner[2], Pablo Hernández López[3], Fredrik Eriksson[1], Sebastian Heeg[3], Florian Libisch[1].

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[3]Humboldt-Universität zu Berlin, Germany

Single-photon emitters play a key role in present and emerging quantum technologies. Point defects in strained WSe_2 allow for optical de-excitation of excitons, creating bright single-photon emitters [1]. Recent measurements demonstrate

strain as an important tuning knob to further investigate these systems, identifying distinct excitonic species [2] and intentionally creating degeneracies that influence excitation lifetimes [3]. Localized phonon modes at the defect site should result in further line broadening, and distinct side-bands in low-temperature photoluminescense spectra.
Modeling the phonons necessitates large defect-supercells which challenges traditional simulation techniques based on density functional perturbation theory. Instead, an active-learning-based machine learning force-fields workflow is used to model the localized defect modes, as well as its effect on the excitonic transitions. We find a characteristic evolution of the defect lineshape with temperature, that reveals further details on the defect involved.

[1] Linhart et al. PRL 123, 146401 (2019)
[2] Kumar et al. Nano Let. 25, 15164–15172 (2025)
[3] Kumar et al. Nature Comm. 15, 7546 (2024)

MON 3
Wavelength-Dependent TERS Response in 2D Transition-Metal Dichalcogenides

Andrey Krayev[1], Jana M. Kalbacova[2].

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[2]HORIBA Jobin Yvon GmbH

TERS continues to evolve as a tool for nanoscale vibrational analysis, especially for two-dimensional materials. Recent measurements on mono- and bilayer WS_2 and MoS_2 on silver show that their (Tip-enhanced) Raman response varies strongly when the excitation is tuned across 473–830nm, reflecting how excitonic resonances interact with the plasmonic cavity. Complementary dual-laser experiments on WS_2 nanoflakes, using 633nm and 785nm simultaneously, demonstrate that recording both spectral responses with the same probe reduces artefacts and provides a more reliable picture of the material's optical behavior. Bringing these approaches together—multi-wavelength excitation and controlled illumination—helps stabilize field enhancement at the tip and improves the chemical contrast achievable in TERS. This combination offers a practical route for more reproducible and informative nanoscale studies of transition-metal dichalcogenides.

MON 4
Visualizing and Modulating Molecular Assemblies on Surfaces

Filippo Giovanni Fabozzi[1], Stefan Hecht[1].

[1]Humboldt-Universität zu Berlin, Germany

Interfaces represent critical zones of interactions where materials exhibit remarkable changes in their physical and chemical properties, often leading to unique phenom-

ena that are essential to both fundamental processes and advanced technological applications. In this context, STM at the liquid–solid interface is not only an imaging technique for unraveling and rationalize formation of 2D-nanoarchitectures at the molecular level, but a means to initiate and control molecular processes confined in the two dimensions of the substrate.
Here, we demonstrate how the design of molecular building blocks enables access to complex, unprecedented supramolecular architectures on surfaces. Furthermore, we take advantage of the local electric field in the vicinity of the STM tip to dynamically modulate supramolecular assemblies and their higher-order superstructures. Moreover, we exploit this control over surface-confined dynamism to construct covalent nanomaterials, such as single-layer vinylene-linked 2D-COFs generated via a dynamic C=C bond process.
Our findings highlight possibilities to create novel 2DMs with exquisite control over their structure and their physicochemical properties.

MON 5
Engineering the Chemistry in the Confined Space of 2D Heterostructures

Sofiia Zuieva[1], Xin Chen[1].

[1]Freie Universität Berlin

This project aims to identify functionalization strategies for achieving covalent patterning of 2D surfaces and methods for fabricating 2D heterostructures. Covalent heterostructures address the limitations of van der Waals interfaces by providing improved stability, stronger bonding, and precise functionalization, unlocking advanced applications in energy, catalysis, and electronics. Building on our previous research, covalently coupled heterostructures can be constructed by connecting molecular linkers attached to functional domains of the bottom layer (MX_2) with the top material layer (Graphene or M'X'$_2$).
We have designed and synthesized three types of molecular linkers: 4′-Bromo[1,1′-biphenyl]-4-diazonium salt, 4-[2-(4-bromophenyl)ethynyl]benzenediazonium salt, and 4-bromo-[p-Terphenyl]-4′-diazonium salt, each optimized to provide specific interlayer spacing. This study provides the synthesis of three new diazonium salts, which are covalently linked to the layers of 2D heterostructures, offering insights into the optical and electronic properties of 2D materials.

MON 6
In-situ control of chiral polaritons in twisted CrSBr cavities

Adrian Dewambrechies[1], Aleksei Tsarapkin[2], Eugenio Coronado[3], Guillermo López-Polin[4], Ignacio Horcas[4], Katja Höflich[2], Kirill Bolotin[1], Niclas S. Müller[1], Oguzhan Yücel[1], Samuel Mañas-Valero[5], Sviat Kovalchuk[1], Yuefeng Yu[1].

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Recent advances in the continuous control of the twist angle in two-dimensional (2D) heterostructures have opened up a new way of studying angle-dependent phenomena in such systems. In this context, the geometry of a twisted structure can show chirality, a fundamental property of nature with extended reach and applications to different areas of physics. In this work, we study the optical tunability and chiral properties of a system comprised of a twisted stack of two sub-wavelength cavities of CrSBr, a two-dimensional antiferromagnet hosting strongly coupled self-hybridized polaritons, quasiparticles formed by the coupling of light and a tightly bound, quasi-1D exciton in the VIS-NIR regime. We observe and control chiral absorption and emission of light from these polariton modes in such combined system, by continuously tuning the twist angle between the two flakes at cryogenic temperatures over a 90° range of angles. Our work expands the understanding on twisted bilayers of 2D materials as a van der Waals chiral object at the nanoscale, and contributes to the efforts towards in-situ control of the twist angle-dependent physical phenomena in 2D heterostructures.

MON 7

Resonance Raman scattering and anomalous anti-Stokes phenomena in $CrSBr_{(1-x)}Cl_x$

Satyam Sahu[1], Charlotte Berrezueta Palacios[2], Sabrina Jürgensen[2], Arsalan Hashemi[3], Mahdi Ghorbani-Asl[4], Jan Maňák[5], János Koltai[6], Kseniia Mosina[7], Zdenek Sofer[7], Matěj Velický[1], Mikko Karttunen[3], Arkady Krasheninnikov[4], Patryk Kusch[2], Otakar Frank[1].

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[6]Department of Biological Physics, Eötvös Loránd University
[7]Department of Inorganic Chemistry, University of Chemistry and Technology Prague

CrSBr, a van der Waals material, stands out as an air-stable magnetic semiconductor with highly extraordinary properties. We investigate its Raman spectral fingerprints, including resonance Raman excitation profiles, accompanied by photoemission, and optical absorption, to reveal (i) the indirect nature of the 1.7 eV emission, (ii) anomalously high anti-Stokes to Stokes intensity ratio, and (iii) a higher order Raman effect, resembling stimulated Raman scattering, with a gain of 1×10^8 cm/GW, nearly four orders of magnitude higher than that of previously studied three-

dimensional systems. We further extend those studies to $CrSBr_{1-x}Cl_x$ (x=0—0.5), and confirm the robustness of the higher-order Raman scattering. We analyze the Raman signature of $CrSBr_{1-x}Cl_x$ as a function of x and discover the appearance of several new modes stemming from the perturbation induced by Cl substitution. We assign those modes with the aid of DFT calculations, which provide a close resemblance to the experimental data both in terms of frequencies and intensities.

MON 8
Self and externally induced spin-orbit torque in the ferromagnet Fe_3GaTe_2

Tamás Prok[1], Zoltan Kovacs-Krausz[1], Milán Varga[1], Szabolcs Csonka[1], Saroj Dash[2], Péter Makk[1], Endre Tóvári[1].

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[2]Chalmers University of Technology

In informatics there is a need for fast-writable, energy efficient, and non-volatile magnetic memories which may be realized via spin–orbit torque (SOT) [1]. The 2D ferromagnet Fe_3GaTe_2 (FGT) [2,3] is a promising host in this regard, and it can be combined with other 2D materials with spin–orbit coupling to produce a strong SOT and may also posses a self-induced torque [4,5].
We quantitatively studied self-torque in FGT as well as SOT induced by 1T-$MoTe_2$ at room temperature using second-harmonic Hall (2HH) technique [6]. We have found that in both systems thermal effects dominate the 2HH signal. In spite of this, we were able to extract the SOT fields, and clearly identify their features in FGT/$MoTe_2$. We have found that for a better description of the 2HH, the current-induced change of the magnetization's magnitude must also be taken into account [7].

[1] Dieny et al., Nat. Electron. 3, 446 (2020)
[2] Burch et al., Nature 563, 47 (2018)
[3] Zhang et al., Nat. Commun. 13, 5067 (2022)
[4] Kao et al., Nat. Mat. 21, 1029 (2022)
[5] Deng et al., Nano Lett. 24(30), 9302 (2024)
[6] Hayashi et al., Phys. Rev. B 89, 144425 (2014)
[7] Noël et al., Phys. Rev. B 111, 144409 (2025)

MON 9
Intravalley reflection asymmetry in rhombohedral and hexagonal graphite nanoribbons

Konrád Kandrai[1], András Balogh[1], Márton Szendrő[1], András Pálinkás[1], Dóra Varga[1], Krisztián Márity[1], Zoltán Tajkov[1], Péter Vancsó[1], Géza István Márk[1], Levente Tapaszto[1], Péter Nemes-Incze[1].

[1]Hungarian Research Network, HUN-REN Centre for Energy Research, Institute of Technical Physics and Materials Science, Budapest, Hungary

Rhombohedral graphite (RG) is a multilayer graphene system hosting a flat surface band arising from the nodal-line topology of its bulk structure. Unlike Moiré superlattices, this flat band appears without twisting and expands in momentum space with increasing layer number. Recently, RG has attracted attention due to correlated phases such as fractional Chern insulators and unconventional superconductivity. We investigate confinement effects in graphite nanoribbons (5–70 nm) formed by domain walls between 6 layer thick rhombohedral and Bernal regions. Maps of the tunnelling conductance at energies within the 6 layer RG gap reveal strong intravalley interference in confined Bernal regions but its absence in rhombohedral ones. We reveal the origin of the reflection asymmetry, using wave-packet dynamics simulations of ABA–ABC stacking boundaries. Tight-binding and a π-orbital continuum model reproduce these observations. We further identify direction-dependent quantum transport: carriers from the rhombohedral side transmit efficiently, whereas those from the Bernal side are strongly reflected. This asymmetry, rooted in distinct lattice symmetries, yields diode-like transport behavior.

MON 10
Molecular Monolayer Growth on 2D Materials via Physical Vapor Deposition

Sabrina Jürgensen[1], Niels Brumby[1], Niclas S. Müller[1], Stephanie Reich[1].

[1]Freie Universität Berlin

Two-dimensional layers can act as templates for molecules. We examine the formation of well-ordered molecular lattices on atomically flat two-dimensional substrates via physical vapor deposition. Using different organic molecules, we optimize the individual growth parameters for molecular monolayers on van der Waals materials. In such molecular lattices the optical excitations couple into collective and delocalized excitons. The coupling changes the energetics and dynamics of the molecules giving rise to characteristic optical properties like strong and narrow emission. We study how the molecules align with respect to the crystal axis of the underlying two-dimensional material by using polarization dependent fluorescence microscopy as well as second harmonic generation spectro-microscopy.

MON 11
Magnetic properties of $Co_xFe_{5-x}GeTe_2$ nanodevices under pressure

Tamás Prok[1], Zoltan Kovacs-Krausz[1], Michael Morgan[1], Szabolcs Csonka[1], Saroj P. Dash[1], Péter Makk[2], Endre Tóvári[1].

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[2]Department of Microtechnology and Nanoscience, Chalmers University of Technology

Realization of solid-state magnetic memory relies on development of novel magnetic materials that are switchable fast and reliably[1]. A promising 2D material is Fe_5GeTe_2, with z-axis ferromagnetic (FM) ordering but T_C typically below room

temperature[2]. Co substitution results in the $Co_xFe_{5-x}GeTe_2$ (CFGT) structure, with enhanced T_C above room temperature, and antiferromagnetic (AFM) ordering at 50% substitution[3]. CFGT can also have canted magnetization[4], which could be useful for magnetic memory via field-free switching[5]. We have studied the effect of pressure on the complex crystal structure of CFGT (50% Co), using a pressure cell method[6]. Magnetotransport shows enhancement of AFM coupling and T_N with pressure, and different magnetic arrangement for crystals of varying thickness, with some maintaining a FM-like feature (likely due to odd layer count). Modeling can also explain the multi-step hysteresis behavior in both even and odd layer samples.

[1]Nature Electronics 3, 446 (2020)
[2]Sci Rep 10, 15345 (2020)
[3]Phys. Rev. Materials 4, 074008 (2020)
[4]Appl. Phys. Lett. 126, 262405 (2025)
[5]ACS Nano 19, 13817 (2025)
[6]J. Appl. Phys. 130, 064303 (2021)

MON 12
Sliding ferroelectricity in misfit layer compound $(PbS)_{1.11}VS_2$

Cinthia Antunes Corrêa[1], Jan Honolka[1], Jiří Volný[2], Johana Vaníčková[1], Kateřina Tetalová[2], Martin Vondráček[1], Václav Petříček[1], Klára Uhlířová[2], Tim Verhagen[1].

[1]Institute of Physics of the Czech Academy of Sciences
[2]Charles University, Faculty of Mathematics and Physics

Twisted heterostructures of two-dimensional crystals can create a Moiré landscape, thereby changing dramatically the properties of its parent crystals. Here, the alternated stacking of posttransition metal monochalcogenides and transition metal dichalcogenides in misfit layer compound crystals is used as a Moiré generator. X-ray diffraction shows the presence of twins with a small twist angle between them. The surface electrical potential from the induced sliding ferroelectricity can be seen by using scanning probe microscopy and electron microscopy with domain sizes up to tens of micrometers [1]. Furthermore, I will show that generated Moiré landscape in $(PbS)_{1.11}VS_2$ is a perfect playground to explore the properties of such Moiré domains. For example, using electron-beam lithography, stable domains of arbitrary shape can be written or the catalytic activity of the micrometer large domains can be straightforwardly followed using optical microscopy.

[1] C. Antunes Corrêa, J. Volný, K. Tetalová, K. Uhlířová, V. Petříček, M. Vondráček, J. Honolka, and T. Verhagen, Phys. Rev. Lett. 134, 056202 (2025)

MON 13
Electrical switching of magnetic phases in Bernal bilayer graphene

Bernd Beschoten[1], Eike Icking[1], Ammon Fischer[2], David Emmerich[1], Frank Volmer[1], Robin Dolleman[1], Kenji Watanabe[3], Takashi Taniguchi[3], Dante Kennes[2], Christoph Stampfer[1].

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[3]National Institute for Materials Science, Tsukuba, Japan

Two-dimensional materials offer a compelling platform for electrically tunable magnetism due to their ability to host a range of metallic and insulating magnetic phases. Among them, pristine Bernal-stacked bilayer graphene (BLG) has recently emerged as a particularly versatile system, exhibiting a rich phase diagram of magnetically ordered metallic states in its valence band. In this work, we demonstrate the emergence of carrier-induced orbital magnetism in BLG, characterized by an intrinsic magnetic ordering between its two graphene layers. In-plane charge transport measurements reveal a built-in giant magnetoresistance of 20%, corresponding to a transition between distinct magnetic configurations. This transition can be induced by low microvolt source-drain bias voltages or, equivalently, ultralow nA currents, without the need for an external magnetic field. Additionally, we observe hysteretic switching between high and low resistance states in response to in-plane magnetic fields or applied bias voltages. These findings point to the potential of BLG-based devices for low-power cryogenic magnetic memory applications.

MON 14
Lasing of Interlayer Excitons in WSe_2–WS_2 Heterobilayers Coupled to hBN-Si_3N_4 Photonic Crystal Cavities

Shengyu Shan[1], Antti Moilanen[1], Simone Iadanza[2], Jonas Ziegler[1], Qia Lin[1], Guodong Xue[3], Takashi Taniguchi[4], Kenji Watanabe[4], Kaihui Liu[3], Kirsten Moselund[2], Lukas Novotny[1].

