TT 20: 2D Materials II – Electronic and Transport Properties (joint session HL/TT)

Time: Monday 15:00–16:30 Location: POT/0081

TT 20.1 Mon 15:00 POT/0081

Ballistic electrostatic graphene superlattices using He ion-milled etching masks — •Rebecca Hoffmann[1], Giulia Piccinini[1], Julien Barrier[1], David Barcons Ruiz[1], Hanan Herzig Sheinfux[1], Takashi Taniguchi[2], Kenji Watanabe[3], Adrian Bachtold[1,4], and Frank H.L. Koppens[1,4] — [1]ICFO-Institut de Ciencies Fotoniques, Castelldefels, Spain. — [2]International Center for Materials Nanoarchitectonics, NIMS, Tsukuba, Japan — [3]Research Center for Functional Materials, NIMS, Tsukuba, Japan — [4]ICREA-Institució Catalana de Recerca i Estudis Avançats, Barcelona, Spain

An electrostatic superlattice is created by applying a periodic electrostatic potential to a material using patterned gates or dielectrics, leading to tunable band structure reconstruction. This approach enables free design of the superlattice geometry and lattice period. While high mobility has been observed, signatures of ballistic transport (e.g. negative resistance in cross geometry, transverse magnetic focusing) remain to be reported. Here, we present a nanofabrication technique combining Helium ion milling of etching masks with damage-free etching of graphite gates [1]. Using these gates in a graphene heterostructure creates an electrostatic superlattice which preserves graphene's high mobility. We report superlattice features. The high electronic quality is confirmed by transverse magnetic focusing and device-size limited mean free path.

[1]D. Barcons Ruiz, et al., Nat. Commun. 13, 6926 (2022)

TT 20.2 Mon 15:15 POT/0081

Tomographic flow regime in the 2D Corbino disk geometry — •Grigorii Starkov — Institute for Theoretical Physics and Astrophysics, University of Würzburg, D-97074 Würzburg, Germany

2D materials offer a unique test ground to study electron transport regimes dominated by the electron-electron collisions. This makes them the perfect platform to observe the electron hydrodynamic flows.

Not so long ago, it has been realized that precisely in 2D, the electron collisions constrained due to Pauli blocking result in the appearance of the long lived collective modes with odd angular character. The corresponding novel transport regime has been dubbed "tomographic".

In the recent experiment [2], magnetoresistance in Corbino-shaped graphene devices was used to disentangle different contributions to the electron transport and to determine viscosity. The obtained temperature-dependence thereof has been linked to the tomographic flow. However, the analysis is based on the bulk expressions for the conductivity and does not treat boundary corrections in detail. At the same time, boundary layers have been shown to be anomalously large in the tomographic flow regime [3].

To take into account the boundary effects, I analyze the magnetoresistance in the 2D Corbino disk geometry across different regimes, using the linearized Boltzmann equation.

[1] P. Ledwith et al, Phys. Rev. Lett. 123, 116601 (2019) [2] Y. Zeng et al, arXiv:2407.05026 (2025) [3] N. Ben-Schachar, J. Hoffmann, arXiv:2503.14431 (2025)

TT 20.3 Mon 15:30 POT/0081

Pulsed-gate spectroscopy of the electron-hole block- ade in bilayer graphene double quantum dots — •Lars Mester[1,2], Hubert Dulisch[1,2], Katrin Hecker[1,2], Konstantinos Kontogeorgiou[3], Samuel Möller[1,2], Leon Stecher[1], Kenji Watanabe[4], Takashi Taniguchi[5], Fabian Hassler[3], Christian Volk[1,2], and Christoph Stampfer[1,2] — [1]JARA-FIT and 2nd Institute of Physics, RWTH Aachen University, Aachen, Germany — [2]PGI-9, Forschungszentrum Jülich, Jülich, Germany — [3]JARA- Institute for Quantum Information, RWTH Aachen University, Aachen, Germany — [4]Research Center for Functional Materials, Na- tional Institute for Materials Science, Namiki, Japan — [5]International Center for Materials Nanoarchitectonics, National Institute for Materials Science, Namiki, Japan

Pauli blockade is an established read-out mechanism for quantum-dot (QD) spin qubits. Using bilayer graphene (BLG) as a platform offers advantages such as a tunable valley degree of freedom. Recently, a strong spin-valley blockade was demonstrated in an electron-hole BLG double quantum dot (DQD) using time-averaged transport measurements. Here, we employ pulsed-gate spectroscopy by pulsing between the (0e, 0h) and (1e, 1h) charge configurations. Comparison with simulations allows us to identify unconventional higher-order tunneling as the dominant blockade-lifting mechanism, with timescales governed by QD-lead coupling and the number of accessible states. Our results provide direct access to blockade-lifting dynamics in a BLG DQD, offering relavant insights for the development of future BLG-based qubits.

