HL 106: Transport, magnetotransport and quantum Hall physics

Time: Friday 10:00–13:00 Location: EW 202

HL 106.1 Fri 10:00 EW 202

Fractional quantum Hall effect in monolayer and bilayer graphene: phase diagrams and edge excitations — •Maxim Kharitonov — Theoretische Physik IV, Universitaet Wuerzburg, 97074 Würzburg, Germany

We analytically investigate the fractional quantum Hall effect in monolayer and bilayer graphene at filling factors pertaining to the zero-energy Landau level, specifically concentrating on the order of the states in the valley-spin space. We obtain generic phase diagrams for the two-component states of arbitrary orbital structure, which turn out to be closely related to that of the $\nu = 0$ state. The transitions between different phases can in practice be realized by tilting the magnetic field and, in bilayer, by applying the perpendicular electric field. These transitions are accompanied by the transformations of the edge states, which could be detected in transport measurements.

HL 106.2 Fri 10:15 EW 202

Observation of quantum states bound by a magnetic field gradient — Bernd Schüler[1], Mihai Cerchez[1], •Thomas Heinzel[1], Dirk Reuter[2], Andreas Wieck[3], and Hengyi Xu[1] — [1]Inst. für Physik d. kondensierten Materie, HHU Düsseldorf — [2]Department Physik, Univ. Paderborn — [3]Angewandte Festkörperphysik, Ruhr-Universität Bochum

Resonant transmission through electronic quantum states that exist at the zero points of a magnetic field gradient inside a ballistic quantum wire is reported. Since the semiclassical motion along such a line of zero magnetic field takes place in form of unidirectional snake trajectories, these states have no classical equivalence. The existence of such quantum states has been predicted more than a decade ago by theoretical considerations.[1] We further show how their properties depend on the amplitude of the magnetic field profile as well as on the Fermi energy.[2]

[1]J. Reijniers et al., Europhys. Lett. 59, 749 (2002). [2] B. Schüler et al., Phys. Rev. B (Rapid Comm.), in print.

HL 106.3 Fri 10:30 EW 202

Snake orbit commensurability resonances in magneto-electric lateral superlattices — •Jakob Schluck[1], Stefan Fasbender[1], Thomas Heinzel[1], Dimitris Kazazis[2], Ulf Gennser[2], Klaus Pierz[3], and Hans Schumacher[3] — [1]Heinrich Heine Universität Düsseldorf — [2]CNRS-LPN, Marcoussis — [3]PTB Braunschweig

Hybrid lateral superlattices composed of a square array of antidots and a periodic magnetic modulation in one dimension are prepared in Ga[Al]As heterostructures. The two-dimensional electron gases exposed to these superlattices are characterized by magnetotransport experiments. The longitudinal magnetoresistivity ρ_{xx}, parallel to the magnetic modulation, shows pronounced resonances that originate from snake orbits that become commensurate with the antidot lattice for characteristic magnetic field amplitudes. The resistivity ρ_{yy} in the direction perpendicular to the magnetic modulation is governed by the magnetic barriers in series and shows weak antidot-induced modulations. Numerical simulations based on the classical Kubo model reproduce the most prominent features of the experimental data.

HL 106.4 Fri 10:45 EW 202

Spin polarization of composite fermions in the N=0 Landau Level — •Lina Bockhorn[1], Dieter Schuh[2], Christian Reichl[3], Werner Wegscheider[3], and Rolf J. Haug[1] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover, 30167 Hannover — [2]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, 93053 Regensburg — [3]Laboratorium für Festkörperphysik, ETH Zürich, CH-8093 Zürich

We study the fractional Quantum Hall effect (FQHE) in a high-mobility two-dimensional electron gas (2DEG) for different in-plane magnetic field components and by using a metallic topgate. Hall geometries are created by photolithography on a GaAs/GaAlAs quantum well containing a 2DEG. The high-mobility 2DEG has an electron density of $n_e = 3.2 \cdot 10^{11}\,\mathrm{cm}^{-2}$ and a mobility of $\mu_e = 11.9 \cdot 10^6 \mathrm{cm}^2/\mathrm{Vs}$.

Around the filling factor ν=3/2 we observe spin transitions of several fractional filling factors ν=8/5, 11/7, 13/9, 10/7, 7/5, and 4/3 [1, 2]. The FQHE is understood in terms of weakly interacting composite fermions (CF). The CF theory provides an understanding of the spin physics of the FQHE. We also observe spin polarization of the fractions ν=6/5 and ν=9/7 which arise from interacting CF [3].

[1] R. G. Clark et al., Phys. Rev. Lett. 62, 1536 (1989).
[2] R. R. Du et al., Phys. Rev. Lett. 75, 3926 (1995).
[3] Y. Liu et al., Phys. Rev. B 90, 085301 (2014).