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Two-dimensional (2D) materials such as transition metal dichalcogenides enable integration of light sources on chip without lattice-matching constraints. Monolayer WSe_2 and WS_2 form a type-II heterostructure supporting interlayer excitons with long lifetimes and reduced absorption. We design photonic crystal cavities made of Si_3N_4 and hexagonal boron nitride, combining compatibility with silicon platform and flexibility for 2D material integration. Using this platform, we report the first lasing of WSe_2–WS_2 interlayer excitons. We observed a nonlinear increase in cavity-coupled interlayer exciton emission with increasing excitation power, together with increased

temporal coherence confirmed via Michelson interferometry. These results demonstrate a pathway toward hybrid 2D-material–based light sources for integrated photonics.

MON 15
Scanning NV magnetometry in a closed-cycle cryostat

Gabriel Puebla-Hellmann[1], Jan Rensius[1], Philipp Leubner[2], Andrea Morales[1], Khaled Karrai[2], Clemens Schäfermeier[2].

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[2]Attocube systems GmbH

The ability to measure magnetic fields on the nanometre scale at cryogenic temperatures is crucial for understanding magnetism on the quantum level, as well as for designing materials for novel data storage devices or quantum computers. Nitrogen vacancy (NV) centres in diamond have proven to be a robust means of harnessing quantum sensing for such applications. We have developed an instrument to measure the magnetic stray field of a sample with nanometre resolution from 2 K - 300 K and that accepts samples without additional preparation, especially without the need to prepare a microwave line on the sample. The instrument features a software interface for controlling and synchronising all included optical, mechanical and electronic devices, which analyses the acquired information in real time. We present the key features and measurement results achieved with atomic force microscopy (AFM) tips hosting an NV centre and a fully remote controllable microscope platform. We show sensitivity of 3 µT/ $\sqrt{Hz}$, low noise AFM tip control and optically detected resonance scans in a closed-cycle cryostat [1].

[1] C. Schäfermeier et al., arXiv:2502.16599 (2025)

MON 16
Raman Spectroscopic Characterisation of Graphene Nanoribbons

Britta Maib[1], Michael Hüttenkofer[1], Jin-Jiang Zhang[2], Philipp Kraus[1], Yuri Koval[1], Ji Ma[2,3], Xinliang Feng[2], Janina Maultzsch[4,5].

[1]Friedrich-Alexander Universität Erlangen-Nürnberg
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[5]Faculty of Chemistry and Food Chemistry, Technische Universität Dresden

Graphene nanoribbons (GNRs) are one-dimensional strips of graphene whose electronic and optical properties can be modified by altering their width, edge structure, and chemical functionalization. Unlike pristine graphene, GNRs can exhibit semiconducting behaviour with tunable band gaps, making them promising candidates for next-generation nanoelectronic. We present recent results on

GNR Raman spectroscopy of different types of GNR to establish characteristic vibrational fingerprints. The GNRs include commercially available 4-zigzag GNRs as powder sample and exfoliated GNR bundles, and novel cyclophane-shielded GNRs. Cyclophane-shielded GNRs utilize flexible carbon chains to link gulf-edged GNRs, effectively suppressing inter-ribbon aggregation and achieving single-ribbon dispersibility [1]. The current work focuses on preparing and characterizing GNR powder samples, polymer-wrapped thin films and mechanically exfoliated GNR layers. Raman measurements are performed with different excitation energies to assess resonant conditions. We plan to investigate the GNR response to perturbations induced by strain and electric field.

[1] J.-J. Zhang et al., sub. 2025

MON 17
Spin-orbit interaction and magnetic moments in a MoS_2 nanotube

Robin Schock[1], Stefan Obloh[1], Korbinian Fink[1], Matthias Kronseder[1], Matjaž Malok[2], Maja Remškar[2], Andreas Hüttel[1].

[1]Universität Regensburg
[2]Jožef Stefan Institute

Molybdenum disulfide MoS_2 is a highly promising semiconductor material both for classical transistor applications and quantum devices. Currently, quantum dots in MoS_2 are discussed as advanced spin/valley qubits, with the strong spin-orbit interaction of the material (compared to, e.g., graphene) playing an important role.
Here, we present electronic transport measurements on a MoS_2 nanotube at milli-Kelvin temperatures. We identify Kramers doublets at zero magnetic field and their splitting in aligned magnetic fields, and extract the corresponding g-factors as well as the energy scale of the spin orbit coupling in the conduction band quantum dot. These results are consistent with theoretical predictions and with data on planar MoS_2. Limitations and potential improvements of the experimental system are discussed.

MON 18
Tunable Topological Superconductivity in Ising-Type 2D $NbSe_2$ from a Symmetry-Guided Pairing Framework

Jozef Hanič[1], Marko Milivojević[2], Martin Gmitra[3].

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[2]Institute of Informatics, Slovak Academy of Sciences
[3]Institute of Physics, Pavol Jozef Šafarik University in Košice, Slovakia, Institute of Experimental Physics, Slovak Academy of Sciences, Slovakia

Topological superconductivity in two-dimensional (2D) quantum materials promises Majorana-bound states for fault-tolerant computation. We develop a symmetry-

guided framework for Ising-type transition metal dichalcogenides, focusing on $NbSe_2$ monolayers and van der Waals heterostructures. From a complete group-theoretical construction of pairing functions for the C_{3v} point group, we enumerate all allowed singlet–triplet mixed order parameters and track their evolution with carrier density. We identify multiple topological phases—classified by Chern numbers and $\mathbb{Z}_2$ invariants—enabled by spin–orbit–induced triplet components. Zigzag-ribbon band structures display Fermi-level crossings consistent with these indices, providing direct spectral signatures of edge modes. The triplet weight, and thus the topological phase, is tunable by electrostatic doping. Notably, the framework extends to novel misfit superconducting structures whose energy bands are captured by an electron-doped single-band transition-metal model, suggesting design rules for robust, gate-controllable topological superconductivity.

MON 19
Many-Body Effects in Lattice Dynamics: A Case Study of the Displacive Phase Transition in $BiVO_4$

Matan Menahem[1], Adi Lanton[1], Shlomo Rand[1].

[1]Weizmann Institute of Science

Poster shifted to Wednesday (WED 48)

MON 20
Optical properties of phthalocyanine monolayers

Jose Arcos[1], Adrian Dewambrechies[1], Sabrina Jürgensen[1], Eduardo Barros[2], Stephanie Reich[1].

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Highly ordered monolayers of organic molecules show intriguing optical properties, arising from the interaction of their transition dipole moments in the lattice. The coupling of these transition dipole moments gives rise to a delocalized collective optical state [1]. The nature of the transition dipole moment has a strong impact on the optical properties of the system. In this work we grow two-dimensional monolayers of metal free phthalocyanine and study optical response to different polarization excitations. We discover an unusual polarization response of the system that does not agree with the symmetry of the molecule. Calculations reveal that this behavior is explained by the different tautomerization states the molecule shows in the lattice.

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MON 21
Chemical Vapour Deposition of 2D Transition Metal Carbides

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Within the broad family of two-dimensional (2D) materials, transition metal carbides (TMCs) represent a relatively less explored subgroup that exhibits a range of promising properties and potential applications. Chemical vapour deposition (CVD) offers a highly advantageous, scalable route for synthesizing 2D materials, enabling the growth of high-quality, large-area films. Among 2D TMCs, molybdenum carbide (Mo_2C) has emerged as the most widely studied material. The first report on its synthesis, using a molten copper catalyst, highlighted its superconducting behaviour. Subsequent studies have extended this approach, exploring growth parameters, fabricating Mo_2C/graphene heterostructures, and demonstrating its electrocatalytic potential. Despite these advances, the precise growth mechanism of 2D Mo_2C during CVD synthesis remains to be fully understood.

In this work, we present recent progress in the development of low-pressure CVD methods for the synthesis of 2D Mo_2C, along with new insights into its growth mechanism. Furthermore, we explore novel growth strategies and provide preliminary investigations into low-pressure growth of non-Mo 2D TMCs.

MON 22
Direct Growth of rGO/$PtSe_2$ Heterostructures via One-Step Process

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Platinum diselenide ($PtSe_2$) is a promising material for next-generation electronics. Owing to its layer-dependent properties, it becomes semiconducting when reduced to a few monolayers, highlighting the need for reliable fabrication methods. Selenization of pre-deposited Pt layers is suitable for $PtSe_2$ growth, but large-area synthesis often faces 3D island growth at certain Pt thicknesses.
We developed a simple one-step strategy to fabricate $PtSe_2$ structures beneath graphene. The Pt layer was covered with graphene oxide and annealed in the presence of selenium, forming $PtSe_2$ while reducing graphene oxide to graphene. The graphene overlayer promotes two-dimensional growth, enabling large-area films with 1–4 $PtSe_2$ monolayers.
Using scanning transmission electron microscopy (STEM), we analyzed the effects of Pt thickness and selenization temperature on growth and performed time- and temperature-resolved in situ atomic-resolution STEM on the rGO/$PtSe_2$ heterostructure.

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MON 23

Optoelectronic memories based on large area exfoliated MoS_2 flakes on ITO

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The growing demand for multifunctional devices for advanced computing and data storage has driven the development of multifunctional memories [1]. Memristors are promising for such uses, but conventional designs based on conductive nanofilaments suffer from slow performance, limited scalability, and poor cyclability [2]. Here, we present large-area mechanically exfoliated MoS_2 flakes integrated onto transparent interdigitated ITO electrodes as memristive devices. A roll-to-roll dry-transfer method enables rapid and uniform fabrication over large areas [3]. These devices exhibit pronounced I–V hysteresis, high ON/OFF ratios at low voltages, fast switching, and excellent reproducibility, with switching governed by Schottky barrier modulation. Scanning photocurrent mapping reveals localized current "hot-spots" from percolative transport, despite uniform flake coverage. The devices also show excellent stability. This scalable, transparent-electrode approach demonstrates MoS_2's potential for next-generation multifunctional memories.

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MON 24

Surface Acoustic Wave–Driven Engineering of Localized Wavefields in Suspended 2D Materials

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Controlling acoustic energy at micro- and nanoscale is essential for advancing on-chip sensing and actuation. 2D materials, with ultralow mass and mechanical tunability, offer key advantages for high-frequency operation, yet existing actuation methods lack broad applicability because they either rely on material-specific properties or are constrained by frequency limitations and substrate coupling. Here, we show that surface acoustic waves (SAWs) can directly actuate suspended 2D membranes and enable engineered localized wavefields. Using 375 MHz Rayleigh waves

to drive suspended graphene and atomic force acoustic microscopy (AFAM) to map vibrations, we visualize wave propagation without substrate interference, including wavelength reduction from ~10 µm on the substrate to ~2 µm in suspended part. Further by varying cavity geometry, cavity architecture becomes a design parameter for shaping wavefields. This SAW-AFAM approach provides a general platform for generating and tuning localized acoustic fields in 2D materials and establishes a basis for on-chip manipulation of nanomaterials and biomolecules.

MON 25
Leveraging graphene substrates to study in-situ crystallization and phase evolution of (AlCrTaTiNb)O2 high entropy oxides in atomic resolution (S)TEM

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High-entropy oxides (HEOs) extend the concept of entropy engineering from metallic alloys to ionic systems, offering a pathway to unprecedented compositionally complex materials with tunable structural and functional properties. Among these, the (AlCrTaTiNb)O_2 system serves as a model to study how multiple cations can coexist at random occupation within a single oxide lattice and how such materials crystallize from the amorphous state or phase separate. A key challenge is however to experimentally access this element-specific structural information of such randomly elementary occupied crystalline lattices, that is the defining feature of high entropy materials. In this work, we leverage suspended monolayer graphene films as an ideal substrate for (scanning) transmission electron microscopy ((S)TEM) studies of ultrathin (AlCrTaTiNb)O_2 HEOs down to atomic resolution and including elucidation of electron-beam-driven in-situ structural dynamics. Thereby, the graphene enables unprecedented insights into high-entropy stabilized phase evolution in this archetypical HEO system.

MON 26
Electron-Hole Plasma/Liquid in suspended monolayer MoS_2

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Two-dimensional materials such as Transition Metal Dichalcogenides (TMDs , MoS_2, WS_2, etc.) exhibit strong Coulomb interactions and reduced dielectric screening,

making them an ideal platforms to investigate excitonic many-body physics. With sufficiently high photoexcitation, these systems can undergo a transition from a non-interacting free exciton gas to a correlated electron-hole plasma (EHP) and eventually to a condensed electron-hole liquid (EHL). Therefore, to increase the exciton density while minimizing heat dissipation, we focused on suspended monolayers of MoS_2 and investigated their steady-state photoluminescence response as a function of excitation intensity. We observed a net redshift of the exciton spectrum, accompanied by spectral broadening and a nonlinear increase in the integrated PL intensity. Collectively, these features indicate a phase transition from the excitonic regime to the electron–hole liquid (EHL) regime [1]. We aim to further our studies on other TMDs and understand how the number of layers plays a role for the generation of EHP.

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MON 27

Dynamical properties of collective excitonic states in a two-dimensional molecular lattice

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Two-dimensional molecular lattices offer a unique platform for studying collective phenomena such as superradiance and strong light–matter coupling, with extremely high tunability enabled by synthetic flexibility. Recently, it has become possible to grow ordered lattices of MePTCDI molecules on hBN over length scales of several tens of microns [1,2]. In such molecular monolayers, signatures of collective molecular states—manifesting as a “giant exciton”—have been observed, exhibiting oscillator strengths comparable to those of inorganic materials such as TMDs [3] and opening up the possibility of room-temperature polariton formation [4]. Despite first spectroscopy studies, little is known about the non-equilibrium properties of these collective molecular states. Understanding how they form and decay may be key to ultimately exploiting them in applications. Here, we study the ultrafast response of delocalized excitons in MePTCDI molecular monolayers on hBN and reveal their characteristic dynamical properties.

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MON 28
Atomic-scale excitonic luminescence nanoscopy of Moiré superlattices in van der Waals heterostructures

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The properties of atomically thin two-dimensional materials are strongly influenced by their surroundings, and stacking them into van der Waals heterostructures enables fine control over their electronic and optical responses. In semiconducting transition metal dichalcogenides, the optical behaviour is dominated by excitons (bound electron–hole pairs), whose properties can be tuned through interfacial interactions. When two layers are twisted and/or lattice-mismatched, a Moiré superlattice forms, creating periodic potentials that spatially modulate electronic and excitonic states. However, diffraction-limited optical methods average over micrometer scales, concealing these nanoscale effects. To overcome this, we employ cryogenic scanning tunneling microscope–induced luminescence [1] (STML, <7 K, ultra-high vacuum) to probe exciton–Moiré interplay in near-aligned WSe_2/WS_2 heterobilayers assembled under inert conditions. We observe interlayer exciton (IXs) emission [2] with site-dependent spectral variations and band-edge modulations[3] within the Moiré unit cell, along with subtle current- and bias-dependent variations, demonstrating nano-optical probing of Moiré-modulated systems.

MON 29
Electric field control of proximity-induced spin-orbit gap in bilayer graphene/WSe_2 quantum dots

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We investigated proximity-induced spin-orbit coupling (SOC) in a bilayer graphene (BLG) quantum dot, which is in proximity to tungsten diselenide (WSe_2). Magneto-transport measurements were performed on the first coulomb-resonance to measure the induced spin-orbit gap ΔSO. Our in-plane magnetic field measurements indicate a significant increase in SOC-induced splitting. Out-of-plane field measurements demonstrate a reduced valley g-factor at larger displacement fields, consistent with weaker lateral confinement of our QD wavefunction. Our measurements reveal an enhanced SOC effect that decreases with the applied displacement field, distinguishing it from the behavior observed in pure BLG. We interpret this as a

decreased influence of the WSe_2, due to stronger layer localization of our QD wavefunction for increased displacement field strength.

MON 30
Local vibrational and geometrical properties of Te nanowires grown on quartz substrate studied by Tip-Enhanced Raman Spectroscopy

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Tellurium nanowires display one-dimensional behavior and are capable of forming helical atomic chains. Their structure is dictated by one-dimensional van der Waals interactions, resulting in physical and electronic properties markedly different from bulk tellurium. The electronic features of Te atomic chains indicate strong potential as a successor to silicon nanowires. The Raman spectrum of Te nanowires reported in literature revealed the presence of strain in the A_1 vibrational mode. However, these observations are constrained by the optical diffraction limit. To investigate the strain characteristics at the nanoscale, we employed Tip-Enhanced Raman Spectroscopy (TERS) on Te nanowires grown on quartz substrates. Our analysis focused on variations in the A_1 peak position across different nanowires, including an individual nanodot. The results demonstrate a strong local correlation between the nanowire geometry and the A_1 peak position. Therefore, this study provides important insights into the nanoscale behavior of Te nanowires and how their geometry influences their vibrational properties.

