Prize Talk PRV I Mon 13:15 H2

Correlated phases in the vicinity of tunable van Hove singularities in Bernal bilayer graphene — •Anna Seiler — ETH Zürich — University of Göttingen — Laureate of the Gustav-Hertz-Prize 2025

The band structure of naturally occurring Bernal bilayer graphene features four linearly dispersed Dirac cones [1] but undergoes significant changes under the application of large electric displacement fields across the two layers. In this regime, tunable van Hove singularities give rise to complex correlated states. Our experiments reveal signatures consistent with various interaction-driven phases, including fractional metals of the Stoner type [2, 3]. More strikingly, we identify competing nontrivial insulating phases at both hole [2] and electron doping [3]. These phases exhibit intriguing temperature dependence and nonlinear I-V characteristics at zero magnetic field, consistent with sliding Wigner crystals of both trivial and nontrivial topology [2-4].

[1] A.M. Seiler, N. Jacobsen, M. Statz, N. Fernandez, F. Falorsi, K. Watanabe, T. Taniguchi, Z. Dong, L.S. Levitov, R.T. Weitz, Nat. Commun. 13, 4187 (2024)
[2] A.M. Seiler, F.R. Geisenhof, F. Winterer, K. Watanabe, T. Taniguchi, T. Xu, F. Zhang, R.T. Weitz, Nature 608, 298-302 (2022)
[3] A.M. Seiler, M. Statz, I. Weimer, N. Jacobsen, K. Watanabe, T. Taniguchi, Z. Dong, L.S. Levitov, R.T. Weitz, Phys. Rev. Lett. 133, 066301 (2024)
[4] A.M. Seiler, M. Statz, C. Eckel, I. Weimer, J. Pöhls, K. Watanabe, T. Taniguchi, F. Zhang, R. T. Weitz, arXiv:2408.16628 (2024)

Prize Talk PRV II Tue 13:15 H2

Single-molecule electron spin resonance by means of atomic force microscopy — •Lisanne Sellies — University of Regensburg, Regensburg, Germany — IBM Research Europe - Zurich, Rüschlikon, Switzerland — Laureate of the Gustav-Hertz-Prize 2025

Recently, we combined the high energy resolution of electron spin resonance (ESR) with the spatial resolution offered by atomic force microscopy (AFM) [1]. This ESR-AFM technique relies on driving electron spin transitions between the non-equilibrium triplet state levels of a single molecule. Since these triplet states typically have different lifetimes, driving such transitions modifies the overall triplet lifetime [1,2], which can be detected by an electronic pump-probe scheme [3].

In this talk, an introduction to ESR-AFM will be given. It will be shown that the ESR-AFM spectra feature a sub-nanoelectronvolt energy resolution. Thereby, molecules only differing in their isotopic configuration can be distinguished. Moreover, due to the minimally invasive nature of the ESR-AFM technique, the electron spins of pentacene can be coherently manipulated over tens of microseconds [4]. The high energy resolution and long spin coherence represent a leap forward for local studies of future artificial quantum systems and fundamental local quantum-sensing experiments.

[1] L. Sellies et al., Nature, 624, 64 (2023)
[2] J. Peng et al., Science, 373, 452 (2021)
[3] J. Köhler et al., Nature, 363, 242 (1993)
[4] J. Wrachtrup et al., Nature, 363, 244 (1993)

Prize Talk PRV III Wed 13:15 H2

Complex liquids under confinement — •Regine von Klitzing[1,2], Michael Ludwig[1], Thomas Tilger[1], and Larissa Braun[1] — [1]Institute for Condensed Matter Physics, Hochschulstrasse 8, 64289 TU Darmstadt — [2]Laureate of the Gentner-Kastler-Prize 2025

Complex liquids are widely used in many applications, from industrial painting processes to personal care products. Despite their numerous applications, they are still actively discussed in basic research, e.g. their structural behaviour under confinement. In the present study, colloidal dispersions (e.g. nanoparticle suspensions, micellar solutions) are confined between two surfaces in a Colloidal Probe Atomic Force Microscope (CP-AFM) or in a Thin Film Pressure Balance (TFPB). When approaching the surface, the depletion of the dispersion from the thin film leads to oscillations of the interaction force between the confining surfaces. The structure of the confined colloidal dispersions is compared with their bulk structure, which is analysed by small-angle neutron or X-ray scattering (SANS, SAXS). The results show that the softness and the charge of the particles have a strong influence on the scaling law for the particle distance and the correlation length of the particle distribution, which is not yet fully understood. Another open question is when a charged object can be considered as an ion contributing to the electrostatic screening between two confining surfaces and when it behaves like a charged particle, where the jellium approach could provide a suitable model to describe the experimental data.