HL 106.5 Fri 11:00 EW 202

Voltage fluctuation to current converter with coupled quantum dots — •Pierre Pfeffer[1], Fabian Hartmann[1], Sven Höfling[1,2], Martin Kamp[1], and Lukas Worschech[1] — [1]Technische Physik, Physikalisches Institut, Universität Würzburg and Wilhelm Conrad Röntgen Research Center for Complex Material Systems, Am Hubland, D-97074 Würzburg, Germany — [2]SUPA, School of Physics and Astronomy, University of St Andrews, St Andrews, KY16 9SS, United Kingdom

Converting random fluctuations into useful energy is a major challenge in electronics and has triggered substantial experimental and theoretical work ranging from solid state to biological systems from the classical down to the quantum regime. Following recent proposals by Sothmann, Sanchez, Jordan and Büttiker [1,2], we realized a Coulomb-coupled quantum dot (QD) system and demonstrate a direct current in one part of the QD circuit due to charge fluctuations in the other part of the QD circuit. Both the direction and the amplitude of the current can be switched by an electric field superimposed on the open QD. No particle exchange between the two QD subsystems is involved and dependent on the noise amplitude, maximum output powers are found in the pW region.

[1] R. Sanchez and M. Büttiker, Phys. Rev. B 83, 085428 (2011).
[2] B. Sothmann, R. Sanchez, A. N. Jordan and M. Büttiker, Phys. Rev. B 85, 205301 (2012).

Coffee break

HL 106.6 Fri 11:30 EW 202

Polarized high power terahertz radiation induced oscillations of magnetoresistivity in GaAs heterostructures — •T. Herrmann[1], Z.D. Kvon[2], D.A. Kozlov[2], V.V. Bel'kov[3], B. Jentzsch[1], P. Olbrich[1], D. Weiss[1], and S.D. Ganichev[1] — [1]University of Regensburg, Regensburg, Germany — [2]Institute of Semiconductor Physics, Novosibirsk, Russia — [3]Ioffe Institute, St. Petersburg, Russia

We report on the study of terahertz (THz) high power laser radiation induced magnetoresistivity oscillations (TIRO) in a high density two-dimensional electron gas in GaAs quantum wells. TIRO were observed at He temperature in Corbino disc samples applying a magnetic field and nanosecond pulses of intense THz radiation of pulsed molecular laser operating in a frequency range from 0.6 to 2 THz [1]. The positions of oscillation maxima in magnetic field correspond to that of high harmonics of the cyclotron resonance (CR). Up to 9 harmonics are detected, having comparable amplitudes and yielding signals larger than that of the CR itself. Applying right- and left-handed polarized radiation we demonstrate that, while for a fixed magnetic field direction the CR is excited only for one light helicity the TIRO are insensitive to the radiation polarization state. Investigating TIRO for different power levels varying in the range from Watts to tens of kW we also show that the amplitude of the oscillations saturates with raising power.

[1] S.D. Ganichev and W. Prettl, Intense Terahertz Excitation of Semiconductors, Oxford University Press (2006)

HL 106.7 Fri 11:45 EW 202

Impurity induced phase transition in GaAs/AlGaAs two-dimensional electron gas — •Eddy P. Rugeramigabo, Lina Bockhorn, and Rolf J. Haug — Institute for Solid State Physics, Dep. Nanostructures, Leibniz Universität Hannover

A phase transition is observed at high magnetic fields in a two-dimensional electron gas (2DEG). The 2DEG is realized in a modulation Si-doped GaAs/AlGaAs quantum well (QW). Additionally, Si atoms were homogeneously incorporated in the GaAs QW layer. Here, they act as impurities. The 2DEG has an electron density of $n_e = 3.2{\cdot}10^{11}\mathrm{cm}^{-2}$ and a mobility of $\mu_e = 1.2{\cdot}10^5\mathrm{cm}^2/\mathrm{Vs}$.
We performed magnetotransport measurements between 30mK and

900mK. Magnetic field sweeps above 6.6T induce a phase transition at temperatures T<600mK. After the transition, we observe at low magnetic fields the formation of beating features in the Shubnikov-de Hass oscillations. At high magnetic fields, fractional filling factors between ν=2 and ν=1 become more developed.
The new phase has a metastable equilibrium at magnetic fields between 7T and 13T ($2<\nu<1$). Such a metastable state of the 2DEG was also reported by Kukushkin et al.[1], but for magnetic field range of $1<\nu<1/2$. We attribute our observations to a change in the scattering potential of the impurity states within the 2DEG. This can be e.g. frozen spin polarization caused by high magnetic fields at low temperatures.