MON 31
Active laser media based on ultranarrow graphene nanoribbons

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Ultranarrow graphene nanoribbons (GNRs) can be considered as a promising material for using as active media in lasers [1]. The individual ribbon is a classical one-dimensional system. The quantum yield of photoluminescence (PL) for GNRs is 40-50%. In this work we studied 7-AGNRs deposited on polystyrene microspheres (with diameter of 6 mkm) serving as microresonators. The microresonator geometry has been optimized [2]. The PL was so bright that it was observable by

naked eyes. The PL lifetime was about 7 nsec. The GNR films were synthesized via a CVD method based on the “bottom-up” approach from DBBA molecules on Ni foil [3], were dispersed in toluene and dropped onto polystyrene microspheres. The PL gain in 7-AGNRs was observed.

The work was supported by project RScF- 24-42-04003.

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MON 32
Polytype switching in Transition metal dichalcogenides

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Transition metal dichalcogenides are class of layered materials which exhibit a variety of structural, electrical, and optical properties. These materials can crystallize in several polytypes due to distinct stable structural configuration, making them suitable for advance optical and electronic devices. In this work we aim to switch the polytypes in transition metal dichalcogenide with electric field. The device structure consists of transition metal dichalcogenides embedded in hBN- graphite stack. Atomic level understanding of polytype switching driven by an electric field will contribute towards the future development of tunable optoelectronic devices.

MON 33
Towards a Universal Assignment of Confined Carbyne’s C-mode frequency to host nanotube chirality

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Carbyne, the truly 1D carbon allotrope, remains considered impossible to synthesize in a free-standing form. Instead, long linear carbon chains within double-walled carbon nanotubes, i.e., confined carbyne (CC) provide a stable analogue to explore its properties [1,2]. Previous Raman studies of isolated CC revealed a linear correlation between the inner nanotube diameter (d) and the C-mode frequency [2] but were limited to d < 0.75 nm (CC’s C-mode < 1835 cm^{-1}) due to the requirement of optical resonance overlap. Here, we combine resonant Raman spectroscopy

(RRS) and tip- enhanced Raman spectroscopy (TERS) to independently probe and co-localize the spectra of both the C-mode and host nanotube in an isolated CC with 20 nm spatial resolution. This approach provides a reliable correlation between the C-mode frequencies and inner nanotubes with diameters up to 1865 cm $^{-1}$ and 0.818 nm, respectively. Additionally, the implementation of TERS allows the study of local modulation on the systems' properties.

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MON 34
Ferroelectric domain engineering in ultrathin freestanding oxide films

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Low-dimensional ferroelectrics exhibit a rich variety of topological polarization textures that could be harnessed in future functional devices. As in other two-dimensional systems, stacking engineering is now being implemented in oxides; however, the behavior of freestanding oxide thin films remains largely unexplored. Understanding how polarization evolves in the absence of substrate- or interface-induced constraints is essential to uncover the fundamental mechanisms driving the formation of complex polar textures.
In this work, we employ an atomistic approach based on first-principles derived interatomic potentials to investigate freestanding $BaTiO_3$ thin films. Molecular dynamics simulations reveal a rich landscape of stable polarization configurations, ranging from nematic-like ferroelectric domains to helical-wave and chiral bubble states. These chiral bubbles exhibit in-plane vortex–antivortex arrangements reminiscent of those recently observed in twisted oxide bilayers.Furthermore, time-dependent electric fields enable reversible switching between distinct polar structures.

MON 35
Broadband non-linear response in noble metal dichalcogenides

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Noble metal dichalcogenides belong to the material class of layered 2D materials and were shown to host type-II Dirac semi-metallic behavior, as well as topological surface states and superconductivity. Intriguingly, noble metal dichalcogenides display strong second order optical and optoelectronic response despite their centrosymmetric crystal structure. We investigate the spectrally resolved response and reveal second and third order nonlinearities including harmonic generation and second order photocurrents covering a frequenc range from DC to optical frequencies. Spectroscopic experiments point towards the symmetry broken surface as origin of the non-linearities. Our results elucidate the spectral opto-electronic response from intra- to interband excitations and discuss its anisotropy in light of underlying symmetry constraints. Altogether, the broadband, symmetry-driven nonlinearities we uncover establish noble-metal dichalcogenides as a versatile platform for integrated frequency-mixing, ultrafast detection and other on-chip photonic technologies that allow simultaneous operation across a large spectral range.

MON 36

Mapping exciton hybridization with nm-resolution in single photon emitting WSe_2 bubbles at cryogenic temperatures

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Two dimensional materials host single photon emitters (SPEs), a crucial component for quantum communication technology. SPEs in monolayer WSe_2 emitting in the 850 nm telecom window, have been extensively reported in different strainengineered devices, coupled with optical cavities and used to implement quantum key distribution protocols. However, the origin of SPEs in WSe_2 remains debated. Here, we study SPEs in 1L-WSe_2 nanobubbles to establish strain-driven hybridization of free and localized defect excitons as the main mechanism behind single photon emission. We compare tip-enhanced photoluminescence (TEPL) on WSe_2 nanobubbles with controlled strain-engineering experiments to map the strain distribution at nanoscale resolution. We analyse bubbles with different strain distributions and find spectral signatures of the previously reported and theoretically described hybridization between dark and localized states. We characterize SPEs at cryogenic temperatures and study their thermal onset with temperature-dependent photoluminescence. Nanobubbles offer a simple system to understand hybridization and SPEs in WSe_2, paving the way towards highly tailored quantum sources

MON 37

Strong band hybridization effects in graphene / MoS_2 heterostructures

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Strained monolayer WSe_2 by prepatterned substrates or indentations has emerged as a prolific source of single photon emitters (SPE) for on-chip quantum communication. Research on the microscopic mechanism behind SPE in WSe_2 has highlighted the role of strain and defects but despite many reports and device demonstrations, a complete explanation remains elusive. Here, we perform confocal hyperspectral imaging of monolayer WSe_2 bubbles down to cryogenic temperatures to track the evolution of photoluminescence as a function of temperature in bubbles both hosting SPE and emitting light classically. We then use tip-enhanced photoluminescence at room temperature to characterize the strain distribution within those bubbles with 15-nm resolution. We find that strain increases concentrically within the bubbles, shifting free excitons in and out of resonance with two defect states at 1.55 and 1.6eV. These states are also observed in tip-enhanced imaging of defects and controlled gate-driven strain experiments. We extend this strain characterization to cryogenic temperatures to predict the occurrence and emission energy of sharp intense peaks associated with single photon emitters. This work advances the understanding of the microscopic mechanism behind SPE in WSe_2.

MON 38
Magnetic-field-programmed anisotropy in quasi-2D oxide nanostructures

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Magnetic-field-assisted synthesis offers a direct strategy to engineer anisotropy and spin relaxation in low-dimensional materials. In this study, lamellar nanostructures grown under a strong magnetic field exhibited pronounced magnetic anisotropy and distinct spin-relaxation behavior compared to field-free controls. High-frequency electron paramagnetic resonance (EPR) revealed rotation of principal g-axes and an enhancement of zero-field splitting in field-programmed samples, indicating the imprinting of anisotropic spin environments during crystal formation. Temperature-dependent linewidth evolution further demonstrated reduced homogeneous broadening and prolonged spin–spin relaxation times, consistent with suppressed magnon damping.SQUID measurements confirmed increased anisotropy fields and effective magnetic anisotropy, along with exchange-bias features emerging only after field-cooling. The results establish that high-field growth conditions can permanently encode magnetic anisotropy and spin-dynamic characteristics into nanoscale lamellae, enabling device-free control of spin texture and dissipation pathways relevant to next-generation spintronic materials.

MON 39

Optimization of Composition and Structure of MoS_2 thin films via Molecular Beam Epitaxy for Hydrogen Evolution Reaction

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MoS_2 is an earth-abundant, promising catalyst for hydrogen evolution reaction (HER) due to its tunable electronic properties. Its layered structure promotes charge transfer and exposes active edge sites. Precise control over defects, stoichiometry and structural ordering can create additional active sites thereby enhancing HER activity but achieving precise control in the growth of MoS_2 by conventional synthesis methods remains challenging. To address this, we used molecular beam epitaxy (MBE) to tailor the MoS_2 structure. Samples were synthesized by optimizing Mo/S ratio, layer number and post-annealing temperature. Reflection high-energy electron diffraction (RHEED), Raman spectroscopy, XRD and X-ray absorption fine structure analysis (XAFS) confirmed structural modifications. It is observed that by reducing the sulfur ratio and layer number, 'defects' are introduced which activate inert basal planes, thereby enhancing the HER activity. Increasing the annealing temperature and layer number increases crystallinity but lowers the HER due to fewer active edge sites. These findings highlight that MBE growth provides a versatile platform for tailoring the catalytic activity of MoS_2.

MON 40

The role of stacking and strain in mean-field magnetic moments of multilayer graphene

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Rhombohedral or ABC stacked multilayer graphene hosts a correlated magnetic ground state at charge neutrality, making it one of the simplest systems to investigate strong electronic correlations. We investigate this ground state in multilayer graphene structures using the Hubbard model in a distance dependent Slater-Koster tight binding framework.
We show that by using a universal Hubbard-U term, we can accurately capture the spin polarization predicted by hybrid density functional theory calculations for both hexagonal (ABA) and rhombohedral (ABC) stackings. Using this U value, we calculate the magnetic moments of 3-8 layers of ABC and ABA graphene multilayers.

We demonstrate that the structure and magnitude of these magnetic moments are robust when heterostructures are built from varying numbers of ABC and ABA multilayers. By applying different types of mechanical distortions, we study the behaviour of the magnetism in graphene systems under uniaxial strain and pressure. Our results establish a computationally efficient framework to investigate correlation-driven magnetism across arbitrary stacking configurations of graphite polytypes.

MON 41
Infrared resonance Raman spectroscopy for probing structural and electronic modifications in few-layer graphene

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This study investigates the effects of doping on bilayer graphene by means of resonance Raman spectroscopy with infrared excitation, which probes electronic states closer to the K points, where electron-phonon coupling (EPC) is enhanced [Phys. Rev. Lett. 130, 256901]. The enhancement, attributed to long-range Coulomb interactions, is expected to be highly sensitive to doping. In this study, we dope bilayer graphene via potassium deposition in an ultra-high vacuum Raman spectroscopy setup [Nanomaterials, 12(15), 2613], achieving Fermi energies up to 1 eV. Alkali metal deposition also induces biaxial strain on the sample surface, which influences the Raman spectra features together with doping. By analyzing Raman spectra collected at varying deposition times and comparing to prior studies [Nanomaterials, 12(15), 2613; Nature Materials, 6, 198–201], we are able to successfully decouple the effects of strain and doping. Finally, we also compare our results on alkali-doped samples to those obtained as a function of external pressure in a diamond anvil cell. In this way we can have a clearer view on the enhancement of electron-phonon matrix elements near band splitting.

MON 42
One-step syntheses of MoS_2 and WS_2 - graphene heterostructure at ambient conditions

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In the previous work [1] we introduced a synthesis method of 2D metal iodides between graphene sheets at ambient conditions. Recently we extended the method to synthesize 2D transition metal dichalcogenide, MoS_2 and WS_2 in graphene under ambient conditions.
Here, we present a study of one step reaction, when precursor molecules $(NH_4)_2MoS_4$ and $(NH_4)2WS_4$ interact with oxygen in graphene oxide. This way graphene oxide is reduced simultaneously with growth of nanograins of MoS_2 and WS_2 between graphene sheets forming heterostructures. During reduction of graphene oxide electrical resistance drops in orders of magnitude, which enabled us a direct measurement of reaction kinetics. While, at room temperature, the spontaneous synthesis of MoS_2 was saturated within tens of hours, for WS_2 the process lasted a few minutes.
The nanograins of MoS_2 and WS_2 embedded in graphene were images by STEM and characterized by Raman spectroscopy. The electrical conductivity was measured from 4.2 up to 340 K indicating that the electronic transport is mediated through graphene sheet network.

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MON 43
Scalable, ultra sensitive and on-chip optomechanical 2D material sensor

Javad Ebrahimipour[1], Tufan Erdogan[1], Peter Steeneken[1], Gerard Verbiest[1].

[1]TU Delft

Two-dimensional (2D) material membranes are compelling platforms for displacement, mass, and force sensing. Electronic transduction has enabled many demonstrations but is constrained by readout noise, parasitic impedances, and practical limits on sensitivity and limit of detection (LOD). Optical methods address these bottlenecks, yet most rely on free-space interferometry, which needs bulky alignment and undermines integration and stability. We report an on-chip optical readout of 2D material membrane nano mechanics operating at ambient conditions. The integrated architecture places the mechanical element and optical circuit on a single die, removing external alignment and minimizing parasitics. The readout achieves lower displacement noise spectral density and a smaller LOD than comparable free-space approaches. Operation at ambient pressure simplifies packaging and long-term use. Calibration to the thermal noise baseline sets the absolute scale for sensitivity and dynamic range. This platform enables compact arrays, multiplexed readout, and hybrid sensing co-integrated with electronics.

MON 44

The long term stable electrocatalyst based on 1D nickel nanospikes decorated by Pd: structure and catalytic performance correlation

Dariusz Lukowiec[1], Adrian Radon[2], Tomasz Wasiak[3], Jerzy Kubacki[3], Grzegorz Gruzeł[4], Dawid Janas[1], Daniele Silvestri[5], Stanislaw Waclawek[5].

[1]Silesian University of Technology
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[3]University of Silesia
[4]University of Rzeszow
[5]Technical University of Liberec

Because of the great social importance of the energy deficit, scientists are conducting a broad and very intensive search for new and stable electrocatalysts. We synthesized novel PdNi unsupported with carbon black catalyst in form of 1D nickel nanopsikes decorated by Pd nanoparticles. The use of support in the form of nanowires (1D) can contribute to faster diffusion through liquid fuel and reduction of surface energy which consequently improve control over agglomeration and solubility of the metal catalyst. The second thing is the oxophilic nature of Ni which increases the tolerance to poisoning of the noble metal by CO.
In this work, the impact of metal catalyst-metal substrate interaction in Pd@Ni on their structure and catalytic stability (50 k cycles in EOR) was studied. For the small Pd nanoparticles surrounded by a large dispersion of Ni substrate atoms, can refer to an increased metal-substrate interaction, which can be associated with the tuning the d-state of Pd metal in Pd@Ni catalyst. This may imply a greater susceptibility to chemisorption of ethanol molecules and easier desorption of intermediates products, which further improves its catalytic activity and stability.

MON 45

Spontaneous attachment of an iron-based molecular complex to the defect-free MoS_2 basal plane

Péter Vancsó[1], Soma Keszei[1], Gergely Dobrik[1], Antal Koós[1], József Sándor Pap[1], Levente Tapaszto[1].

[1]Hungarian Research Network, HUN-REN Centre for Energy Research, Institute of Technical Physics and Materials Science, Budapest, Hungary

Due to the lack of dangling bonds on their surface, the functionalization of two-dimensional (2D) crystals, such as MoS_2 typically relies on defect creation that act as anchoring sites but simultaneously degrade the structural and electronic integrity of the material. Here, we report the functionalization of pristine MoS_2 single and few layers by simply immersing them in an iron complex solution, under ambient conditions. Our STM measurements and DFT calculations revealed that the Fe-complex molecules spontaneously anchor onto MoS_2 without requiring lattice defects, due to a dual bonding mechanism: the coordinative Fe–S bonding to the MoS_2 lattice, rein-

forced by strong van der Waals interactions of the quasi-planar organic ligand. The stable and uniform Fe–S–Mo motifs that form across the MoS_2 basal plane act as catalytic active sites for hydrogen production, substantially reducing hydrogen evolution onset potential of MoS_2. Our results highlight the potential of surface-confined molecular catalysts as a sustainable platform that integrates molecular-level precision with the robustness and scalability of heterogeneous platforms.

MON 46
Functional Properties of Coal-Derived Graphene Quantum Dots and their Derivatives

George Bepete[1].