Prize Talk PRV IV Wed 13:15 H4

Nanowire-based THz polarimetry — •Michael Johnston — Department of Physics, University of Oxford, Oxford, UK. — Laureate of the Max-Born-Prize 2025

Semiconductor nanowires show extreme polarization selectivity for both visible and terahertz photons. We are utilising an in-depth knowledge of ultrafast charge-carrier dynamics in nanowires to develop unique devices for THz polarimetry. Our photoconductive THz sensors based on a hash-nanowire architecture are compact and recover the full polarisation state of THz pulses. These nanowire-based devices are showing promise in areas including semiconductor characterisation and the development of metamaterials for THz polarisation manipulation.

Prize Talk PRV V Thu 13:15 H2

Altermagnetism and spin symmetries — •Libor Šmejkal — Max Planck Institute for the Physics of Complex Systems — Laureate of the Walter-Schottky-Prize 2025

Since the 1930s, magnetism had been divided into two main branches: ferromagnetism and antiferromagnetism. Recently, we have identified a new branch, altermagnetism, characterized by a d-, g-, or i-wave spin order [1]. Our discovery emerged from our systematic spin symmetry classification [1], analogous to the well-established classifications in the fields of superconductors, superfluids, or the Standard Model.

In this talk, we will outline our decade-long journey to uncover altermagnets, including the prediction of the anomalous Hall effect and unconventional electronic structure in compensated collinear magnets [2,3]. We will present our systematic classification that revealed beside the even-partial wave altermagnets also odd-partial wave unconventional magnets [4]. Additionally, we will highlight experimental observation of altermagnetism using photoemission spectroscopy [5] and nanoscale X-ray microscopy [6]. Finally, we will explore emerging research directions [7], more than 300 material candidates, and potential applications of altermagnets across and beyond solid-state physics [8], e.g. in ultrafast and low power nanoelectronics.

[1] PRX 12, 031042 (2022)
[2] Science Adv. 6, 23 (2020)
[3] PNAS 118 42 (2021)
[4] arXiv:2309.01607v3
[5] Nature 626, 517(2024)
[6] Nature 636, 348 (2024)
[7] arXiv:2411.19928
[8] https://www.science.org/content/article/breakthrough-2024, https://www.economist.com/science-and-technology/2024/01/24/scientists-have-found-a-new-kind-of-magnetic-material

Prize Talk PRV VI Thu 13:15 H4

Confining strongly correlated quasiparticles in 2D semiconductors — •Wouter Jolie — II. Physikalisches Institut, Universität zu Köln, Germany — Laureate of the Gaede-Prize 2025

Electrons are prone to strong correlations when confined into one-dimensional (1D) or 0D cavities. Many exotic ground states can emerge, depending on the type of interactions at play. Examples are Peierls transitions, Tomonaga-Luttinger liquids or Anderson impurities.

An ideal experimental testbed for the observation of correlated electronic behaviour are metallic mirror twin boundaries (MTBs) in the two-dimensional semiconductor MoS_2. These MTBs have well-defined structural and electronic properties, are only weakly coupled to the environment and accessible to spatially resolved spectroscopic techniques such as scanning tunnelling microscopy.

In my talk I will show that the confined quasiparticles within finite MoS_2 MTBs transform into spin and charge excitations as described by the Tomonaga-Luttinger liquid theory of strongly interacting 1D electrons. In addition, a Kondo resonance emerges when the highest occupied state is filled by a single electron, in quantitative agreement with the Anderson impurity model. Lastly, I will outline possible ways to create and manipulate new types of correlated states in this system.