[1] I. V. Kukushkin, et al., Phys. Rev. B **51**, 18045 (1995)

HL 106.8 Fri 12:00 EW 202

Electrical and THz magnetospectroscopy studies of InAs-based micro- and nanostructures — •Olivio Chiatti[1], Sven S. Buchholz[1], Christian Heyn[2], Wolfgang Hansen[2], Mehdi Pakmehr[3], Bruce D. McCombe[3], and Saskia F. Fischer[1] — [1]Neue Materialien, Institut für Physik, Humboldt-Universität zu Berlin, 12489 Berlin, Germany — [2]Institut für Angewandte Physik, Universität Hamburg, 20148 Hamburg, Germany — [3]Department of Physics, University at Buffalo, the State University of New York, Buffalo, NY 14260, USA

Nanostructures in narrow-gap semiconductors with strong spin-orbit interaction (SOI) offer the possibility to electrically manipulate spin-polarized currents. We present magnetotransport and THz magnetospectroscopy studies of Hall-bars from an InGaAs/InAlAs quantum well with an InAs-inserted channel. The two-dimensional electron gas is at 53 nm depth and has a carrier density of about $6 \cdot 10^{11}$ cm^{-2} and mobility of about $2 \cdot 10^5$ cm^2/Vs. The measurements reveal an effective mass of $0.038m_0$ and an anisotropic g-factor of up to 20, larger than for bulk InAs. We demonstrate that quasi-one-dimensional channels (Q1D) can be successfully formed by micro-laser lithography and that the subband population is controlled by in-plane gates. Contrary to previous reports, asymmetric in-plane gate voltages applied to Q1D channels did not show signs of SOI-induced conductance anomalies [1].
[1] Chiatti *et al.*, arXiv:1410.8588v2 [cond-mat.mes-hall] (2014).

HL 106.9 Fri 12:15 EW 202

Mode-selected heat flow through a one-dimensional waveguide network — •Christian Riha[1], Philipp Miechowski[1], Sven S. Buchholz[1], Olivio Chiatti[1], Dirk Reuter[2], Andreas D. Wieck[3], and Saskia F. Fischer[1] — [1]Neue Materialien, Humboldt-Universität zu Berlin, D-10099 Berlin — [2]Optoelektronische Materialien und Bauelemente, Universität Paderborn — [3]Angewandte Festkörperphysik, Ruhr-Universität Bochum, D-44780 Bochum

Cross-correlated measurements of thermal noise are performed to determine the electron temperature in nanopatterned channels of a GaAs/AlGaAs heterostructure at 4.2 K. Two-dimensional (2D) electron reservoirs are connected via an extended one-dimensional (1D) electron waveguide network. Hot electrons produced by a current I_h in a source 2D reservoir are transmitted through the ballistic 1D waveguide and relax in a drain 2D reservoir. We find that the electron temperature increase ΔT_e in the drain is proportional to the square of the heating current I_h, as expected from Joule's law. We find that electron-phonon interaction is negligible for heat transport between 2D reservoirs at temperatures below 4.2 K. Furthermore, we demonstrate mode control of heat flow in the 1D electron waveguide by a top-gatevoltage [1].
[1] Riha *et al.*, arXiv:1410.2831

HL 106.10 Fri 12:30 EW 202

Influence of thiophene and pyridine containing fluorinated diketone-based passivation on the performance of ZnO TFTs — •Yulia Trostyanskaya, Marlis Ortel, Nataliya Kalinovich, Gerd-Volker Röschenthaler, and Veit Wagner — Jacobs University Bremen, Campus Ring 1, 28759 Bremen, Germany

Metal oxide TFTs are known to show unstable performance when the back channel is exposed to humid atmosphere. Therefore, ZnO TFTs deposited by spray pyrolysis were passivated by two different fluorine terminated diketones containing a pyridinyl- or a thienyl-group. All three groups are known to bind selectively to Zn-ions. XPS, AFM, UV-Vis and IV characterization of the passivated devices were conducted to distinguish between the effects of each bond type.

TFTs coated by thienyl-containing compounds showed a rise in mobility by 1,4 cm2/V and a shift of Von into negative direction. From XPS data, it was concluded that the diketo- and the thienyl-group bind to the back channel which indicates doping of the semiconductor due to the S-Zn bond. Samples passivated by pyridine-containing compound showed almost ideal Von of 0V, a small increase in mobility and only binding of the diketo-group to the surface. The tested materials stabilized the TFTs under negative and positive bias stress in ambient condition which indicates a successful passivation of active surface sites.

HL 106.11 Fri 12:45 EW 202

Current noises through a quantum dot in the presence of an oscillating gate voltage — •takafumi suzuki and takeo kato — Institute for Solid State Physics, University of Tokyo, Kashiwa, Chiba, Japan

We study photon-assisted transport in a quantum dot system under a periodically oscillating gate voltage. Photon-assisted current noises in the presence of the Coulomb interaction are calculated based on a gauge-invariant formulation of time-dependent transport. We derive an explicit expression of the vertex corrections within the self-consistent Hartree-Fock approximation in terms the Floquet-Green's functions. Moreover, we introduce an effective temperature to characterize nonequilibrium properties under the influence of the AC field. The vertex corrections are suppressed by the rise of the effective temperature, whereas characteristic resonant structures appear in the frequency spectra of the vertex corrections. The present result provides a useful viewpoint for understanding photon-assisted transport in interacting electron systems.