[1]Concordia University

Coal-derived graphene quantum dots (GQDs) represent a sustainable and versatile class of carbon nanomaterials with tunable optical, electronic, and chemical properties. Using alkali-metal intercalation and reductive exfoliation, anthracite coal is converted into a stage-I potassium-intercalated coal salt that dissolves spontaneously in N-methyl-2-pyrrolidone (NMP), yielding uniform sub-5 nm GQDs with narrow size distributions. These GQDs exhibit excitation-dependent photoluminescence, high quantum yield, and nonlinear thermo-optical behavior, revealing efficient heat–light conversion. Solution-processed graphene/GQD heterostructure films, fabricated by combining graphene and the coal-derived GQD dispersions, show p-type semiconducting characteristics and excellent performance in photodetection and molecular sensing. Overall, these results demonstrate a scalable and sustainable approach for producing high-quality carbon nanomaterials, positioning coal-derived GQDs and their derivatives as promising candidates for solution-processed optoelectronic, sensing, and energy-conversion applications.

MON 47
Strain tuning of vibrational modes in $PtSe_2$

Janos Papp[1], Cormac Ó Coileáin[1], Georg Duesberg[1], George De Coster[2], Martin Gerlei[1,3], Natalie Galfe[1,3], Paul Seifert[1], Simon Schlosser[1], Stefan Heiserer[1].

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[2]DEVCOM Army Research Laboratory, MD, USA
[3]SENS Research Center, University of the Bundeswehr Munich, Neubiberg, Germany

Two-dimensional (2D) layered materials are prime candidates for next-generation micro- and nano-electro-mechanical systems (MEMS/NEMS). In order to understand the underlying physics in 2D based MEMS, a thorough study of strain driven changes in material properties is needed. In this work, we report the realization of $PtSe_2$ on flexible substrates, allowing the application of controlled strain via mechanical deformation. The samples are prepared using two different approaches,

mechanical exfoliation and direct growth, enabling a comparison between different structural qualities. The resulting samples are characterized using Raman spectroscopy. Our approach shows how the vibrational modes in $PtSe_2$ change with applied uniaxial strain. We elucidate the underlying physics of phonon modes under deformation and modified rotational symmetry and provide a comparison on different levels of crystallinity and strain in free-standing and substrate-supported platforms. The universality of the platform opens the possibility to manipulate material properties via strain and thus might also be adapted as additional control knob for (opto-)electronic properties in 2D materials.

MON 48
Synthesis of a graphene antidot lattice from molecular precursor

Katayoun Gharagozloo-Hubmann[1], Charlotte Berrezueta Palacios[1], Felix Jeschek[2], Jürgen P. Rabe[3], Nikolai Severin[3], Stephanie Reich[1].

[1]Department of Physics, Freie Universität Berlin, Germany
[2]Technische Universität Berlin, Germany
[3]Humboldt-Universität zu Berlin, Germany

Materials with confined dimensions are of great interest when it comes to studying fundamental physical effects, such as light-matter interaction, as well as for use in electronic or magnetic applications in device manufacturing. Two-dimensional (2D) materials are particularly well-suited to this purpose as they can be stacked to form multilayers and used as building blocks for other artificial materials. The aim of this work was to produce a single-layer crystalline carbon film with a regular lattice structure of holes, known as a graphene antidote (GAD) lattice. Such lattices have been the subject of extensive theoretical discussion, and their properties are considered highly interesting. Previous productions have been realized using a top-down approach. These films already demonstrate the predicted interesting properties. Like graphene nanoribbons or bilayer graphene, GADs can create a band gap in graphene, making them promising candidates for use as high-order topological insulators. Motivated by this, we attempted to synthesize micrometer-sized samples using hexabromo-triphenylene (HBTP) as a precursor via chemical vapor deposition (CVD).

08:30 – 09:30	Max von Delius *Using Molecular Rings to Functionalize Carbon Allotropes and Create Few-Qubit Architectures*
09:30 – 10:00	Farnaz Niroui *Computing with Molecular Building Blocks*
10:00 – 10:30	Coffee Break
10:30 – 11:00	Stephan Hofmann *Accelerated Process Discovery for Quantum Materials*
11:00 – 11:30	Nicola Marzari *The electronic-structure genome of inorganic materials*
11:30 – 12:00	Kimmo Mustonen *Hexatic phase in covalent two-dimensional silver iodide*
12:00 – 17:00	Mini Workshops
17:00 – 18:30	Dinner
18:30 – 19:00	Moshe Ben Shalom *Multiferroic Superlubric Arreys of vdW Polytypes*
19:00 – 19:30	Hyobin Yoo *Atomic reconstruction at engineered van der Waals interfaces*
19:30 – 20:00	Marija Drndic *Atomic-Scale Sculpting of 2D Materials and Spin Textures for Quantum and Other Applications*

08:30
Using Molecular Rings to Functionalize Carbon Allotropes and Create Few-Qubit Architectures
Max von Delius[1].

[1]Ulm University

Molecular rings (“macrocycles” or “hosts”) have long been used by chemists to encapsulate ions or molecules (“guests”). Over the past two decades, curved rings have been used to bind, solubilize and functionalize curved carbon allotropes (fullerenes, SWCNTs).[1]

In this talk, I will present recent work by our group on three challenges that will be of interest to the IWEPN community (fullerenes, SWCNTs, OPV, OFET, spintronics, QIS):
A) Can curved rings be used to control the selectivity of fullerene (multiple-)addition reactions?.[2]
B) Can rigid rings be used to functionalize and disperse SWCNTs in water?[3]
C) Can rigid rings be used to precisely control the relative geometry and orientation of molecular qubit candidates and endow them with unusual optical and magnetic properties?[4]

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09:30
Computing with Molecular Building Blocks
Farnaz Niroui[1].

[1]Massachusetts Institute of Technology

As artificial intelligence advances, the growing demand for computing performance is outpacing the capabilities of conventional platforms. This widening gap has driven the need for new computing paradigms. Of particular interest are platforms inspired by natural systems, where computation is highly energy-efficient, distributed and adaptive, capable of performing higher-order intelligent tasks. To this end, molecules – with their atomic design, rich physical properties, and multifunctional control – serve as promising building blocks for next-generation computing, where information processing is embedded within the nanoscale material itself. By engineering the complex electrical, ionic, and mechanical properties of molecules and their dynamic tuning, we have developed energy-efficient molecular computing platforms for artificial intelligence applications, which will be discussed in this talk.

10:30
Accelerated Process Discovery for Quantum Materials
Stephan Hofmann[1].

[1]University of Cambridge

Chemical vapor deposition (CVD) has emerged as key technology for bringing next-generation materials to market, yet process discovery still largely follows an Edisonian trial-and-error approach, blind and constraint by conventional reactors. This is not only wasteful and frustratingly slow, but hinders scientific breakthroughs in crystal growth and innovation in new deposition technology. This talk will introduce a versatile micro-CVD platform that enables direct in-line process screening by electron microscopy as well as interaction in real time - synchronously or on-the-fly - with ongoing atomic-scale reactions. We show how this can transform process exploration, focussing on the crystal growth of atomically thin transition metal dichalcogenide layers.[1] We use large datasets on spatio-temporal basal plane nucleation kinetics and propagation of tens of thousands of individual 1D reaction facets to self-consistently guide atomistic reaction exploration via machine-learned interatomic potentials based on the MACE architecture.[2]

[1] Yang et al., Chem. Mat. 37, 989 (2025)
[2] Gsanyi et al., arXiv:2401.00096, 2023

11:00
The electronic-structure genome of inorganic materials
Nicola Marzari[1].

[1]École Polytechnique Fédérale de Lausanne (EPFL)

We explore the world of inorganic, experimentally known, stoichiometric materials with high-throughput first-principles simulations. Thanks to recent progress in automated and robust Wannierization techniques (projectability disentanglement and manifold remixing), we are able to calculate the electronic structure (first, at the DFT level) of ~22,000 materials, resulting in 1.9M maximally-localized Wannier functions describing both the valence and low-energy conduction manifolds of metals and semiconductors/insulators. For ~5,000 semiconductors/insulators we mix these Wannier functions into valence-only descriptors, giving access to Berry phases and polarization. We showcase the power of the approach with three distinct applications: high-performance thermoelectrics; candidate materials with large non-linear Hall responses; and lattice-matching heterostructures with polarization discontinuities that give rise to a two-dimensional electron gas. Finally, we'll briefly highlight beyond-DFT approaches (Koopmans spectral functionals) that deliver the correct spectral properties and band gaps of materials, with much improved efficiency compared to GW/many-body perturbation theory.

11:30
Hexatic phase in covalent two-dimensional silver iodide
Thuy An Bui[1], David Lamprecht[2], Viera Skakalova[3], Kimmo Mustonen[1].

[1]University of Vienna
[2]Institute of Microelectronics, TU Wien
[3]Institute of Electrical Engineering of Slovak Academy of Sciences, Bratislava, Slovakia

When a crystalline solid melts, long-range order collapses into a disordered liquid — a 1st-order transition characteristic of 3D materials. In 2D, however, melting can proceed differently: through defect-mediated unbinding of dislocations and disclinations as described by Kosterlitz–Thouless–Halperin–Nelson–Young theory, via a 1st-order grain-boundary process, or through a combination of both. These scenarios predict an intermediate hexatic phase, which retains short-range positional but quasi-long-range orientational order, akin to a liquid crystal.
Here, we study melting of covalent hexagonal monolayers of AgI encapsulated in graphene. Encapsulation stabilizes the 2D phase and prevents transformation into bulk polymorphs, while lattice incommensurability minimizes substrate constraints. Time- and temperature-resolved in situ scanning transmission electron microscopy combined with convolutional neural network analysis reveals a hexatic phase — the first such observation in a covalent material — and supports a mixed defect- and grain-boundary-mediated melting scenario [1].

1. Bui, T. A., Lamprecht, D., et al. (accepted). Hexatic phase in covalent 2D silver iodide. Science.

18:30
Multiferroic Superlubric Arreys of vdW Polytypes
Moshe Ben Shalom[1].
[1]Tel Aviv University

We introduce superlubricant arrays of van der Waals polytypes (SLAP): reconfigurable lattices composed of nanoscale commensurate domains embedded within a structurally superlubricant matrix. This architecture enables electrically driven lattice reorganization at room temperature, giving rise to robust, non-volatile multiferroic responses with exceptionally low switching energies.
I will present: (1) Charge redistribution and shifted electronic dispersions in hBN, TMDs, and graphene polytypes [1–3]; (ii) Stability of these structural phases versus their rapid, reversible reconfiguration through sliding boundary solitons [4]; and (iii) Long-range elastic interactions mediated through the superlubricant medium [5].
Together, these results establish a new, low-energy route for designing and controlling structural phase transitions in vdW materials - opening opportunities for scalable slide-tronic devices and novel structural-electronic functionalities.

[1] 10.1038/s41586-022-05341-5 (Science,2021)
[2] 10.1038/s41586-022-05341-5 (Nature,2022)
[3] 10.1002/apxr.202300095 (ADPR,2024)
[4] 10.1038/s42254-024-00781-6 (NRP.2024)
[5] 10.1038/s41586-024-08380-2 (Nature,2025)

19:00
Atomic reconstruction at engineered van der Waals interfaces
Hyobin Yoo[1].

[1]Seoul National University

Twisted interfaces between two-dimensional (2D) van der Waals (vdW) materials enable control of structural symmetry and functionality at the atomic scale. Varying the stacking angle produces moiré superlattices and lattice reconstruction, where interlayer registry competes with intralayer strain to form ordered domains with emergent electronic, optical, or ferroic properties. This talk will show how stacking configurations and reconstruction govern domain formation and functionality, examined by electron diffraction contrast in transmission electron microscopy (TEM). By integrating TEM with semiconductor device fabrication, we perform operando measurements of domain dynamics in working devices, directly linking local symmetry breaking to macroscopic responses such as ferroelectric switching in twisted bilayer TMDs[1]. Extending to multilayers introduces additional interfaces and symmetry degrees of freedom, yielding complex tessellations with distinctive structural and functional characteristics[2]. Understanding these reconstructions is key to controlling emergent phenomena in twisted vdW materials.
[1] Ko et al., Nat. Mater. 22, 992 (2023)
[2] Park et al., Nature 641, 896 (2025)

19:30

Atomic-Scale Sculpting of 2D Materials and Spin Textures for Quantum and Other Applications

Marija Drndic[1].

[1]Department of Physics, University of Pennsylvania

We have shown the ability to create nanometer and sub-nm scale defects in 2D and layered 2D materials using electron and ion irradiation, as well as chemical etching, and characterize them under various treatment conditions (temperature, gases, etc.) using microscopy and optical methods and evaluate their fundamental properties and benefits for quantum and other applications. I will discuss the creation and characterization (in-situ and operando) of defects in 2D materials such as hBN and other 2D materials (including 2D ferromagnets) using AC-STEM electron-beam drilling, and measurements of resulting photoluminescence and other physical properties which are relevant for quantum device applications such as in quantum computing and quantum sensing.
We also probe the effects of geometric confinement on magnetic properties in 2D ferromagnetic materials using low-temperature Lorentz transmission electron microscopy, a powerful technique which enables direct observation of magnetic domains down to the nanometer scale.

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08:30 – 09:30	Junichiro Kono *From Superfluorescence to the Magnonic Phase Transition: Dicke Physics in Quantum Materials*
09:30 – 10:00	Angel Rubio *Cavity Quantum Electrodynamics in 2D Materials: Photon-Mediated Interactions and Electronic Structure Engineering*
10:00 – 10:30	Coffee Break
10:30 – 11:00	Hope Bretscher *Cavity-electrodynamics of van der Waals heterostructures*
11:00 – 11:30	Anna Seiler *Optical Injection and Detection of Long-Lived Interlayer Excitons in van der Waals Heterostructures*
11:30 – 12:00	Alberto Guandalini *Optical and low-momenta excitations in 2D systems from momentum resolved EELS*
12:00 – 17:00	Mini Workshops
17:00 – 18:30	Dinner
18:30 – 19:00	Yuval Ronen *Even & odd denominator quantum Hall interferometry in bilayer graphene*
19:00 – 19:30	Jun Zhu *The Quantum Valley Hall Effect and Topological Valleytronics*
19:30 – 20:00	Martina Hentschel *A particle tracing view on complex electron dynamics in warped and anisotropic materials*
20:00	Poster III

08:30
From Superfluorescence to the Magnonic Phase Transition: Dicke Physics in Quantum Materials
Junichiro Kono[1].

[1]Rice University

Ultrastrong light–matter interaction in solids can reveal collective optical phenomena that are traditionally studied in quantum optics [1]. We explore Dicke phenomena in materials. We demonstrated superfluorescence in electron–hole ensembles [2], a burst of emission where peak intensity scales as N^2 [3]. We also observe cooperative radiative damping of cyclotron resonance in a 2D electron gas [4]. Motivated by the Dicke superradiant phase transition (SRPT), we explored the ultrastrong coupling regime in Landau polaritons [5,6]. Finally, we demonstrated Dicke cooperativity [7] and the magnonic SRPT [8] in the Er^{3+}-Fe^{3+} exchange interaction in $ErFeO_3$. These studies demonstrate that cooperative light–matter interactions profoundly shape the dynamics of correlated electrons.

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2. G. T. Noe II et al., Nat. Phys. 8, 219 (2012).
3. R. H. Dicke, Phys. Rev. 93, 99 (1954).
4. Q. Zhang et al., Phys. Rev. Lett. 113, 047601 (2014).
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6. X. Li et al., Nat. Photon. 12, 324 (2018).
7. X. Li et al., Science 361, 794 (2018).
8. D. Kim et al., Sci. Adv. 11, eadt1691 (2025).

09:30

Cavity Quantum Electrodynamics in 2D Materials: Photon-Mediated Interactions and Electronic Structure Engineering

Angel Rubio[1].

[1]Max Planck Institute for the Structure and Dynamics of Matter

Structuring the photon density of states in optical cavities enables control of material properties through strong light–matter coupling. Quantum Electrodynamical Density Functional Theory (QEDFT) extends TDDFT by incorporating quantized electromagnetic fields into electronic structure theory, providing an ab initio framework for predicting cavity-induced phenomena. Experiments such as photon-mediated superconductivity and optically engineered topological phases show that vacuum fluctuations, rather than classical light, can reshape material ground states and drive new quantum phases.

We present an ab initio approach to study cavity effects in two-dimensional materials. Using QEDFT, we show how vacuum fields modify van der Waals systems, inducing charge localization, tunable band gaps, and interlayer spacing that alter ferroelectric and optical responses. A non-perturbative Hartree–Fock framework further reveals cavity-mediated electron interactions in graphene and dichalcogenides, where anisotropic photon modes open Dirac gaps while isotropic ones renormalize the Fermi velocity. Cavity photons thus emerge as a new control parameter for correlated quantum states.

10:30
Cavity-electrodynamics of van der Waals heterostructures
Hope Bretscher[1].