TT 20.4 Mon 15:45 POT/0081

Temperature Dependent Electrical Transport in Thin $SnSe_2$ — •Lars Thole[1], Aarti Lakhara[2], Preeti A. Bhobe[2], and Rolf J. Haug[1] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover, 30167 Hannover, Germany — [2]Department of Physics, Indian Institute of Technology Indore, Khandwa Road, Indore, Simrol, 453552, India

The two-dimensional material $SnSe_2$ shows special temperature dependent behavior [1], which has not been understood to its full capacity as of now.

We fabricated thin samples of $SnSe_2$ and investigated its electrical transport behavior in regards to its temperature dependence [2]. These samples show a metal-insulator transition with a metallic state for higher temperatures. The low-temperature transport regime is dominated by variable-range hopping. Additionally, the influence of defect states in these samples is investigated by looking at the thickness dependence for different samples [3].

[1] C. Guo, et al., Appl. Phys. Lett. 109, 203104 (2016).
[2] A. Lakhara, L. Thole, R. J. Haug, and P. Bhobe. arXiv: 2507.14536 (2025).
[3] A. Lakhara, L. Thole, R. J. Haug, and P. Bhobe. Phys. Rev. B 112, 235401 (2025).

TT 20.5 Mon 16:00 POT/0081

Polarization resolved Electron Spin Resonance in two-dimensional electron systems — •Daniiar Khudaiberdiev[1], Alexey Shuvaev[1], Michail Glazov[2], Anton Shchepetilnikov[3], Viacheslav Muravev[3], Christian Reichl[4], Werner Wegscheider[4], and Andrei Pimenov[1] — [1]Institute of Solid State Physics, Technische Universität Wien, 1040 Vienna, Austria — [2]St. Petersburg, Russia — [3]Chernogolovka, Russia — [4]Laboratory for Solid State Physics, ETH Zurich, CH-8093 Zurich, Switzerland

Electron spin resonance (ESR) has long served as a powerful probe of g-factor anisotropy, spin-orbit interactions, hyperfine coupling, and collective many-body spin phenomena in two-dimensional electron systems (2DESs). Most prior studies detect ESR in the photoresistance of Hall bars, where the excitation-field distribution and polarization are distorted, complicating the analysis of the excitation conditions.

In contrast, we report polarization-resolved ESR in sub-THz transmission using a quasi-optical setup and large-area samples that ensure high polarization purity. First we study the 2DES hosted in a 4.5-nm AlAs quantum well with a single isotropic valley. The selection rules indicate that Dresselhaus spin-orbit coupling mediates the electric-dipole-active spin absorption. Further we examine systems with more complex spectra such as wide AlAs wells with an active pseudospin, HgTe and InAs quantum wells with low effective mass and strong spin-orbit coupling enhancing the effects.

TT 20.6 Mon 16:15 POT/0081

First-Principles Investigation of Electronic Transport in 2D GaSe: Backward Diodes, p-i-n FETs, and Double-Gate MOS-FETs — •Dogukan Hazar Ozbey and Engin Durgun — UNAM - National Nanotechnology Research Center and Institute of Materials Science and Nanotechnology, Bilkent University, Ankara, Turkey

In this study, we present a comprehensive first-principles investigation of charge transport in monolayer GaSe nanodevices by combining density functional theory with the nonequilibrium Green's function (DFT + NEGF) formalism. Three representative architectures, namely p–n junctions, p–i–n field-effect transistors (FETs), and double-gate MOSFETs, are systematically analyzed. Our calculations reveal that GaSe p–n junctions display an unconventional backward diode response, in which reverse currents within the ±1 V window exceed forward currents owing to tunneling-assisted transport, as evidenced by the projected local density of states. When configured as p–i–n FETs, electrostatic gating allows selective control over tunneling conduction. Moderate gate biases suppress the reverse current, whereas stronger gating reactivates and amplifies it. Finally, double-gate GaSe MOSFETs with channel lengths of approximately 5 nm exhibit competitive figures of merit that meet or surpass the ITRS-2028 high-performance benchmarks, achieving an on/off ratio of 1.2×10^4, intrinsic delay time of 0.24 ps, and power–delay product of only 0.06 fJ$\cdot\mu$m^{-1}. Our results highlight GaSe as a single 2D semiconductor capable of integrating backward-diode behavior with high-speed transistor operation.