HL 42: Transport

Time: Thursday 15:00–16:45 Location: EW 015

HL 42.1 Thu 15:00 EW 015

Linear magnetoresistance in ultra-high mobility GaAs quantum wells with a parabolic dispersion — •Thomas Khouri[1], Uli Zeitler[1], Christian Reichl[2], Werner Wegscheider[2], Nigel Hussey[1], Steffen Wiedmann[1], and Jan Kees Maan[1] — [1]High Field Magnet Laboratory (HFML-EMFL), Radboud University, Nijmegen 6525 ED, NL — [2]Laboratory for Solid State Physics, ETH Zürich, 8093 Zürich, Switzerland

The observation of a linear magnetoresistance is often invoked as evidence for exotic quasiparticles in new materials such as topological semi-metals, though its origin remains controversial. Here we show that a strong non-saturating LMR is observable in GaAs quantum wells with a parabolic dispersion and ultra-high mobility (μ*25*106 cm2 V-1s-1). This LMR persists over a large magnetic field range up to 33 T and a wide temperature range between 0.3 K and 60 K. The simplicity of our system in combination with an almost defect-free environment allows us to exclude most exotic explanations that are known to give rise to a LMR. Instead our analysis suggests that small density fluctuations are the primary origin of the phenomenon. Interestingly, both the LMR and the quantum oscillations at low temperatures obey the empirical resistance rule with an α that remains unchanged over the entire temperature range. Only at low temperatures, small deviations from this resistance rule are observed beyond ν=1.

HL 42.2 Thu 15:15 EW 015

Interlayer Tunneling between Imbalanced Double Quantum Wells in the Quantum Hall Regime — •Gunnar Schneider[1], Rolf J. Haug[1], and Werner Dietsche[2] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover, 30167 Hannover, Germany — [2]Max Planck Institut for Solid State Reasearch, 70569 Stuttgart, Germany

Bilayer phenomena such as 2D-2D Tunneling [1] or excitonic Bose-Einstein condensates (BEC) [2] are observable within double quantum wells in the quantum Hall regime. The BEC was found to arise at balanced layer densities with the filling factor combination of 1/2 and 1/2. In our work we are focusing on imbalanced layers, allowing not only the investigation of the filling factor combination 1/3 and 2/3 but also the systems behavior at various combinations of greater filling factors. All measurements were performed on a MBE grown GaAs double quantum well separated by a 10 nm AlAs/GaAs barrier. Gates allow tuning the charge carrier densities between 1E10 and 4E10. The interlayer tunneling for imbalanced charge carrier densities is measured and compared to balanced conditions existing in the samples leads. Measurements were performed at magnetic fields up to three Tesla and for varying density ratios. We were able to map the emergence of the excitonic condensate in the filling factor space. Furthermore regions of conductance and insulation were found at combination of higher filling factors referable to each layers individual Quanten Hall state.

[1]N. Turner et al., Phys. Rev. B 54(15), (1996).

[2]J.P. Eisenstein and A.H. MacDonald, Nature 432, 691-694 (2004)

HL 42.3 Thu 15:30 EW 015

Classical magnetoconductivity maximum in two-dimensional Lorentz gases — Jakob Schluck[1], Nima Siboni[2], Jürgen Horbach[2], and •Thomas Heinzel[1] — [1]Solid State Physics Laboratory, Heinrich-Heine-Universität Düsseldorf — [2]Institute for Theoretical Physics, Heinrich-Heine-Universität Düsseldorf

Two-dimensional Lorentz gases in the classical regime, formed by electrons moving in an array of identical but randomly placed obstacles, show a magnetoconductivity maximum that becomes visible only for high obstacle densities where the mean free path is comparable to the size of the obstacles.[1] It has been predicted by numerical simulations but its origin has remained obscure.[2,3] Here, we show that this maximum is a consequence of superdiffusive electron motion at intermediate time scales. The conductivity maximum turns out to be located at a magnetic field dependent obstacle density which equals the geometric mean of the two phase boundaries of the system.[1] The dependence of this effect on the size and shape of the obstacles is discussed as well. [1]N. H. Siboni et al., preprint arXiv:1708.01039 [cond-mat.dis-nn]. [2]A. Kuzmany and H. Spohn, Phys. Rev. E 57, 5544 (1998). [3]W. Schirmacher et al., Phys. Rev. Lett. 115, 240602 (2015).