[1]Max Planck Institute for the Structure and Dynamics of Matter

Van der Waals (vdW) heterostructures exhibit a wide range of exotic many-body quantum phenomena that can be tuned in situ using electrostatic gates. Understanding the conditions under which these phenomena emerge and finding ways to engineer them, is of great fundamental interest and important for deterministically designing materials for new applications. In this talk, I will discuss how vdW heterostructures form sub-wavelength cavities in the THz frequency range due to their micron-size, confining low-energy light into the near field. I will introduce time-domain on-chip THz spectroscopy as a technique to capture the cavity electrodynamics, probing the response of 2D materials to light on their natural frequency (~THz/meV) scales. This technique overcomes the mismatch between free-space THz wavelengths (~300 um) and sample size (~10 um) by measuring the optical conductivity on-chip, in the near field, and at finite momenta. I will illustrate how the properties of gate-tunable vdW heterostructures can be modified and controlled due to cavity effects.

11:00

Optical Injection and Detection of Long-Lived Interlayer Excitons in van der Waals Heterostructures

Anna Seiler[1], Alperen Tugen[1], Arthur Christianen[1], Martin Kroner[1], Atac Imamoglu[1].

[1]ETH Zürich

Interlayer excitons (IX)—electron-hole pairs spatially separated between two layers of two-dimensional materials—have gained attention for their potential to enable the exploration of novel bosonic quantum phases and Bose-Fermi mixtures. A promising route to stabilize IXs is to use transition metal dichalcogenide (TMD) bilayers seperated by thin hexagonal boron nitride (hBN), which isolates itinerant electrons and holes. While these systems have primarily been studied through transport measurements, challenges such as difficulties in making ohmic contacts to TMD monolayers and the lack of photoluminescence have limited their broader exploration.
Here, we demonstrate the optical generation of IXs in bilayer TMD heterostructures separated by up to seven hBN layers. Remarkably, the 2s excitons in each layer persist in the presence of opposite charges, indicating strong binding into stable interlayer excitons. We measure lifetimes up to eight µs, highlighting the potential of these excitons for exploring exotic quantum phases, such as Bose-Fermi mixtures and excitonic condensates. These phenomena can be efficiently probed using optical spectroscopy, paving the way for future studies.

11:30

Optical and low-momenta excitations in 2D systems from momentum resolved EELS

Alberto Guandalini[1], Jinhua Hong[2], Christian Kramberger[3], Ryosuke Senga[4], Paolo Barone[5], Thomas Pichler[3], Kazu Suenaga[4], Francesco Mauri[1].

[1]Sapienza University of Rome
[2]University of Hunan
[3]University of Vienna
[4]University of Osaka
[5]Consiglio Nazionale delle Ricerche (CNR)-SPIN

Momentum-dependent electron energy-loss spectroscopy (q-EELS) has recently proven to be a pivotal tool for investigating charge excitations in suspended low-dimensional (2D) materials using a transmission electron microscope (TEM). Unlike optical techniques, q-EELS provides access to the energy dispersion of phonons, excitons, and plasmons.
Comparing instead with other finite-momentum scattering techniques, such as neutron and X-ray spectroscopies, q-EELS with TEM does not require substrates or large crystals, making it an ideal tool to study freestanding 2D materials. With sufficiently high momentum resolution, q-EELS can probe the optical-limit regime ($q \approx 0$) as well as low-momentum dispersions, thus enabling an unprecedented characterization of monolayer materials.
In this talk, I will discuss how the low-momentum loss functions of a 2D material can be linked to its optical properties introducing what we called optical conductivity approximation (OCA). Then, I will present recent experimental observations of phonon, exciton, and plasmon dispersions in prototypical 2D materials and show how their peculiar 2D dispersions can be interpreted within the OCA framework.

18:30
Even & odd denominator quantum Hall interferometry in bilayer graphene
Yuval Ronen[1].

[1]Weizmann Institute of Science

Anyons are quasiparticles that obey exchange statistics distinct from those of fermions and bosons. These exotic particles can be realized within the framework of the fractional quantum Hall effect, representing a highly coveted goal in condensed matter physics. In this talk, I will present our group's recent efforts in exploring Anyons within bilayer graphene-based van der Waals heterostructures. I will begin by discussing the fractional phase-space in bilayer graphene, highlighting its rich landscape of topological orders, including various non-Abelian states. Following this, I will shift the focus to our interferometry studies at both odd- and even-denominator filling, aimed at detecting the exchange statistics of Abelian and non-Abelian Anyons.

19:00
The Quantum Valley Hall Effect and Topological Valleytronics
Jun Zhu[1].
[1]Penn State University

Topological edge states are potential quantum information carriers. In this talk, I will discuss our effort in realizing the quantum valley Hall effect and the properties of its edge state, the kink states. Using van der Waals stacking and precision lithography, we create valley-momentum locked kink states in bilayer graphene and demonstrate its precise resistance quantization, a hallmark of ballistic edge state transport. The quantization is robust to temperatures of tens of Kelvin, which bolds well for potential applications. The all-electrical construction of the kink states gives us the ability to realize a variety of electron quantum optics operations, now in an edge state platform. I will show the workings of a topological switch, a reconfigurable ballistic waveguide, a topological valley valve, and a continuously tunable electron beam splitter. Time permitting I will also discuss the evolution of the kink states in a magnetic field, where its four-fold degeneracy can be sequentially broken to result in a single pair of spin-momentum locked edge modes. Our ongoing experiments explore its potential as on-chip quantum interconnects.

19:30

A particle tracing view on complex electron dynamics in warped and anisotropic materials

Martina Hentschel[1].

[1]TU Chemnitz

Mesoscopic cavities with typical sizes of several resonance wavelengths are well-known model systems for investigating complex dynamics. While the breaking of spatial resonator symmetries is typically considered to be the origin of chaotic dynamics, we show that anisotropies, i.e., broken symmetries in momentum space such as the trigonal warping in bilayer graphene, can also cause chaotic particle dynamics. Such anisotropic properties prevent angular momentum to be a conserved quantity, and consequently the angles of incidence and of reflection of a particle trajectory deviate. We take this into account by implementing a hybrid particle tracing algorithm that incorporates the electronic properties of bilayer graphene in a gate-voltage defined cavity and can be easily applied to other materials. We show that the presence of anisotropies induces chaotic dynamics even in circular cavities and illustrate the intricate interplay of cavity shape and Fermi line geometry. In addition, we use Kwant to demonstrate particle-wave correspondence by comparing the tracing results with wave solutions in real space as well as in phase space using the Husimi function.

POSTER III

WED 1
Probing Long-Range Physics in Twisted Bilayer Materials with Machine Learning for the Electronic Density

Zekun Lou[1], Alan Lewis[2], Mariana Rossi[3].

[1]Max Planck Institute for the Structure and Dynamics of Matter
[2]York University
[3]MPI for Structure and Dynamics of Matter

Moiré superlattices in twisted bilayer (TB) 2D materials exhibit extraordinary quantum phenomena, but first-principles understanding remains limited by computational costs. While most machine learning (ML) methods for DFT acceleration are based on a locality assumption, we demonstrate that accurate moiré electronic structure prediction requires long-range encoding due to charge transfer, d-orbital hybridization, and moiré potential modulation. Using long-range representations [1] for density prediction [2,3], we achieve low-energy band predictions with <15 meV errors across twisted bilayer graphene (TBG), hBN, and transition-metal dichalcogenides (TMDCs), while ~100 times faster than DFT. Descriptor requirements are material-dependent: homoatomic systems (e.g., TBG) are well-described by local descriptors, while hBN and TMDCs require long-range encoding. We summarize physical implications connecting ML and fundamental physics governing twisted bilayer electronic structure [4].

[1] Grisafi, Ceriotti, JCP 151, 204105 (2019)
[2] Lewis, Grisafi, Ceriotti, Rossi, JCTC 17, 7203 (2021)
[3] Grisafi, Lewis, Rossi, Ceriotti, JCTC 19, 4451 (2023)
[4] Lou, Lewis, Rossi, in preparation (2025)

WED 2
Remote electron tunneling in van der Waals tunnel junctions

Antti Moilanen[1], Bhaskar Ghawri[2], Cao Jiang[1], Jian Zhang[1,2], Jonas Ziegler[1], Kenji Watanabe[3], Luisier Mathieu[1], Lukas Novotny[1], Mickael Perrin[1,2], Nicolas Vetsch[1], Sotirios Papadopoulos[1], Takashi Taniguchi[4], Yang Xu[1].

[1]ETH Zürich
[2]EMPA
[3]Research Center for Electronic and Optical Materials, Japan
[4]National Institute for Materials Science, Japan

Quantum tunneling in solids has been mainly centered on the schematic of two conducting electrodes separated by an insulating barrier. Here we report a new pathway of remote electron tunneling. Electrons in one electrode can tunnel through the barrier and the other electrode to reach the semiconductor layer placed outside the tunnel junction. We examine this by observing prominent conductance peaks in transport measurements of TMD/Gr/hBN/Gr structure. Meanwhile, electrical exiton

generation can be observed as well. Through simultaneous transport and electroluminescence (EL) spectroscopy, we elucidate that the conductance peaks are originated from remote electron tunneling process and they are independent of electrical generation of excitons in this system. These remotely injected carriers can be controlled to be radiative through the engineering of graphene quenching. Our work real a new tunneling pathway and generate platforms for multi-degree investigation of junctions for comprehensive understanding of tunneling processes. The study will invoke new designs of optoelectronic devices and platforms for studying tunneling electrochemical reactions with reactors outside the barrier.

WED 3
Mapping edge state vibrational modes in armchair graphene nanoribbon

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We use scanning tunneling microscopy (STM) and inelastic tunneling spectroscopy to map the low frequency vibrational modes of 7-atom wide armchair graphene nanoribbon (7-AGNR). To enhance the inelastic tunneling channel, 7-AGNR is bonded to the apex of an STM tip.
This setup has led to resonant inelastic tunneling between vibrational states of supported 7-GNR on Au(111) substrate and the states of the functionalized STM tip. The low energy spectra reveal two localized peaks at the armchair edges with energies at ±14 mV and ±30 mV. The peaks are assigned to twice the energies of longitudinal compressive and shear-like modes of 7-AGNR, respectively. Remarkably, the well separated peaks evolve rapidly into one broader peak toward the bulk of the ribbon due to scattering from substrate interactions. This suggests that edge state phonons are uniquely protected from microenvironment and may have profound effects on transport properties of GNR devices.

WED 4
Emergence of Metallic Conductivity and Quantum Oscillations in Two-Dimensional Metal-Organic Frameworks

Jonas Pöhls[1], Chatrawee Scheiger[2], Mersad Mostaghimi[3], Lena Pilz[2], Mariana Kozlowska[3], Yidong Liu[2], Zhiyong Wang[4], Renhao Dong[5], Lars Heinke[6], Carlos Cesar Bof Bufon[7], Wolfgang Wenzel[3], Christof Wöll[2], Xinliang Feng[4,8,9], Thomas Weitz[10].

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Since their discovery - an achievement recognized with the 2025 Nobel Prize in Chemistry - Metal-Organic Frameworks (MOFs) have established themselves as one of the most versatile and tunable classes of materials in modern chemistry. Owing to their exceptional structural diversity, high porosity, and modular design, MOFs have been explored extensively for applications ranging from gas storage and catalysis to sensing and drug delivery. Despite this remarkable range, their use in electronic devices has remained limited. For many years, MOFs were largely regarded as electrical insulators, and their potential in condensed matter physics was considered minimal.
We report results on new two-dimensional (2D) MOFs that exhibit genuine metallic conductivity, challenging the long-held perception of MOFs as insulating materials. Our results reveal pronounced 2D electronic features, including the emergence of Dirac cones in their band structures - an electronic signature typically associated with materials such as graphene. Moreover, we present the first experimental observation of quantum oscillations in MOFs, providing direct evidence of coherent charge transport at low temperatures.

WED 5
Excitons as a probe of interfacial coupling in a WSe_2/Gr van der Waals heterostructure

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Interfacial coupling plays a crucial role in the properties of van der Waals (vdW) heterostructures [1]. Benefiting from the sub-nanometer vdW gap, monolayer graphene (Gr) has been used to filter TMD emissions (e.g. $MoSe_2$) at cryogenic temperatures, yielding narrow-line emitters [2].
Owing to its richer excitonic structure [3], WSe_2 is a promising system to further explore the optical filtering effect and gain a deeper insight into the underlying

microscopic mechanisms.
Here, we investigate the interfacial coupling between WSe_2 and graphene. We fabricated a h-BN capped WSe_2/Gr vdW heterostructure which was then optically and spatially characterized by PL, Raman and differential reflectance at room and low temperature, revealing clear spatial variations of excitonic features.
Despite an efficient interlayer coupling, low-energy peaks with fine structure splitting (~0.6 meV) and narrow linewidths (~100-200 μeV) emerge over large WSe_2/Gr regions, suggesting localized states worth further investigation.

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WED 6

First-Principles Insights into the Structural and Electronic Properties of Graphene-Encapsulated Two-Dimensional Metal Iodides

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Two-dimensional (2D) materials exhibit exceptional mechanical and electronic properties, making them promising candidates for next-generation flexible electronics, spintronics, and opto-spintronics. However, only a small subset of the theoretically predicted 2D materials has been experimentally realized to date, with many still awaiting synthesis.
A new chemical synthesis technique has recently been proposed for fabricating 2D metal iodides directly between graphene sheets [1]. This method offers a significant advantage over conventional growth approaches: the encapsulating graphene layers help stabilize the otherwise unstable 2D crystal structures.
In this study, we employ first-principles calculations to investigate the structural and electronic properties of newly synthesized 2D metal iodides, including CuI, AgI, Au_2I_4, and BiI_3. Using 2D-STEM data, we predict their ground-state three-dimensional crystal structures and analyze the electronic characteristics of both pristine and graphene-encapsulated forms. Additionally, we explore the role of graphene in facilitating the formation and influencing the dynamics of these 2D materials [2].

WED 7

Magneto-Raman Study of a $NbSe_2$-CrSBr Superconductor-Magnet Hybrid-Interface

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Interfacing the superconducting transition-metal dichalcogenide $NbSe_2$ with the magnetic semiconductor CrSBr (A-type antiferromagnet) provides a van der Waals platform to explore proximity effects for quantum electronics. This interplay could enable Josephson junctions and SQUIDs with magnetic-field controlled critical current and ultrathin spin-filtering junctions. We use magneto-Raman spectroscopy to probe $NbSe_2$, CrSBr and their interface conducted for both, superconductor–magnet interface at 4K and CDW-magnet interface at 15K. An external field tunes CrSBr from antiferromagnetic to ferromagnetic order, enabling magnetization-dependent investigation of the interface. We observe changes in the Raman spectra relative to isolated $NbSe_2$ that suggest proximity effects tied to ferromagnetic alignment of CrSBr. Apparent proximity-induced changes of $NbSe_2$ collective modes are consistent with coupling to CrSBr magnetism, hinting that these interfaces could serve as platforms for quantum devices.

This project has received funding from the European Union's Horizon Europe research and innovation program under grant agreement No 101130224 'JOSEPHINE'.

WED 8
Encoded Dipolar Chains : from single molecule arrays to cooperative emitters

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Boron nitride nanotubes (BNNTs) have been identified as a promising dielectric host template for fluorescent molecules because of their wide-gap semiconductors of ~5.5 eV [1-3]. In this presentation we will focus on the different way to organize luminescent dyes and molecular spacers inside BNNTs, to form 1D chains from single molecules arrays to periodic J-aggregates. Finally, combining ac-HRTEM, Electron Energy Loss Scanning TEM (STEM-EELS) at 80 kV and time resolved fluorescence images we will demonstrate that assemblies of aligned and regularly spaced dyes in BNNTs display strong superradiant light emission fingerprints at room temperature with shortened lifetime by more than a decade, while keeping high brightness [4]. These multifunctional nanohybrids open a new route toward robust and low cost materials platform for quantum photonics technologies.

WED 9
Symmetries of excitons and its consequences for exciton-phonon coupling

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For a long time, the symmetry of excitons has been discussed (if at all) in the Wannier picture of hydrogen like (s, p, ...) excitonic states. While this classification is valid in the limit of dilute (weakly bound) excitons, it ceases to be valid in the limit of tightly bound excitons (e.g., in 2D materials), where the space group symmetry of the underlying crystal structure becomes important. We have implemented the full symmetry analysis (including non-symmorphic symmetries) of excitonic states calculated with the Bethe-Salpeter equation. We give examples, where the knowledge of the excitonic symmetries is helpful: (i) the excitonic dispersion and optical absorption spectrum of LiF, where we examine the selection rules of exciton–photon interactions; (ii) resonant Raman scattering in monolayer $MoSe_2$, where we demonstrate how the conservation of total crystal angular momentum governs exciton–phonon interactions. We give also an overview over the code development in Luxembourg, which enables the calculation of exciton-phonon couplings in the irreducible Brillouin zone and full analysis of selection rules.

