HL 48: Transport

Time: Tuesday 14:00–16:00 Location: POT 006

HL 48.1 Tue 14:00 POT 006

Fermi liquid theory of the strongly interacting quantum RC circuit — •Michele Filippone — Dahlem Center for Complex Quantum Systems - Freie Universitat Berlin

The quantum coherence effects between electrons in nanodevices lead to a rich variety of phenomena in quantum transport. One of these is the violation of Kirchhoff's laws in the quantum RC-circuit. In this system, a metallic lead exchanges electrons coherently with a quantum dot driven dynamically by a top metallic gate. In the non interacting case, the charge relaxation resistance of the system differs from the usual dc-transport resistance given by the Landauer formula. The charge relaxation resistance is universally fixed to $h/(2e^2)$ for a single mode conductor, regardless of the transmission of the mode. We show that the Fermi liquid behavior of these systems at low energy explains this universality even in the presence of strong interactions in the dot. Moreover, we discuss the emergence of a giant dissipation regime associated to the breaking of the Kondo singlet for Zeeman energies of the order of the Kondo temperature. We provide a comprehensive analytical description of the peak of the charge relaxation resistance associated to this giant dissipation and demonstrate its persistence out of the Kondo regime.

HL 48.2 Tue 14:15 POT 006

Weak Localization and Antilocalization in Two-Dimensional Hole Gases — •Paul Wenk[1], Tobias Dollinger[1], Andreas Scholz[1], Roland Winkler[2], John Schliemann[1], and Klaus Richter[1] — [1]Institut I - Theoretische Physik, Universität Regensburg, D-93040 Regensburg, Germany — [2]Department of Physics, Northern Illinois University, IL 60115 DeKalb, USA

We investigate the appearance of persistent spin states in two-dimensional hole gases including both Rashba and Dresselhaus spin-orbit coupling. To this end, we extend previous models for III-V semiconductors by going beyond the axial approximation. Using an effective 2×2 heavy-hole model, we find persistent and long persisting spin states by analyzing the crossover from weak localization to weak antilocalization. The findings are derived using both Landauer-Büttiker framework and diagrammatic perturbation theory by exact diagonalization of the Cooperon.

[1] T. Dollinger *et al.*, `arXiv:1304.7747` (2013)
[2] J. Schliemann *et al.*, Phys. Rev. Lett. **90** 146801 (2003)
[3] S. Kettemann, Phys. Rev. Lett. **98** 176808 (2007)
[4] P. Wenk, S. Kettemann, Phys. Rev. B **81** 125309 (2010)

HL 48.3 Tue 14:30 POT 006

Magneto-Oscillations in GaAs/InAs Core/Shell Nanowires — •Fabian Haas[1,2], Tobias Wenz[1,2], Patrick Zellekens[1,2], Natalia Demarina[1,2], Torsten Rieger[1,2], Mihail Lepsa[1,2], Detlev Grützmacher[1,2], Hans Lüth[1,2], and Thomas Schäpers[1,2] — [1]Peter Grünberg Institute - 9, Forschungszentrum Jülich, 52425 Jülich, Germany — [2]JARA - Fundamentals of Future Information Technology

In GaAs/InAs core/shell nanowires the electrons are confined in the hollow cylindrical conductive InAs shell. The ring geometry of this InAs nanotube allows flux periodic modulation of the electron concentration in magneto-transport measurements, if a magnetic field is aligned alongside the nanowire axis. Magneto-oscillations with h/e periodicity are expected due to one-dimensional transport through angular momentum states, which are solutions to the Schrödinger equation for a radially confined system.

In this contribution, we present magneto-transport measurements of several GaAs/InAs core/shell nanowires of different dimensions. Pronounced oscillations with h/e periodicity are found in the magneto-conductance of all the wires. By variation of external parameters such as temperature, gate voltage and tilt angle with the magnetic field the underlying energetic spectrum is analyzed.

HL 48.4 Tue 14:45 POT 006

Electronic transport through nano sized GaAs pillars — Thorben Bartsch, Christian Heyn, and •Wolfgang Hansen — Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Jungiusstraße 11, 20355 Hamburg, Germany

We perform magneto-transport experiments on GaAs nanopillars embedded in an AlGaAs matrix. The nanopillars are about 10 nm long, 100 nm in diameter and are epitaxially grown with perfect lattice match to n-doped, three-dimensional GaAs contact areas. Current-voltage characteristics and the magneto-conductance are investigated and compared to two reference samples containing undoped pillars and no pillars, respectively. A pronounced conductance peak observed in a magnetic field oriented along the pillar axis is discussed in terms of Chambers breakdown. In the voltage dependence of the differential conductance distinctive resonances are found that are not present in undoped pillars and the sample without pillars. These peaks slightly change with magnetic field. So far, the origin of the resonances is not clear. A possible mechanism leading to such oscillations will be discussed.

