TT 41: Quantum Transport and Quantum Hall Effects II (joint session HL/TT)

Time: Wednesday 15:00–17:00 Location: POT 251

TT 41.1 Wed 15:00 POT 251

Aharonov-Bohm-type oscillations in phase-pure core/shell GaAs/InAs nanowires — •Farah Basaric[1,2], Anton Faustmann[1,2], Erik Zimmermann[1,2], Gerrit Behner[1,2], Alexander Pawlis[1,2], Christoph Krause[1,2], Hans Lüth[1,2], Detlev Grützmacher[1,2], and Thomas Schäpers[1,2] — [1]Peter Grünberg Institut (PGI-9), Forschungszentrum Jülich, 52425 Jülich, Germany — [2]JARA-Fundamentals of Future Information Technology, Jülich-Aachen Research Alliance, Forschungszentrum Jülich and RWTH Aachen University, Germany

Epitaxially grown phase-pure GaAs/InAs core/shell nanowires offer uniformity in their electrical, mechanical and optical properties due to the absence of a crystallographic disorder. Magnetotransport measurements were carried out at variable temperatures and for different gate voltages, under an applied in-plane magnetic field. Pronounced Aharonov-Bohm-type oscillations in the conductance are observed for this nanowire type. In measurements at different gate voltages, significantly higher oscillation amplitudes are observed in comparison to the corresponding measurements on polymorphic core/shell nanowires. Furthermore, measurements at different temperatures show robustness of these oscillations against high temperatures as a result of reduced disorder. Finally, strong indications of a quasi-ballistic transport regime could be recognized for the phase-pure nanowire type. Obtained results indicate a strong effect of disorder reduction in GaAs/InAs nanowire transport properties, manifested in superior transport properties.

TT 41.2 Wed 15:15 POT 251

Spin valves based on bilayer graphene quantum point contacts — •Eike Icking[1,2], Christian Volk[1,2], Christopher Schattauer[3], Luca Banszerus[1,2], Kenji Watanabe[4], Takashi Taniguchi[5], Florian Libisch[3], Bernd Beschoten[1], and Christoph Stampfer[1,2] — [1]RWTH Aachen University, Germany — [2]Forschungszentrum Jülich, Germany — [3]TU Vienna, Austria — [4]Research Center for Functional Material, Japan — [5]International Center for Materials Nanoarchitectonics, Japan

Bernal bilayer graphene (BLG) is a unique material as it allows opening and electrostatically tuning a sizeable band gap by applying a perpendicular electric field. Recently, charge carriers have been confined successfully in one dimension to form quantum point contacts (QPC) based on split gates separated by a channel of a few hundred nanometers. Moreover, spin-polarized quantum transport through such structures has been demonstrated up to 6 e^2/h using a high in-plane magnetic field. The threshold magnetic field at which the lowest modes become spin-polarized depends on the subband spacing and thus on the width of the split gate channel. In this work, we combine two QPCs of different geometric widths, resulting in different threshold magnetic fields, to spin-polarize the first QPC and use it as a filter for the second QPC. In particular, we report on a spin-valve achieving spin-polarized channels with a total conductance of up to 10 e^2/h.

TT 41.3 Wed 15:30 POT 251

Optical and electrical tuning between the normal insulating and topological insulating phase of InAs/GaSb bilayer quantum wells — •Manuel Meyer[1], Tobias Fähndrich[1], Sebastian Schmid[1], Sebastian Gebert[1], Gerald Bastard[1,2], Fabian Hartmann[1], and Sven Höfling[1] — [1]Technische Physik, Physikalisches Institut and Würzburg-Dresden Cluster of Excellence ct.qmat, Am Hubland, D-97074 Würzburg, Germany — [2]Physics Department, École Normale Supérieure, PSL 24 rue Lhomond, 75005 Paris, France

Topological insulators (TI) based on InAs/GaSb bilayer quantum wells (BQW) are appealing due to their rich phase diagram with a TI and normal insulating (NI) phase[1]. The switching between both phases can be achieved by external electric fields using a top and back gate (TG and BG)[2]. However, especially a fully functional BG is difficult to realize in antimonides due to leakage issues. To overcome this bottleneck we present another tuning knob using optical excitation to switch from the NI to the TI phase over the TI gap[3]. By monitoring the charge carrier densities we can identify the hybridized band structure and in-plane magnetic field measurements evidence the TI gap. Furthermore, a top-gated sample is investigated. Without a back gate we find properties from both phases for magnetransport measurements which points to a mixing of NI and TI states. This is further indicated by the resistance peak evolutions with temperature for both samples.