WED 10
Transient Reflection Microscopy of 2D Materials - Understanding Signal Formation

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Transient reflection microscopy is widely used for probing the excited state dynamics in 2D materials. In this technique, changes induced by a pump laser pulse are detected by monitoring the intensity of a reflected probe pulse for varying time delays. The obtained signal transients are discussed in terms of local excited state populations and their spectral dynamics. For tightly focused excitation pulses, however, signal formation turns out to become complex due to the angular dependence of photo-induced reflectivity changes. Experimentally, this can be recognized as an extreme sensitivity of the temporal evolution observed in signal transients towards defocusing.
We investigate this signal formation process by first studying the angular dependent reflectivity of monolayer $MoSe_2$ on glass without excitation pulse. Images of the reflected light detected in the Fourier plane reveal characteristic signal contributions that can be described using the energy dependent optical sheet conductivity of the 2D material. We then report on the angular resolved detection of reflectivity tran-

sients and their theoretical modelling considering both changes in absorption and refraction.

WED 11
Revealing charge density wave related structural phase transitions and lattice dynamics in bulk $TiSe_2$

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In low-dimensional or layered materials, strong electron-phonon coupling may induce structural distortions and charge density waves (CDW) – standing wave-like charge modulations exhibiting exotic properties, such as charge and/or spin transport in a highly correlated fashion. Hence, CDWs attract great interest for applications in quantum technologies. $TiSe_2$ is a prototypical member of the class of layered CDW materials. In its high-temperature phase, $TiSe_2$ has a hexagonal structure ($P\bar{3}m1$) and exhibits a soft phonon mode at the L and M points in the hexagonal Brillouin zone, inducing a transition into a distorted CDW phase for temperatures below T$\approx$200K. The CDW phase has been systematically studied theoretically and, among other approaches, through ARPES measurements at different temperatures and doping levels. While there is consensus of the high-temperature phase, the emergence of chirality at lower temperatures remains subject of active debate.
In our poster, we present our latest findings from synchrotron based high-resolution inelastic X-ray scattering on phonons, allowing to access the material's properties through the lens of the vibrational dynamics.

WED 12
Electric-field tunable valley excitons in proximity coupled WSe_2/CrI_3 heterostructures

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Transition metal dichalcogenides have attracted significant interest due to their unique optical properties. The possibility to address the K and K' valley selectively via σ^+ and σ^- polarized light enables optical initialization and readout of the valley degree of freedom. The valley degeneracy can be lifted by an external magnetic field or via magnetic proximity coupling to a 2D magnet such as CrI_3. However, in the latter heterostructures, the resulting exciton splitting lacks tunability, limiting its applicability in device architectures that demand adjustable valley splitting. Our

work shows a large tunability of the exciton splitting in a WSe_2/CrI_3 heterostructure via external displacement fields. Reflection contrast measurements show a change in the exciton resonance energy with external displacement field of up to -5 meV. This change is asymmetric with respect to the excitons at the K and K' valleys, with a stronger redshift at the K valley leading to a 35% increase in exciton splitting at a displacement field of -0.4 V/nm. We attribute the change in resonance energy to a reduction in the optical bandgap, caused by a displacement field-induced change in the band alignment.

WED 13
Correlating AFM-IR with Confocal Raman and µ-IR for all-in-one Vibrational Analysis at Multiple Length Scales

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Atomic force microscopy (AFM) is a versatile tool for nanoscale imaging and probing. Advanced modes such as PFM, KPFM, and cAFM expanded its role beyond topography, while AFM-IR added local vibrational information, linking mechanical interaction with chemical specificity. The integration of confocal Raman microscopy further extended the spectroscopic dimension while keeping AFM as the structural backbone.
In this talk, we present the next step: a correlative platform unifying AFM, AFM-IR, Raman microspectroscopy, nano-IR, and µ-IR. This approach enables seamless investigation across length scales from micrometers to sub-10-nm resolution with direct correlative analysis.
Case studies include phase separation in polymer blend films, where AFM provides morphology, AFM-IR and nano-FTIR deliver nanoscale chemistry, and Raman confirms spectral signatures. For micron-sized MOF crystallites, AFM and AFM-IR reveal nanoscale heterogeneity and contaminants, while Raman and LDIR supply complementary larger-scale chemical maps.
This evolutionary path from AFM to multimodal vibrational spectroscopy demonstrates how IRa-SCOPE enables comprehensive micro- to nanoscale characterization for polymers and functional materials.

WED 14
Anisotropic Optical Response of Horizontally Aligned Single-Walled Carbon Nanotube Arrays for Photonics

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2D materials are key building blocks for modern optoelectronics and photonics. While optically anisotropic monolayers enable control over light–matter interaction and polarization, their use is limited by random optical-axis orientation in large-area samples. A promising alternative is a monolayer of aligned single-walled carbon nanotubes (SWCNTs) with an anisotropic dielectric tensor. Here, the anisotropic optical constants of aligned SWCNT monolayers are measured for the first time over a broad spectral range of 250–1700 nm [1]. As a result, the optical constants of aligned SWCNT monolayers are added to the optical anisotropy database, facilitating the integration of one-dimensional structures into two-dimensional architectures and enabling rapid nanotube characterization. Additionally, carbon nanotube networks exhibit controllable orientation and programmable optical properties, allowing switching between isotropic and anisotropic dielectric responses and wavelength-dependent rotation of principal optical axes [2].

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WED 15
Ultraconfined Terahertz Phonon Polaritons in Hafnium Dichalcogenides

Niclas S. Müller[1], Ryan Kowalski[2], Gonzalo Álvarez-Pérez[3], Maximilian Obst[4], Katja Diaz-Granados[2], Giulia Carini[5], Aditha Senarath[2], Saurabh Dixit[4], Richarda Niemann[4], Raghunandan B. Iyer[6], Felix G. Kaps[7], Jakob Wetzel[7], Michael Klopf[8], Ivan I. Kravchenko[9], Martin Wolf[5], Thomas G. Folland[6], Lukas M. Eng[7], Susanne C. Kehr[7], Pablo Alonso-Gonzalez[10], Alexander Paarmann[5], Joshua D. Caldwell[2].

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Phonon polaritons are hybrid light-matter quasiparticles that emerge from the ultra-strong coupling of infrared photons with lattice vibrations. Over the past decade, this has enabled the miniaturization of infrared photonic components, including nanoscale waveguides, coherent thermal light sources, and sensors, where most research focused on the mid-infrared spectral range [1,2].
Here we introduce the transition metal dichalcogenides $HfSe_2$ and HfS_2 as a platform to extend phonon-polariton nanooptics to the terahertz (THz) [3]. These materials enable an extreme confinement compressing free-space wavelengths of ~60 µm down to ~250 nm guided mode wavelengths in thin films. A key ingredient is the exceptionally strong light-matter interaction, which approaches the excitation frequency itself.

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WED 16
Superconducting and dielectric properties of monolayer α-$TaSi_2N_4$

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The monolayer α-$TaSi_2N_4$ belongs to the recently discovered MA_2Z_4 family of two-dimensional intercalated materials, which exhibit a wide range of physical properties, including semiconducting, metallic, topological, and superconducting behavior. Members of this group, such as $MoSi_2N_4$, WSi_2N_4 have already been synthesized, highlighting the tunability of this material class.
We investigated the superconducting and dielectric properties of monolayer α-$TaSi_2N_4$ using a combination of ab initio and effective model approaches. The phonon-mediated superconductivity is examined through first-principles calculations, an effective tight-binding Hamiltonian constructed from maximally localized Wannier functions, and the Fan–Migdal formulation of the electron–phonon interaction, further analyzed within the Migdal–Eliashberg theory of superconductivity. Our results reveal that α-$TaSi_2N_4$ is an anisotropic two-band superconductor. In addition, we investigate the dielectric response characterized by the electric susceptibility derived within linear response theory combining the Green function formalism with tight-binding modelling.

WED 17
Modulated Elemental Reactants Growth of Two-Dimensional MnS

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Interest in multiferroic materials arises from their diverse physical properties and wide range of applications. However, the number of known compounds that exhibit multiferroic properties at room temperature is very limited. Therefore, the use of two-dimensional heterostructures to create multiferroic compounds appears to be a promising direction. An exemplary case is MnS, which, depending on growth conditions, can crystallize into different polymorphic forms [1]. We aim to optimize the Mn–S thin-film growth conditions to achieve stable, well-defined structures on a macroscopic scale, using the method of modulated elementary reactants within an MBE system.
The characterization of the resulting samples was performed using in situ reflection high-electron diffraction, as well as various ex-situ X-ray, spectroscopic, and microscopic techniques.
The obtained results pave the way to a growth of stable 2D multiferroics heterostructures formed by strongly coupled interlayers with MnS in the role of the magnetic component.

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WED 18
Quantum description of 2D polaritons

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Polaritons are hybrid light-matter quasi-particles that arise from the coupling of electromagnetic fields with collective matter excitations, such as plasmons, phonons, excitons and magnons. In this work we use a quantum microscopic description of the electromagnetic excitations of 2D materials to investigate their shrinking and squeezing capabilities. We show that in-plane dipole excitations in 2D materials couple to the free photons to form both transverse electric and transverse magnetic polaritons, both producing electric fields evanescing into the surrounding material. Our results indicate that while the transverse magnetic mode is appropriate for both the shrinking and the squeezing of light, the 2D transverse electric polaritons can

also be used for the efficient production of squeezed electric fields, although having limited applicability for light-shrinking. The presented approach sheds light on the exquisite physics of polaritons in 2D materials while also allowing for the development of efficient strategies for their application.

WED 19

Dynamic charge transfer in $MoSe_2$/CrSBr van der Waals Heterostructure with orthogonal spin texture

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We report a comprehensive optical study of a monolayer (ML) $MoSe_2$ on the layered A-type antiferromagnetic semiconductor CrSBr.
Initial magneto-photoluminescence (PL) measurements suggest a type-III band alignment in this heterostructure, revealing asymmetric magnetic proximity interactions [1]. By performing co-circular polarized PL and reflection contrast experiments, we observe that the atomic proximity of the materials leads to a breaking of time-reversal symmetry [2].
Moreover, time-resolved PL and time-resolved reflectivity measurements identify a very long-lived dynamic charge-transfer process in the heterostructure, consistent with a type-III band alignment of the ML-$MoSe_2$/CrSBr heterostructure.
Additionally, time- and polarization-resolved experiments suggest that the excited charge carriers exhibit behavior resembling band bending, alongside evidence of efficient Förster resonance energy transfer, highlighting the potential of vdW heterostructures for manipulating spin, charge, and valley degrees of freedom.

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WED 20

Direct observation of flat bands in near-magic-angle twisted bilayer CVD graphene

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Chemical vapor deposition (CVD) of graphene is achieving an increasingly high quality of the grown crystals, yet it remains to be determined if disorder-sensitive electronic configurations such as flat bands and correlated states in magic-angle (MA) twisted bilayer graphene (TBG) can be realized with this material. Here, we report on the experimental observation by room-temperature nano angle-resolved photoemission spectroscopy (nano-ARPES) of flat bands in a TBG sample close to the MA, assembled via a grow-and-stack protocol based on low-pressure CVD of graphene on copper and the PVA-mediated pick-and-flip technique. In addition, we analyze how the stacking configuration varies across defects in the heterostructure, proposing a method to track the relaxation of the twist angle towards the thermodynamically favored AB stacking from ARPES data. Our study indicates electronic bands fully comparable to those measured in exfoliation-based samples and determines the size of the largest near-MA domain to be compatible with electronic transport experiments, motivating further experiments on flat band physics in CVD-graphene.

WED 21
NiPS3: Possible XY Spin System in Real Life

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The van der Waals antiferromagnet $NiPS_3$ is a promising candidate for a real-world representation of the XY spin model, thanks to its low in-plane magnetic anisotropy and the observed loss of magnetic order in the monolayer. We study its few-layer and monolayer behavior through nanomechanical experiments combined with literature review and DFT calculations. Mono- and few-layer flakes are obtained via gold-assisted exfoliation on Si/SiO_2, with thicknesses confirmed by optical contrast and AFM.
Suspended regions over cavities in the chip form nanomechanical resonators, whose resonance frequency reveals minute strain changes as temperature varies through the Néel point. Prior work shows bulk resonators can be used to probe

phase transitions via resonance frequency and quality factor. We characterize strain in thin $NiPS_3$ resonators to explore XY-model behavior in the monolayer limit and the potential Kosterlitz–Thouless transition. Next steps include applying controlled strain to study anisotropic magnetic and elastic responses, and probing static mechanics by AFM indentation.

WED 22
Electric Control of van der Waals Polytypes in Graphite

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Van der Waals (vdW) polytypism in layered materials such as graphite provides a unique platform for exploring metastable stacking configurations with distinct electronic properties. Recent advances have shown that controlled interlayer sliding can dynamically switch between these polytypes, opening pathways toward electrically reconfigurable materials. In this work, we present model devices designed to induce and monitor transitions between graphite polytypes through the application of electrical pulses. By combining superlubric cavities and vertical gating geometries, we demonstrate controlled manipulation of interlayer stacking order and study the resulting changes in transport and optical responses. These experiments aim to establish electrical control over vdW stacking as a new degree of freedom in 2D material systems

WED 23
Atomic Encoding in a Sliding Ferroelectric van der Waals Heterostructure

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Recently, out-of-plane ferroelectricity has been observed in aligned structures of hBN and transition-metal dichalcogenides (TMD's). Here, switching between polarisation states is dictated by a net shift of adjacent layers equal to $1/\sqrt{3}$ of the lattice parameter. In this work, we induce sliding in a ferroelectric hBN structure by applying uniaxial strain using a piezoelectric substrate. Through in situ electrostatic force microscopy (EFM) imaging, we observe full, repeated, and controllable electric switching of the sliding area. The frequency of switching events provides evidence of atomic-scale displacement encoding, which indicates its potential use in future displacement sensing applications. Multiscale modelling of dislocation energetics coincides with experimental observations of their propagation, highlighting the role of Burgers vector selection in governing switching behaviour.

WED 24
Infrared markers of topological phase transitions in quantum spin Hall insulators

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Vibrational infrared optical response can be used to discriminate between the electronic topological states of two-dimensional quantum spin Hall insulators (QSHI). First principles phonon infrared spectra of germanene and jacutingaite, Kane-Mele systems of recent experimental investigation, exhibit a large discontinuity concomitant with the topological phase transition [1]. Such significant changes are explained in the framework of the low energy Kane-Mele model by the connection between the vibrational and the electronic responses at the valleys [2]. By means of first-principle calculations, our results are extended to the 1T' transition metal dichalcogenides, including $\mathrm{WSe_2}$-stable in air if encapsulated, with topological properties robust at elevated temperatures. Finally, even when the infrared active phonon resonate with the energy gap of the material, the vibrational resonances show Fano profiles with remarkable differences in the intensity and the shape between the two topological states [2].

[1] Fachin et al., Phys. Rev. B,110, L201405, 2024
[2] Fachin et al., npj Computational Materials, 11,307, 2025

WED 25
Coherent Bunching of Anyons and Dissociation in an Interference Experiment

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Aharonov-Bohm (AB) interference of fractional quasiparticles in the quantum Hall Effect generally reveals their elementary charge (e^*). Here, we report interference measurements of 'particle-hole conjugated' states at filling factor ν=2/3, 3/5, and 4/7, revealing unexpected flux periodicities of $\Delta\Phi = \nu^{-1}\Phi_0$. The measured shot noise Fano factor (F) of the partitioned quasiparticles in each of the interferometer's quantum point contacts (QPCs) was found to be, F=ν, and not that of the elementary charge, F=e^*/e. These observations point to interference of bunched (clustered) elementary quasiparticles as coherent pairs, triples, and quadruplets, respectively. A small metallic gate ('top gate,' TG), deposited in the center of the interferometer bulk, forming an antidot (or a dot) when charged, thus introducing local quasiparticles at the (anti)dot's perimeter. Surprisingly, such charging led to

a dissociation of the 'bunched quasiparticles' and thus recovered the conventional flux periodicity set by the elementary quasiparticles' charge.

