Fritz-Haber-Institut der Max-Planck-Gesellschaft

Physikalische Chemie — Direktor: Prof. Dr. Martin Wolf

MAX-PLANCK-GESELLSCHAFT

Department Seminar:

Wednesday, July 31, 2019, at **10:00** a.m.

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Synthesis and Spectroscopy of Bismuthene

PC Seminar Room G2.06, Building G, Faradayweg 4 L. Rettig

Abstract:

In search for future applications in spin-based electronics and computation, exploring new quantum spin Hall (QSH) materials with large band gap has become one of the major research thrusts of solid state physics. Not least because these two-dimensional materials host conducting helical electron states strictly confined to the one-dimensional boundaries that are protected byvtime-reversal symmetry against single-particle backscattering. In a first part of this talk I report on the realization of so-called bismuthene, which is synthesized on the wide-bandgap substrate SiC(0001). Scanning tunneling microscopy imaging clearly displays the honeycomb structure. Using scanning tunneling spectroscopy (STS), we find a huge bulk gap of 800 meV, with the Fermi level positioned well inside this gap. Interestingly, metallic edge states are observed when the bismuthene film edge is approached. A comparison of angle-resolved photoemission measurements and density functional theory band structure calculations is a further manifestation of the formation of bismuthene.

In a second part of this talk I report on the effect of the interelectronic Coulomb interaction which is relevant at low energies. *Two*-particle scattering is not impeded by topological protection and may hence affect the edge state conductance. For the novel QSH material bismuthene on SiC(0001) we are able to explore the impact of electronic correlations on the highly-localized edge states via STS. Based on the observed spectral behavior and its universal scaling with energy and temperature we demonstrate the correspondence with a (helical) Tomonaga Luttinger liquid [2].

Pristine helical edge electrons are predicted to show exceptional quantum coherence in the absence of time-reversal symmetry breaking. Notwithstanding, quantum interference between helical edge state electrons becomes relevant when a multitude of helical edge state pairs are being brought into direct proximity in a nano-constriction. In a third part of this talk I report on the realization of a helical edge state nano-constriction embedded in bismuthene, formed by an anti-phase domain boundary of limited extent. Via STS, we prove quantum interference between counter propagating helical electrons and make use of an analogy to a Fabry-Pérot electronic resonator.

[1] F. Reis, et al., Science 357, 287-290, (2017).
[2] R. St¨uhler, et al., arXiv:1901.06170 (2018).