[1] C. Liu et al., PRL 100, 236601 (2008)
[2] F. Qu et al., PRL 115, 036803 (2015)
[3] G. Knebl et al., PRB 98, 041301(R) (2018)

30 min. break

TT 41.4 Wed 16:15 POT 251

Transport in high mobility HgTe heterostructures — •Michael Kick, Lena Fürsst, Johannes Kleinlein, Saquib Shamim, Hartmut Buhmann, and Laurens W. Molenkamp — Experimentelle Physik III, Physikalisches Institut, Universität Würzburg, Am Hubland, 97074 Würzburg, Germany

The Fractional Quantum Hall Effect (FQHE) has not yet been observed in the material system of HgTe. Due to recent progress in MBE growth, routinely charge carrier mobilities of HgTe heterostructures of over $\mu > 1 \cdot 10^6$ cm^2/Vs are obtained which is in the same order of magnitude as in the first reported experimental observation of the FQHE in GaAs/GaAlAs heterostructures. This opens up new prospects for transport investigations into the long time still open question of fractional states in this material system.

In 2-dimensional HgTe quantum wells, transport measurements show well pronounced quantum Hall plateaus for all filling factors, but no indication of any fractional state. High magnetic field measurements show a prolonged $\nu = 1$ plateau and a transition to an insulating state. Intriguingly, the $\nu = 1$ plateau exhibits a transition to an insulating state for filling factor $\nu = 1/2$.

Another possibility to observe the FQHE in HgTe is provided by the 2D surface states of a 3D topological insulator. High mobility layers, $\mu > 1 \cdot 10^6$ cm^2/Vs, of tensil strained HgTe are subject of extensive magneto-transport investigations. First results reveal a good and detailed correspondence to recent k.p band structure calculations for non-interacting electron systems.

TT 41.5 Wed 16:30 POT 251

Electron Density Depended Giant Negative Magnetoresistance — •Lina Bockhorn and Rolf J. Haug — Institut für Festkörperphysik, Leibniz Universität Hannover, 30167 Hannover, Germany

Ultra-high mobility two-dimensional electron gases not only show an increasing number of new fractional filling factors, but also an astonishing robust negative magnetoresistance at zero magnetic field [1 -5]. The theoretical description of this negative magnetoresistance is still an open issue due to its complex dependencies on several parameters.

The behavior of the giant negative magnetoresistance is affected by different scattering events, e. g. interface roughness, oval defects, background impurities and remote ionized impurities, which leads to a strong dependence on different parameters. Here, we take a closer look on the temperature dependence of the giant negative magnetoresistance for different electron densities. At low temperatures we observe the predicted temperature dependence of $T^{1/2}$ [6].

[1] L. Bockhorn et al., Phys. Rev. B 83, 113301 (2011).
[2] A. T. Hatke et al., Phys. Rev. B 85, 081304 (2012).
[3] R. G. Mani et al., Scientific Reports 3, 2747 (2013).
[4] L. Bockhorn et al., Phys. Rev. B 90, 165434 (2014).
[5] L. Bockhorn et al., Appl. Phys. Lett. 108, 092103 (2016).
[6] I. V. Gornyi et al., Phys. Rev. B. 69, 045313 (2004).

TT 41.6 Wed 16:45 POT 251

Massless Dirac fermions on a space-time lattice with a topologically protected Dirac cone — •Michal Pacholski[1], Alvaro Donís Vela[3], Gal Lemut[3], Jakub Tworzydlo[2], and Carlo Beenakker[3] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [2]Warsaw University, Warsaw, Poland — [3]Lorentz Institute, Leiden, The Netherlands

The symmetries that protect massless Dirac fermions from a gap opening may become ineffective if the Dirac equation is discretized in space and time, either because of scattering between multiple Dirac cones in the Brillouin zone (fermion doubling) or because of singularities at zone boundaries. Here we introduce an implementation of Dirac fermions on a space-time lattice that removes both obstructions. The quasi-energy band structure has a tangent dispersion with a single Dirac cone that cannot be gapped without breaking both time-reversal and chiral symmetries. We show that this topological protection is absent in the familiar single-cone discretization with a linear sawtooth dispersion, as a consequence of the fact that there the time-evolution operator is discontinuous at Brillouin zone boundaries.