HL 42.4 Thu 15:45 EW 015

Magnetotransport in narrow-gap semiconductor nanostructures — •Olivio Chiatti[1], Christian Riha[1], Johannes Boy[1], Aron Castro Martinez[1], Sergio Pezzini[2], Steffen Wiedmann[2], Christian Heyn[3], Wolfgang Hansen[3], and Saskia F. Fischer[1] — [1]Novel Materials Group, Humboldt-Universität zu Berlin, 12489 Berlin, Germany — [2]High Field Magnet Laboratory, Radboud University Nijmegen, 6525ED Nijmegen, The Netherlands — [3]Institut für Angewandte Physik, Universität Hamburg, 20355 Hamburg, Germany

Electric transport measurements in magnetic fields are powerful tools to investigate the transport properties of low-dimensional electron systems. Our experimental work has been directed at the magnetotransport in semiconductor heterostructures and nanostructures with spin-orbit interaction (SOI), under the influence of in-plane and out-of-plane electric fields. We have combined quantum point contacts (QPCs) with in-plane gates, and Hall-bars with top- and back-gates in a narrow-gap semiconductor heterostructure with strong SOI. The Hall-bars and the constriction were fabricated by micro-laser photolithography and wet-chemical etching from an InGaAs/InAlAs quantum well with an InAs-inserted channel [1]. We have performed transport measurements at low temperatures in the QPC and Hall-bar structures in magnetic fields. We observe the transition from reflection to transmission of the quantum Hall edge channels at the QPC.

[1] Chiatti *et al.*, Appl. Phys. Lett. **106**, 052102 (2015).

HL 42.5 Thu 16:00 EW 015

Investigation of an electrochemically operated metallic Pb single-atom transistor — •Fangqing Xie[1], Falco Hüser[2], Fabian Pauly[3], and Thomas Schimmel[1,4] — [1]Institute of Applied Physics, Karlsruhe Institute of Technology (KIT), D-76128 Karlsruhe, Germany — [2]Institut für Theoretische Festkörperphysik, KIT — [3]Department of Physics, University of Konstanz, D-78464 Konstanz, Germany — [4]Institute of Nanotechnology, KIT

The projected scaling limit of the gate lengths is 5 nm in silicon transistors. One focus of nanoelectronics research is to exploit the physical limits in size and energy efficiency. Here, we demonstrate a device in the form of a single-atom transistor based on a Pb quantum point contact. The atomic configuration of the point contact determines the conductance of the Pb single-atom transistor, which is confirmed with the charge transport calculations based on density functional theory for various ideal Pb contact geometries. The performance of the single-atom transistors indicates that both the signatures of atomic valence and conductance quantization play roles in electron transport and bistable reconfiguration. The bistable reconfiguration of the electrode tips is an underlying mechanism in the switching of the single-atom transistors. The operation voltage for the single-atom transistor is less than 30 mV. The dimension of the switching unit in the single-atom transistor is in the range of 1 nm, which is smaller than the projected scaling limit in silicon transistors. Therefore, the single-atom transistors may provide perspectives for electronic applications beyond silicon.

HL 42.6 Thu 16:15 EW 015

Semiclassical origin of quantum oscillations in high-mobility electrostatic superlattices — •Jakob Schluck[1], Juraj Feilhauer[2], Klaus Pierz[2], Hans Schumacher[2], and Thomas Heinzel[1] — [1]Universität Düsseldorf — [2]PTB Braunschweig

Semiconductor superlattices have long been a testground for the validity of semiclassical descriptions of electronic transport. Here we present experimental results of magnetotransport measurements on two-dimensional electrostatic superlattices prepared in high-mobility GaAlAs heterostructures. Superimposed on the classical commensurability resonances we find quantum oscillations, exhibiting an irregular behavior with respect to the quantum Hall transitions. Their semiclassical origin is discussed with the help of numerical simulations based on the Kwant package [1]. We propose an explanation based on the coexistence of skipping and hopping transport.

[1]: C.W. Groth et al., New Journal of Physics 16 063065 (2014)

HL 42.7 Thu 16:30 EW 015

Electron focusing at closed magnetic barriers — Bernd Schüler, •Mihai Cerchez, and Thomas Heinzel — Heinrich Heine

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Ballistic electrons may pass through closed magnetic barriers [1] (high enough to turn the electrons around) in 2DEGs only by means of ExB drift at the edge [2]. We show that the exiting electron flow is restricted to a certain angular range. Experimentally, we probe this by using a second magnetic barrier placed at various distances from the first one, and measuring the magnetoresistance. The ballistic effects observed are oscillations of the magnetoresistance with a maximum amplitude of more than twice the magnetoresistance of a single magnetic barrier. [1] F. M. Peeters and A. Matulis, Phys. Rev. B 48, 15166, 1993. [2] M. Cerchez, S. Hugger, T. Heinzel, and N. Schulz, Phys. Rev. B 75, 035341, 2007.