[1] B.Ghosh, et al., Nature, 642, 922-927 (2025).
[2] B.Ghosh, et al., Nature Physics, 21, 1392–1397 (2025).

WED 26
Electrical excitation of self-hybridized exciton-polaritons in a van der Waals antiferromagnet

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Van der Waals materials continue to drive advances in solid-state physics, with emerging layered compounds expanding the applicability of two-dimensional phenomena. The antiferromagnetic semiconductor CrSBr has recently attracted particular interest due to its combination of strongly bound excitons, quasi-one-dimensional electronic bands, a high Néel temperature and robust light–matter interactions. However, a central outstanding challenge has been the efficient electrical generation of optically active quasiparticles in two-dimensional systems. Here, we employ a novel electrical excitation mechanism, creating excitons by the near field coupling of tunneling electrons. We explore the different pathways of electrons in a van der Waals heterostructure, showing evidence for tunneling beyond the electrodes. In CrSBr, we reveal strong, linearly polarized electroluminescence confirming the excitonic origin, independent of the layer thickness. The open electrode design further enables injection of self-hybridized exciton-polaritons governed by the strong light-matter coupling of CrSBr.

WED 27
Ultrafast Electrically Driven Light Emission from Carbon Nanotubes Integrated into High-Frequency Coplanar Waveguides

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Electrically driven single-photon sources emitting at telecommunication wavelengths are a cornerstone for future quantum communication networks. Carbon nanotubes, particularly when chemically functionalized to create quantum defects, offer a promising route toward scalable, room-temperature single-photon emission. However, probing the ultrafast dynamics of these emitters under electrical excitation requires device architectures capable of sustaining picosecond pulses with minimal signal distortion. Here, we report the design, fabrication, and characterization of a high-frequency coplanar waveguide platform on sapphire, capable of driving integrated carbon nanotubes with electrical pulses as short as 50 ps. We demonstrate the site-selective integration of semiconducting CNTs via dielectrophoresis and characterize their electroluminescence in both continuous and pulsed regimes. Using time-correlated single-photon counting, we resolve optical pulses with a full-width at half-maximum of 120 ps from electrically driven CNTs, demonstrating the platform's capability for sub-nanosecond time-resolved electroluminescence spectroscopy.

WED 28
Mapping and detecting few-layer graphite polytypes by electronic Raman scattering

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Graphite has two defect-free polytypes, hexagonal (Bernal) and rhombohedral, a topological semimetal. Mixed configurations can appear and have been experimentally identified as stacking faults. In few-layer samples, the number of stacking polytypes grows exponentially because each new graphene layer can align either in the hexagonal or rhombohedral position. Each polytype has a unique electronic structure; stacking thus provides an additional tuning parameter to tailor the properties of few-layer graphite, with recent work revealing ferroelectricity in polytypes lacking inversion and mirror symmetry. However, identifying all stacking configurations remains challenging. Infrared scattering SNOM is commonly used but does not offer unambiguous identification. Here we show that electronic Raman scattering (ERS) serves as a robust fingerprinting tool for FLG polytypes. We calculate all ERS spectra for thicknesses up to 15 layers (>6000 spectra) and demonstrate experimentally that the polytypes exhibit distinct ERS responses measurable at room temperature. This establishes ERS as a reliable technique for identifying graphite polytypes for exploring emergent 2D electronic phases.

WED 29
Correlation of near-field optical microscopy and tip-assisted photoluminescence

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Nanoscale optical imaging enables exploration of structural, electronic, and optical properties of low-dimensional materials with resolutions beyond the diffraction limit. Techniques such as tip-enhanced and tip-assisted photoluminescence (TEPL, TAPL) and scattering-type scanning near-field optical microscopy (s-SNOM) provide complementary insights into local strain, exciton dynamics, and dielectric heterogeneity, yet their integration in one setup remains difficult. Here we present correlative TEPL/TAPL and s-SNOM measurements realized within a single side-illuminated near-field microscope. We address challenges of side illumination, including laser focus alignment, far-field background suppression, and mitigation of parasitic scattering. Using monolayer WSe_2, we achieve correlative imaging of topography, strain-induced photoluminescence shifts, and dielectric variations. Nanoscale mapping of a bubble-like feature reveals complementary contrast in TAPL and s-SNOM, demonstrating a unified platform that bridges nanoscale optical spectroscopy and near-field imaging for probing local strain, doping, exciton behavior, and dielectric inhomogeneity.

WED 30
Coherent vibrational control in a van der Waals sliding ferroelectric

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Van der Waals sliding ferroelectrics are an emerging platform for information processing. Their unique coupling of structural distortions and polarization enables control of ferroelectricity through lattice motion. Optical excitation has been shown to launch coherent sliding modes and drive transitions between ferro- and paraelectric states. However, the roles of electron–phonon coupling, large-amplitude sliding motion, and minimum-energy pathways for switching remain largely unexplored.
Here, we report coherent control over sliding motion in the vdW ferroelectric WTe_2. Using double-pulse optical excitation, we enhance the sliding amplitude beyond the limit of single-pulse excitation. Time-resolved SHG, combined with DFT calculations, reveals that the amplitude is constrained by the population of high-lying electronic

states. Performing vibrational spectroscopy, we identify a new decay mechanism for the sliding mode directly linked to its coherent amplitude. We uncover the transition pathway between Td and 1T1T' phases, involving both interlayer sliding and intralayer shear motion. Our results provide landmarks for ultrafast polarization inversion in sliding ferroelectrics.

WED 31
Thickness control of BN films epitaxially grown on Ni (111) by rapid thermal CVD

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Among 2D materials, boron nitride has been identified as a key component for the fabrication of nano-devices in optics, electronics or spintronics. Most high-performance proofs of concept have been done with hBN flakes obtained by mechanical exfoliation, which gives flakes with a high crystalline quality but limited area. Mastering large area synthesis is essential however controlling the film thickness with a high quality remains a challenge.
In this context, we develop a synthesis route to sp^2-hybridized boron nitride layers in a rapid thermal CVD reactor. The growth is done on Ni(111) substrate at low pressure with borazine as a precursor[1]. The films are then transferred on SiO2 substrate and characterized from the mm scale to the nm scale by Raman spectroscopy, XPS, AFM, SEM and TEM. We have been able to synthesize and transfer homogeneous films of several mm2 with various thicknesses. We discuss the impact of different synthesis parameters, namely the substrate thickness, the borazine quantity and the cooling rate on the BN films, and how it helps to understand the growth mechanism of BN on Ni(111) by CVD.

[1]L. Tailpied et al. Cryst. Growth Des. 24, 7432. 2024

WED 32
Stabilizing Unreconstructed Low-Angle Twisted Bilayer Graphene Superlattices through Dielectric Intercalation

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In rigid graphene bilayers, the moiré domain size increases sharply with decreasing twist angle, reaching tens of nanometers near 0.1–0.2°. At such angles, lattice relaxation reconstructs the structure into large AB/BA domains with narrow solitons, shrinking AA sites to tiny spots. This disperses flat bands and removes high-DOS regions crucial for surface phenomena like catalysis and adsorption. To overcome this, we propose dielectric intercalation between the layers. Using classical molecular dynamics, density functional theory, and a Bistritzer–MacDonald model, we show that intercalation increases interlayer spacing to an optimal value: weakening adhesion to prevent reconstruction while maintaining coupling through dielectric screening. The dielectric spacer allows graphene π orbitals to overlap over larger distances, preserving flat-band conditions at small twist angles. This enables large, unreconstructed AA domains with high local DOS and offers a route to engineer flat-band surfaces for enhanced functionality.

WED 33

Pressure-tunable phase transitions in atomically thin Chern insulator $MnBi_2Te_4$

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Topological insulators that break time-reversal symmetry can host the quantum anomalous Hall (QAH) effect. Odd-layer $MnBi_2Te_4$ is a promising platform due to its intrinsic magnetism, yet quantization remains rare. We study few-layer $MnBi_2Te_4$ under hydrostatic pressure using magnetotransport measurements. In the antiferromagnetic phase, we observe a trivial insulating state, likely arising from disorder, while a high magnetic field induces a Chern insulator phase. Analysis of temperature and field dependence shows that pressure enhances interlayer exchange coupling but weakens intralayer interactions. The trivial band gap also narrows under compression, indicating reduced disorder effects.
Our findings demonstrate that pressure serves as a clean, reversible tuning parameter for both magnetic and topological properties in $MnBi_2Te_4$. These results offer valuable insight into how structural control and magnetic coupling can be leveraged to stabilize the elusive quantum anomalous Hall state in intrinsic magnetic topological insulators.

WED 34
KPFM on molecular 2D TMDC heterostructures

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Kelvin Probe Force Microscopy (KPFM) enables high-resolution mapping of surface potential and work function variations in two-dimensional (2D) materials and hybrid heterostructures, offering insights into local electronic structure. In molecularly functionalized 2D systems, KPFM is particularly effective for identifying charge transfer, local doping effects, and electronic inhomogeneities with nanometer-scale spatial resolution. When combined with complementary techniques such as photoluminescence (PL), Raman spectroscopy, and scattering-type scanning near-field optical microscopy (s-SNOM), it provides a comprehensive view of structure–property relationships in complex, multi-component systems. This correlative approach reveals how molecular functionalization influences local dielectric environments, excitonic behavior, and polariton propagation, even in the presence of structural or compositional inhomogeneities. KPFM thus serves as a sensitive, non-destructive tool for probing local electronic interactions and complements optical methods in the study of emerging 2D material systems.

WED 35
Half-integer thermal conductance in integer quantum Hall states

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Considering a range of candidate quantum phases of matter, half-integer thermal conductance (κth) is believed to be an unambiguous evidence of non-Abelian states. It has been long known that such half-integer values arise due to the presence of Majorana edge modes, representing a significant step towards topological quantum computing platforms. Here, we challenge this prevailing notion by presenting a comprehensive theoretical and experimental study where half-integer two-terminal thermal conductance plateau is realized employing integer quantum Hall (QH) states. Our proposed setup features a confined geometry of bilayer graphene, interfacing distinct particle-like and hole-like integer QH edges. Each segment of the device exhibits full charge and thermal equilibration. Our approach is amenable to general-

ization to other QH platforms, and may give rise to other values of fractional (electrical and thermal) quantized transport. Our study demonstrates that the observation of robust non-integer values of thermal conductance can arise as a manifestation of mundane equilibration dynamics as opposed to underlying non-trivial topology.

WED 36
Controllable preparation and structural modulation of low-symmetry 2D materials

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Low-symmetry 2D materials, prized for their superior nonlinear optics and ferroelectricity, face a synthesis bottleneck for multi-element composition. We report a novel high-pressure growth method driven by thermal-expansion mismatch (between Cu and graphite), which generates ~200 atm local pressure to "squeeze" the growth of ultrathin 2D non-centrosymmetric oxides, exemplified by $\mathrm{MnTeMoO_6}$. This approach effectively suppresses phase separation and enables the formation of atomically ordered, stoichiometric 2D flakes.
Detailed characterization confirms the non-centrosymmetric structure and reveals a giant nonlinear optical response. A strong second-harmonic generation is observed across a broad 800-2400 nm range, with a second-order nonlinear susceptibility ranking among the highest for wide-bandgap 2D materials. This growth strategy is reproducible and universal, also successfully applied to other systems like $\mathrm{ZnTeMoO_6}$ and $\mathrm{Bi_2OSe_2}$, providing a robust platform for exploring low-symmetry 2D materials in nonlinear optics and beyond.

WED 37
High-Efficiency Electrical Excitation of Quantum Dots Using Energy Transfer

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Photonic circuits represent a highly promising alternative to purely electronic circuits, using photons instead of electrons. They are expected to have with higher speeds, lower energy consumption and smaller sizes than the current silicon based technology. A rising approach is the use of low dimensional materials. Two-dimensional (2D) materials such as graphene, hBN and TMDs have already been shown to

produce efficient light emitting devices. However, achieving more complex applications such as single photon sources, lasing or polariton behavior remains challenging. In this regard, Quantum dots (QDs) are a well-suited alternative. They exhibit well established single-photon emission and unraveled emission tuning. However, efficient electrical excitation is a key challenge. Here, we present a novel approach which uses a 2D material based light emitting device to excite proximate QDs through Förster resonant energy transfer (FRET). We demonstrate the potential of this method by exciting a film of CdSe nanoplatelets with a FRET efficiency of 40%. This efficient electrical excitation mechanism could pave the way to more complex light sources such as single photon emission or lasing.

WED 38
Asymmetric electron-hole double quantum dots in bilayer graphene

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Electron-hole double quantum dots (DQDs) in bilayer graphene (BLG) are a promising platform for single-particle qubits. A symmetry-protected single-particle blockade mechanism enables a unique readout scheme, making BLG electron-hole DQDs of particular interest, especially given that they are difficult to realize in other material systems, such as silicon or germanium. Controlling the individual quantum dots (QDs) is essential for selectively manipulating qubit states in such an ambipolar system. In this study, we present an electron-hole DQD in BLG that exhibits pronounced carrier-type asymmetry, and we examine its characteristics using magneto-transport spectroscopy. We find that the valley g-factors of the two dots differ by an amount comparable to their absolute values, indicating the feasibility of independently controlling states with different valley quantum numbers. We also observe signatures of finite intervalley coupling in the QDs, which is a key feature for implementing single-particle state qubits in this architecture, such as valley qubits or Kramers qubits. Our conclusions are supported by simulations that quantify the impact of the relevant symmetry-breaking terms.

WED 39
Fabry-Perot Resonance Approach to Optical Conductivity of 2D Dichalcogenides

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Transition metal dichalcogenides (TMDs) containing Pt, Pd, or Mo exhibit diverse electronic behaviours ranging from semiconducting to semimetallic. Optical spectroscopy provides an effective means to distinguish materials with different electronic structures. While optical spectra are often reported in the visible range, measurements in the infrared and far-infrared remain scarce, despite their sensitivity to free charge carriers. We present optical measurements of selected TMD thin films in these spectral regions. Since the standard Kramers–Kronig approach cannot be directly applied to thin films on substrates, we employ an alternative method based on high-resolution monitoring of interference fringe variations in a Fabry–Perot resonator formed by the substrate with the film acting as a perturbation. The data are analysed using a model-independent retrieval of the dielectric function, yielding the frequency-dependent optical conductivity. Differences among 2D materials and their possible relation to the band structure will be discussed.

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WED 40
Fabrication of Functionalized Janus-type Graphene Field-Effect Transistors by Stepwise Laser Writing

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Janus graphene, with distinct chemical properties on its two surfaces, is a promising material for engineering asymmetric electronic responses. However, achieving precise and quantitative dual-side functionalization—crucial for device integration—remains challenging. Here, We present a stepwise laser-induced radical approach for the programmable formation of Janus graphene with asymmetric chemical functionality. Raman spectroscopy reveals defect distance of 1.5 nm and 2D-band broadening up to 71 cm^{-1}, indicating dense covalent attachment. KPFM and AFM show cumulative work-function shifts of 175 mV and surface corrugation of 10 nm, while electrical transport exhibits a +78 V Dirac-point shift and a fourfold carrier-density increase. h-BN control experiments reveal enhanced reactivity on h-BN-supported graphene (ID/IG = 3.33, +60 mV KPFM shift) compared to SiO2/Si (2.51, –100 mV) due to reduced charge trapping, whereas h-BN capping blocks top-side activation. Together, these results establish stepwise laser writing as a robust and tunable platform for programmable Janus graphene electronics.

WED 41
Probing frictional anisotropy in two-dimensional materials

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Understanding interlayer friction in two-dimensional materials is crucial for nanoscale mechanics and lubrication. However, conventional friction force microscopy is limited by tip-induced damage and cannot probe the full range of twist angles where friction transitions from superlubric to lock-in states. Here, we introduce the Twist-angle-resolved Interfacial Friction Analyser (TIFA): a platform employing lithographically shaped silicon nitride membranes and high-aspect-ratio silicon pillars to enable direct measurements of interfacial shear forces. By tracking the membrane's displacements optically, TIFA provides quantitative access to both static and kinetic friction across all twist angles. Using graphite/graphite as a model system, we demonstrate reproducible, twist-angle-dependent frictional responses that reveal pronounced frictional anisotropy in two-dimensional materials.