HL 48.5 Tue 15:00 POT 006

Microscopics of Disordered Quantum Hall Systems with Rashba Spin-Orbit Interaction: Spectral Properties and Transport in the Hydrodynamic Regime — •Daniel Hernangomez-Perez[1], Jascha Ulrich[2,3], Serge Florens[3], and Thierry Champel[1] — [1]Laboratoire de Physique et Modélisation des Milieux Condensés, CNRS and Université Joseph Fourier, Grenoble, France — [2]Institute of Physics and JARA-FIT, RWTH Aachen University, Aachen, Germany — [3]Institut Néel, CNRS and Université Joseph Fourier, Grenoble, France

We develop a semicoherent state Green's function formalism to study disordered two-dimensional electron gases (2DEG) in the quantum Hall regime with random Rashba interaction and Zeeman coupling. As a first step, we calculate the energy spectrum in weakly curved smooth disorder potentials with fluctuating Rashba fields and compute a microscopic non-perturbative expression for the local density of states (LDoS). The expression, valid in different temperature regimes, is used to interpret recent experimental data through the study of the spatial dispersion and linewidth of the LDoS peaks. Next, we discuss transport properties of these systems in the hydrodynamic regime. We compute analytical expressions for the edge and bulk current densities and show that, in the semiclassical limit, the Hall conductance presents robust (quantized) Hall plateaux even in the presence of Rashba interaction. Finally, we discuss the dissipationless transport of angular momentum in the 2DEG and show that the semiclassical spin Hall conductance is free of resonances, contrary to previous predictions in the literature.

HL 48.6 Tue 15:15 POT 006

In-plane Magnetic Field Effects in Antidot Lattices in High Mobility Heterostructures — •Jakob Schluck[1], Mihai Cerchez[1], Thomas Heinzel[1], Dimitris Kazazis[2], Klaus Pierz[3], and Hans Werner Schumacher[3] — [1]Solid State Physics Laboratory, Heinrich-Heine University Düsseldorf, Universitätsstr. 1, D-40225 Düsseldorf — [2]Route de Nozay CNRS-LPN F-91960 Marcoussis — [3]PTB Braunschweig, Bundesallee 100 D-38116 Braunschweig

Antidot lattices in two-dimensional electron gases are known to cause peaks in the magnetoresistance whenever the cyclotron radius of the electrons is commensurate with the superlattice. Furthermore, phase coherent oscillations can be observed at low temperatures in hexagonal lattices.

We report the effects of a strong in-plane magnetic field on those two phenomena in large-period hexagonal antidot lattices (superlattice constant between 750 nm and 1.5 μm), defined in high-mobility Ga[Al]As based two-dimensional electron gases at temperatures below 1 K. We observe modifications of the magnetoresistivity which can be traced back to magnetic mass effects.

HL 48.7 Tue 15:30 POT 006

Magnetoresistance studies in GaAs/AlGaAs quantum wells with additional impurity — •Eddy P. Rugeramigabo[1,2], Lina Bockhorn[1], and Rolf J. Haug[1] — [1]Institute for Solid State Physics, Dep. Nanostructures, Leibniz Universität Hannover — [2]QUEST Centre for Quantum Engineering and Space-Time Research, Leibniz Universität Hannover

GaAs/AlGaAs heterostructures, with the two-dimensional electron gas being located in GaAs single quantum wells, were grown using the molecular beam epitaxy technique. Beside the modulation-doping, additional homogeneous Si-doping of the quantum well was performed,

the Si-atoms in the quantum well acting as impurity scattering sites. The samples differ by the density of the incorporated Si-atoms. The quantum well of the reference sample was left undoped, reflecting the unintentional background impurity. Transport measurements were performed on the samples for a wide range of temperatures. For the reference sample we found a high mobility $\mu = 2 \times 10^6$ cm^2/Vs. For increasing additional impurity density we found a drastic decrease of the mobility down to 1×10^4 cm^2/Vs. All samples exhibit parabolic magnetic field dependence at low magnetic fields and low temperatures, attributed to electron-electron interaction. A narrow peak around zero magnetic field in the samples with additional impurity is attributed to weak localization. The differences in the magnetoresistance curves are analyzed in detail in order to study the direct influence of the impurity density on the magnetotransport in 2DEG systems

HL 48.8 Tue 15:45 POT 006

Study of the doping of crystalline silicon nanoparticle films with TCNQ molecules — •Willi Aigner[1], Stanislav Abramov[1], Hartmut Wiggers[2], Rui N. Pereira[1,3], and Martin Stutzmann[1] — [1]Walter Schottky Institut, Technische Universität München, Germany — [2]Institute for Combustion and Gasdynamics - Reactive Fluids, Universität Duisburg-Essen, Germany — [3]Institute for Nanostructures, Nanomodelling and Nanofabrication, Department of Physics, University of Aveiro, Portugal

Electronic devices incorporating solution-processable, semiconducting nanocrystals have been the subject of many studies in the last years. Recently, a significant enhancement of the electron conduction in silicon nanocrystal (Si-NC) thin films has been found by simply doping the films with a small amount of tetrafluorotetracyanoquinodimethane (F4-TCNQ) [1]. The F4-TCNQ molecules provide empty electronic states within the free space between the Si-NCs, which are close to the lowest unoccupied states of the NCs and, in this way a more efficient charge transport in the Si-NC network is achieved. In this work, we carried out a comprehensive study of doping Si-NC thin films with tetracyanoquinodimethane and compare the results with those obtained with F4-TCNQ. For a deeper understanding of the physics governing the molecule-induced electrical activation, films made of p- and n-type Si-NCs were also studied. According to theory [1], the electronic states introduced by the small molecules are solely accessible to electrons, implying that they are not expected to lead to an enhancement of hole conduction. [1] R. N. Pereira, J. Coutinho, et al. submitted, (2013)