DS 19: 2D Materials 7 (joint session DS/CPP)

Time: Wednesday 15:00–16:00 Location: H17

DS 19.1 Wed 15:00 H17

Gate-Tunable Helical Currents in Commensurate Topological Insulator/Graphene Heterostructures — •Jonas Kiemle[1,2], Lukas Powalla[3,4], Katharina Polyudov[3,4], Lovish Gulati[3], Maanwinder Singh[1,2], Alexander Holleitner[1,2], Marko Burghard[3,4], and Christoph Kastl[1,2] — [1]Walter Schottky Institut and Physics Department, Technical University of Munich, Garching, Germany — [2]MCQST, München, Germany — [3]Max-Planck-Institut für Festkörperforschung, Stuttgart, Germany — [4]Institut de Physique, Ecole Polytechnique Fédérale de Lausanne, Lausanne, Switzerland

Van der Waals heterostructures made from graphene and three-dimensional topological insulators promise very high electron mobilities, a non-trivial spin texture and a gate-tunability of electronic properties. Here, we explore epitaxially grown interfaces between graphene and the lattice-matched topological insulator Bi_2Te_2Se. For this heterostructure, spin-orbit coupling proximity has been predicted to impart an anisotropic and electronically tunable spin texture. Polarization-resolved second-harmonic generation, Raman spectroscopy, and time-resolved magneto-optic Kerr microscopies are combined to demonstrate that the atomic interfaces align in a commensurate symmetry with characteristic interlayer vibrations. By polarization-resolved photocurrent measurements, we find a circular photogalvanic effect which is drastically enhanced at the Dirac point of the proximitized graphene. We attribute the peculiar gate-tunability to the proximity-induced interfacial spin structure.

DS 19.2 Wed 15:15 H17

Topological Invariant of Acoustic Phonons in 2D materials — •Gunnar Lange[1], Adrien Bouhon[1], Bartomeu Monserrat[1,2], and Robert-Jan Slager[1] — [1]Cavendish Laboratory, University of Cambridge, UK — [2]Department of Materials Science and Metallurgy, University of Cambridge, UK

2D materials that live in a 3D space display an unusual acoustic phonon mode: the flexural mode. This mode disperses quadratically away from the center of the acoustic Brillouin zone, and corresponds to a flexing of the material out-of-plane. This differs markedly from the linear dispersion displayed by the in-plane modes, and leads to an unusual triple degeneracy at the zone center. This triple degeneracy is enforced by the Nambu-Goldstone theorem, rather than symmetry, as will be discussed. Such band degeneracies frequently have associated topological invariants. For this triple degeneracy, the topological invariant turns out to generically be of quaternionic type (Euler topology), but reduces to a $\mathbb{Z}_2$ invariant under fairly general assumptions. The invariant has important implications for 2D materials grown on a substrate, as it dictates how the bands are split due to the presence of the substrate. This will be discussed in the context of graphene, where the $\mathbb{Z}_2$ invariant turns out to be non-trivial.

This talk is based on: Lange, G. F., Bouhon, A., Monserrat, B., and Slager, R.-J., "Topological continuum charges of acoustic phonons in two dimensions and the Nambu-Goldstone theorem" Phys. Rev. B **105**, 064301 (2022)

DS 19.3 Wed 15:30 H17

Coupled Bilayer Graphene Quantum Dots — •Angelika Knothe[1,2] and Vladimir Fal'ko[2,3] — [1]Institute of Physics, Technische Universität Chemnitz, D-09107 Chemnitz, Germany — [2]National Graphene Institute, University of Manchester, Manchester, UK — [3]Henry Royce Institute for Advanced Materials, University of Manchester, Manchester, UK

Bilayer graphene quantum dots are promising for spin and valley qubits [1,2,3]. A functional quantum information architecture requires scalable multi-qubit systems. We theoretically study electrostatically confined double-dots and few-dot arrays in bilayer graphene. We quantify the inter-dot couplings for different dot parameters such as the field-induced gap, the confinement shape, and the inter-dot distance. This dependence on external parameters allows tuning the dot arrays into different regimes for which we study the extended Hubbard Hamiltonians and identify the spin and valley level structure. Our results will help to advance the use of bilayer graphene quantum dots for quantum technologies.

[1] A. Knothe, L. I. Glazman, V. Fal'ko, New Journal of Physics 24 (4), 043003 (2022)

[2] S. Möller, L. Banszerus, A. Knothe, C. Steiner, E. Icking, S. Trellenkamp, F. Lentz, K. Watanabe, T. Taniguchi, L. Glazman, V. Fal'ko, C. Volk, C. Stampfer, Phys. Rev. Lett. 127, 256802 (2021)

[3] A. Knothe, V. Fal'ko, Phys. Rev. B 101, 235423 (2020)

DS 19.4 Wed 15:45 H17

Electron cavity optics in bilayer graphene — Lukas Seemann[1], •Angelika Knothe[1], Klaus Richter[2], and Martina Hentschel[1] — [1]Institute of Physics, Technische Universität Chemnitz, D-09107 Chemnitz, Germany — [2]Institut für Theoretische Physik, Universität Regensburg, 93040 Regensburg, Germany

Rapid developments in the field of 2D materials and their nanostructures make it possible to trap charge carriers with different dispersions in various confinement geometries with a high degree of control. This progress now allows studying 2D electron optics phenomena enriched by the charge carriers' different electronic and topological properties compared to the photonic case. Here, we theoretically investigate cavities in gapped bilayer graphene employing an approach based on ray-wave correspondence [1]. We identify the influence of the materials' trigonally warped band structure [2] on the fermion optics characteristics that we show to be conveniently tuneable by gate voltages. Similar considerations can be applied to electron optics in other 2D materials.

[1] J.-K. Schrepfer, S. Chen, M.-H. Liu, K. Richter, and M. Hentschel, Phys. Rev. B 104, 155436 (2021)

[2] C. Gold, A. Knothe, A. Kurzmann, A. Garcia-Ruiz, K. Watanabe, T. Taniguchi, V. Fal'ko, K. Ensslin, T. Ihn, Phys. Rev. Lett. 127, 046801 (2021)