WED 42
Photoluminescence and Transmittance Signatures of Excitonic States in Thin $(PEA)_2PbI_4$ Slabs

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Two-dimensional Ruddlesden–Popper perovskites provide a unique platform for examining how dimensionality, dielectric environment, and structural distortions shape excitonic optical response in low dimensional semiconductors. Here, we present temperature-dependent photoluminescence (PL) and transmittance spectra from $(PEA)_2PbI_4$ slabs spanning in thickness from 24 nm to several micrometers, connecting common observables to the slab optical response. Low-temperature PL resolves the bright X, Y exciton manifold and weaker interlayer features while transmittance reveals reproducible, thickness-dependent structures correlating with but not always matching individual PL bands. A phenomenological dielectric model in a transfer-matrix framework is used to describe line shapes and their thickness and temperature dependencies. In addition, first-principles calculations with polarization-resolved PL benchmark the excitonic manifold and its sensitivity to distortions and interlayer interactions. This approach links PL and transmittance fingerprints in $(PEA)_2PbI_4$ to robust optical signatures, providing new and valuable guidance for interpreting layered perovskite spectra.

WED 43
Amorphous excitonic crystals using the synergy of ferroelectric domains and two-dimensional semiconductors

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Translational symmetry governs the electronic and optical behaviour of materials, and deliberately reshaping it enables the creation of artificial lattices and emergent quantum phases. While moiré engineering in twisted 2D crystals provides tunable supercells, it is restricted to hexagonal lattices. A more flexible route arises in ferroelectric (FE)/2D heterostructures, where the polarization of the FE layer produces a spatially modulated electrostatic potential with virtually arbitrary symmetry and periodicity. I demonstrate this concept using FE thin films tuned to the morphotropic phase boundary. Upon cooling, the films develop strain-coupled multidomain patterns that we track via strain-sensitive Raman modes. Their spatially random arrangement creates a natural platform for excitonic Anderson localization, revealed at cryogenic temperatures by sharp, discrete emission lines from localized excitons. The emission shows characteristic intensity blinking, which we attribute to exciton–exciton interactions and which can be tuned via excitation conditions.

WED 44
Selective defect creation in 2D hexagonal boron nitride via ultra-low energy Ar ion irradiation

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Hexagonal boron nitride (hBN) has recently become the focus of intense research as a material that can host quantum emitters. Although it's well known that the emission is associated with point defects, so far no conclusive correlation between the spectra and defects has been demonstrated, partly due to the challenge of controlling and characterizing their atomic structure. Here, we prepare atomically-clean, freestanding, monolayer hBN samples and subject them to ultra-low energy (150 eV) ion irradiation. The samples are characterized before and after irradiation to assess the defect density and distribution. The samples have an intrinsic defect density of ca. 0.023 nm^{-2} with a roughly even distribution of B and N single vacancies. After irradiation we measure a defect density of ca. 0.243 nm^{-2} with a 85:15 ratio in B:N single vacancies. However, we also observe vacancy filling by C and Si atoms that originate from surface contamination. These results demonstrate some selectivity in the defect type, and further work explores the possibility of altering the defect distribution by irradiating with different noble gases (He and Xe) and with a reactive gas (O_2).

WED 45

In Situ Mapping of Pressure-Induced Exciton Traps in Suspended MoS_2 Monolayers Using Fabry-Perot Interference

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We demonstrate the in-situ readout of the spatial profile of suspended MoS_2 monolayers hosted on substrates with nanostructured holes. As the profiles are spatially bent, the suspended MoS_2 monolayers act as exciton traps with a tunable luminescence intensity and energy. The tunability is realized by controlling the environmental pressure on the monolayers, which allows one to control hundreds of suspended MoS_2 monolayers on a single substrate. The in-situ readout is based on Fabry-Perot interferences and a model of the corresponding reflectance contrast maps of the investigated monolayers [1].

[1] L. Geilen, et al. *ACS Appl. Opt. Mater,* 3, 2283 (2025).

WED 46

Coexisting tunneling and molecular charge transport in scanning tunneling microscopy and spectroscopy measurements of hydrocarbon contaminated graphene

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Ambient hydrocarbon contamination is an inevitable factor to consider in measurements of van der Waals (vdW) materials. In recent years, our group has identified the structure of this contamination as a self-organized layer of normal alkanes formed upon exposure to air. These molecules are common in the environment and are invariably present on two-dimensional vdW materials. Here we investigate their impact on scanning tunneling microscopy (STM) and spectroscopy. We show that, due to conductance through the alkane molecules, the well-known phonon-induced gap vanishes, resolving the persistent question from previous STM studies as to why this feature is often absent. Additionally, the contamination layer significantly alters the observed current–distance curves (I(z)) by flattening the exponential decay by at least a factor of two. Both effects can be explained by charge transport between the tip and sample through the alkane molecules. This break-junction-like behavior

is supported by systematic statistical evaluation of I(z) curves. Furthermore, our conclusions are supported by ab initio calculations of the wave function decay on pristine and alkane-contaminated graphene surfaces.

WED 47

On the spatial coherence of luminescent exciton ensembles in $MoSe_2$/WSe_2 heterostructures

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We discuss the spatial coherence of interlayer exciton ensembles as formed in $MoSe_2$/WSe_2 heterostructures and characterized by Michelson-Morley interferometry. Below 10 K, the measured spatial coherence length of the interlayer excitons can reach values equivalent to the lateral expansion of the exciton ensembles [1,2]. In this regime, the light emission of the excitons is homogeneously broadened in energy with a high temporal coherence. At higher temperatures, the spatial coherence length and the temporal coherence time decrease. The presented findings point toward a spatially extended, coherent many-body state of interlayer excitons at low temperature [1-6].

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Many-Body Effects in Lattice Dynamics: A Case Study of the Displacive Phase Transition in $BiVO_4$

Matan Menahem[1], Adi Lanton[1], Shlomo Rand[1].

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Displacive phase transitions, driven by soft-mode instabilities, are often modeled using independent vibrational excitations. However, such simplifications overlook the critical role of mode coupling and many-body interactions—especially near structural instabilities—limiting their ability to capture anomalous vibrational spectra. This work presents a coupling-based dynamical model that embeds interaction terms directly into the lattice equations of motion. Using as a case study, we reproduce key spectral anomalies—intensity redistribution, asymmetric lineshapes, and polarization-dependent snaking—that conventional Lorentzian models cannot explain. These results demonstrate that mode coupling is an intrinsic feature of the dynamics of displacive phase transitions. Our approach links many-body lattice effects to experimentally observed features, offering a powerful tool for studying anharmonicity and phase transitions in complex materials.

08:30 – 09:00	Thomas Ihn *Josephson junctions as vortex detectors*
09:00 – 09:30	Luca Banszerus *Artificial flat bands in frustrated Josephson junction arrays based on superconductor/semiconductor hybrids*
09:30 – 10:00	Rebeca Ribeiro *Twist-Angle-Controlled Anomalous Gating in Bilayer Graphene/BN Heterostructures*
10:00 – 10:30	Coffee Break
10:30 – 11:00	Mike Crommie *Imaging Wigner Solids in 2D Semiconducting Devices*
11:00 – 11:30	Bruno Schuler *Probing Atomic Defects in 2D Semiconductors with Light-Coupled STM*
11:30 – 12:00	Felix von Oppen *Microscopy with a twist - exploring reciprocal space by tunneling*
12:00 – 17:00	Mini Workshops
17:00 – 17:30	Stéphane Berciaud *2D semiconductor/graphene heterostructures: form optical spectroscopy to optomechanics*
17:30 – 18:00	Kirill Bolotin *Nanomechanical probing, manipulation, and control of excitons in 2D materials*
18:00 – 18:30	Florian Libisch *Summary*
19:30 – 21:00	Farewell Dinner (Bauernbuffet)

08:30
Josephson junctions as vortex detectors

Marta Perego[1], Clara Galante Agero[1], Peter Koopmann[1], Artem Denisov[1], Filippo Gaggioli[1], Alexandra Mestre Tora[1], Kenji Watanabe[2], Takashi Taniguchi[2], Vadim Geshkenbein[1], Gianni Blatter[1], Klaus Ensslin[1], Thomas Ihn[1].

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Experimentally, magic-angle twisted multilayer graphenes have been found to exhibit gate-tunable superconducting phases, enabling the realization of monolithic superconducting devices controlled purely by electrostatic gating. A fundamental feature of type II superconductors is the presence of vortices, whose dynamics strongly influence dissipation. We use a Josephson junction in magic-angle twisted quadruple layer graphene as a vortex sensor enabling the detection of the quantum dynamics of individual Pearl-vortices penetrating or leaving the supeconducting leads. The vortices lead to abrupt shifts in the Fraunhofer interference pattern. Time-resolved measurements allow us to investigate the dynamics of individual vortices, providing access to the characteristic vortex energy scale and the London penetration depth. Our measurements reveal a high-temperature regime dominated by classical thermal activation over an energy barrier, which crosses over at low temperatures to a regime of macroscopic quantum tunneling through the barrier.

09:00
Artificial flat bands in frustrated Josephson junction arrays based on superconductor/semiconductor hybrids
Luca Banszerus[1].

[1]University of Vienna

Epitaxial semiconductor-superconductor hybrid materials provide a novel highly-tunable platform to study emergent quantum phenomena, taking advantage of gate-controlled density, ballistic transport, and non-sinusoidal current-phase relations. Recently, hybrid Josephson junction arrays have been used to probe the gate-controlled superconductor-insulator transition (SIT), where Josephson couplings can be tuned to be greater than or less than the charging energy of the islands. A perpendicular magnetic field introduces frustration, leading to complex ground states that depend on the geometry of the array. The talk will focus on two-dimensional Josephson junction arrays in the dice lattice geometry, that are predicted to host flat bands when frustrated. I will discuss our efforts to map out the phase diagram as a function of frustration: Frustrations commensurate with the lattice geometry lead to the formation of vortex lattices, which are absent at incommensurate values of frustration. When the array is frustrated by half a flux quantum per plaquette, quantum interference localizes individual Cooper pairs, corresponding to the formation of a flat-band system.

09:30

Twist-Angle-Controlled Anomalous Gating in Bilayer Graphene/BN Heterostructures

Dominique Mailly[1], Gaia Maffione[1], Herve Aubin[1], Liam Farrar[1], Maelle Kapfer[1], Kenji Watanabe[2], Takashi Taniguchi[2], Rebeca Ribeiro[3].

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[2]National Institute for Materials Science, Tsukuba, Japan
[3]Centre National de la Recherche Scientifique (CNRS)

Anomalous gating effects-such as gate ineffectiveness and pronounced hysteresis-have been observed in graphene-based systems encapsulated in boron nitride (BN) and linked to a possible ferroelectric state. However, their origin, stability, and reproducibility remain under debate. Here, we present charge transport experiments in dual-gated, dynamically rotatable van der Waals heterostructures based on bilayer graphene encapsulated in BN. Remarkably, the angular degree of freedom acts as an ON/OFF switch for the anomalous gating response. We show that the angular alignment between the two BN layers – not the presence of a moiré superlattice with graphene – is the key parameter governing these effects. The relevant alignment between the two BN layers, to observe the anomalous gating effect at room temperature, lies between 15 deg and 45 deg, with no evidence of the expected 60 deg periodicity. Both gate ineffectiveness and hysteresis are highly sensitive to small angular changes, which we classify into three distinct regimes. Our results clarify the conditions necessary to reproduce these phenomena and pave the way for theoretical investigation of their microscopic origins.

10:30
Imaging Wigner Solids in 2D Semiconducting Devices
Mike Crommie[1], Zhehao Ge[1], Zehao He[1], Qize Li[1], Ziyu Xiang[1], Jianghan Xiao[1], Hongyuan Li[2], Feng Wang[1], Shaowei Li[3], Conor Smith[4], Shiwei Zhang[4], Takashi Taniguchi[5], Kenji Watanabe[5], Sefaattin Tongay[6].

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[2]Cornell University Physics Department
[3]UC San Diego Chemistry Department
[4]Flatiron Institute, NY
[5]Natural Institute for Material Science, Tsukuba, Japan
[6]Arizona State University

Electronic behavior depends on a balance between kinetic energy (KE) and electron-electron interactions (PE). When KE dominates, electrons become delocalized and behave like a liquid, whereas when PE dominates they freeze into different crystal-like arrangements ("Wigner crystals"). I will discuss recent experiments using STM that enable this behavior to be directly visualized in 2D semiconductors involving TMD materials. The ability to assemble individual TMD layers into van der Waals-bonded stacks allows the competition between solid and liquid electronic phases to be visualized for different 0D, 1D, and 2D energy landscapes. These include bare, unconstrained potentials, moiré superlattices, domain walls, and quantum dots. The electron density in these systems is controlled by incorporating TMD layers into field-effect transistor (FET) devices compatible with STM imaging. We observe that electron crystallization and melting phenomena are strongly affected by charged defects and the dimensionality of confinement potentials. Comparison of STM images to quantum Monte Carlo simulations helps to clarify the role of defects in electronic solid/liquid phase transitions.

11:00
Probing Atomic Defects in 2D Semiconductors with Light-Coupled STM
Bruno Schuler[1].

[1]Empa - Swiss Federal Laboratories for Materials Science and Technology

2D semiconductors provide an exciting platform to engineer atomic quantum systems in a robust, yet tunable solid-state system. This talk explores the intriguing physics of single point defects in transition metal dichalcogenide (TMD) monolayers, investigated through atomically resolved scanning probe microscopy.
We demonstrate electrically induced exciton emission from both pristine MoS_2 and individual charged defects using scanning tunnelling microscope luminescence (STML) on ultrathin hBN decoupling layers [1]. Furthermore, I will present our recent advances in time-resolved THz-STM, enabling the investigation of charge [2] and exciton dynamics [3] with atomic spatial, millielectronvolt energy, and picosecond temporal resolution.
By combining the structural and electronic properties from conventional scanning probe microscopy with the optical fingerprint from STML and the excited-state dynamics revealed through pump-probe THz-STM, we gain a comprehensive microscopic understanding of localized quantum states in low-dimensional materials.

References
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11:30
Microscopy with a twist - exploring reciprocal space by tunneling
Felix von Oppen[1].

[1]Freie Universität Berlin

In this talk I will discuss the theory of the quantum twisting microscope (QTM), covering both elastic and inelastic tunneling spectroscopy. Elastic tunneling spectroscopy probes electronic dispersions, which will be illustrated for both normal-conducting and superconducting systems. Inelastic tunneling spectroscopy probes collective-mode dispersions. Based on a experiment-theory collaboration, I will discuss the theory of QTM measurements of phonon dispersions and electron-phonon coupling strengths. Extraction of the electron-phonon couplings - of interest in the context of superconductivity in magic angle twisted bilayer graphene - requires careful analysis of various contributing inelastic tunneling processes. Phonon spectroscopy will be contrasted with a theoretical analysis of plasmon spectroscopy in QTM measurements. Unlike phonons, plasmons of moire systems are expected to be stongly affected by the interlayer coupling, making them a complementary case study of QTM spectroscopies of collective modes.

17:00
2D semiconductor/graphene heterostructures: form optical spectroscopy to optomechanics
Stéphane Berciaud[1].

[1]Université de Strasbourg and Centre National de la Recherche Scientifique (CNRS)

This talk reviews our efforts to probe van der Waals heterostructures in- and out-of-plane at the nanometer scale, with a focus on the optical properties of transition metal dichalcogenide (TMD)/graphene heterobilayers.
We exploit van der Waals engineering and diffraction-limited optical spectroscopy to precisely probe interfacial coupling between TMD monolayers and graphene through excitons [1,2] and phonons [1,3] and unravel intriguing physical effects driven by charge energy transfer [1,2] and dielectric screening [3]. Further insights are provided by optical spectroscopy studies within a scanning tunneling microscope (STM-induced excitonic emission) [4] and within a strain tunable drum-like structure [5].

Acknowledgement: This was work done within the Nano-Optics and Low-Dimensional Materials team at IPCMS, in collaboration with the STM team at IPCMS and the LPCNO (INSA Toulouse).

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17:30
Nanomechanical probing, manipulation, and control of excitons in 2D materials

Kirill Bolotin[1].

[1]Freie Universität Berlin

Mechanical strain offers a powerful means of manipulating a material's symmetries. Here, we demonstrate an approach to induce mechanical strain with controlled tensorial components in 2D materials and heterostructures at cryogenic temperatures. We use this technique to investigate the many-body behaviors of excitons. First, we show that normally "dark" excitons with vanishing oscillator strength can be accessed and studied in strained devices. Second, we establish the valley character of intervalley excitons by analyzing their distinct strain signatures. Finally, we demonstrate that uniaxial strain manipulates the valley degree of freedom analogously to a spin in a magnetic field. We use this insight to establish the many-body character of debated excitonic states.

18:00
Summary
Florian Libisch[1].
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