HL 7 Transporteigenschaften

Zeit: Freitag 10:45–13:00 Raum: TU P-N226

HL 7.1 Fr 10:45 TU P-N226

A Practical Scheme for Quantum Transport using Time-Dependent Density Functional Theory — •Stefan Kurth[1], Gianluca Stefanucci[2], Carl-Olof Almbladh[2], Angel Rubio[3], and Eberhard K.U. Gross[1] — [1]Institut für Theoretische Physik, FU Berlin, Berlin, Germany — [2]Solid State Theory, Lund University, Lund, Sweden — [3]Donostia International Physics Center, San Sebastian/Donostia, Spain

The Landauer formalism is a popular method to calculate the current of non-interacting electrons through a mesoscopic or nanoscopic system connected to two (or more) macroscopic electrodes in the steady-state. Here we present a *time-dependent* description of transport based on the time evolution of the non-interacting Schrödinger equation. We develop a numerical algorithm for the time propagation of extended states. For simple model systems, the scheme is used to compute the time-dependent current in response to an external dc or ac bias. As expected, for a dc bias the system evolves to a steady state. Using the algorithm in the framework of time-dependent density functional theory allows for the description of transport of *interacting* electrons beyond the Landauer formalism.

HL 7.2 Fr 11:00 TU P-N226

Electron localization in quantum networks — •Dario Bercioux[1,2], Michele Governale[3], Vittorio Cataudella[1], and Vincenzo Marigliano Ramaglia[1] — [1]Coherentia-INFN and "Federico II"University of Naples, I-80126, Italy — [2]Institut für Theoretische Physik, Universität Regensburg, D-93040, Germany — [3]NEST-INFM and Scuola Normale Superiore, Pisa, I-56126, Italy

Quantum networks are graphs of one-dimensional wires connected at nodes. For networks made up of quantum wires realized in semiconductor heterostructures, spin-orbit coupling due to the lack of inversion symmetry in the growth direction (Rashba effect[1]) plays an important role. We show that in particular quantum network extending in only one-dimension (chain of square loops connected at one vertex), Rashba effect gives rise to a electron localization phenomena [2]. This localization effect can be attributed to the spin precession due to the Rashba effect. Similar localization phenomena are observed in presence of magnetic field [3,4]. Both the effects are due to the strong interplay between the external fields and the geometry of the network. Here we present these effect in one- and two-dimensional cases showing that in special situation the interplay of magnetic field and Rashba effect completely destroys the localization effect.

[1] Yu A. Bychkov and E.I. Rashba, J. Phys. C: Solid State Phys. **17**, 6039 (1984). [2] D. Bercioux, M. Governale, V. Cataudella and V. Marigliano Ramaglia, Phys. Rev. Lett. **93**, 56802 (2004). [3] J. Vidal, R. Mosseri and B. Douçot, Phys. Rev. Lett. **81**, 5888 (1998). [4] C. Naud, G. Faini, and D. Mailly, Phys. Rev. Lett. **86**, 5104 (2001).

HL 7.3 Fr 11:15 TU P-N226

Magneto-transport measurements on evenly curved Hall bars — •Olrik Schumacher[1], Stefan Mendach[1], Matthias Holz[2], Holger Welsch[1], Christian Heyn[1] und Wolfgang Hansen[1] — [1]Institut für Angewandte Physik, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg — [2]I. Institut für Theoretische Physik, Universität Hamburg, Jungiusstr. 9, 20355 Hamburg

We present transport measurements on evenly curved Hall bars integrated into InGaAs-microtubes. The method of self-rolling strained semiconductor double layers enables to build tubes with tuneable radii [1,2]. By the use of an optimized epitaxial layer design combined with a special lithographic procedure we are able to fabricate GaAs/InGaAs-microtubes containing a two-dimensional electron system (2-DES) in the tube walls. This opens up the possibility to perform transport measurements on evenly curved Hall bars with a strongly modulated magnetic field component perpendicular to the 2-DES plane. Transport measurements on such curved Hall bars with current direction along the curvature exhibit pronounced Shubnikow-de Haas oscillations which are found to be associated with the maximum perpendicular magnetic field component between the voltage contacts. Furthermore, we find a magnetic field inversion asymmetry depending on the perpendicular field component distribution along the curved Hall bar. For small magnetic fields we explain this asymmetry in classical terms using numerical simulations, for higher magnetic fields the Landauer Büttiker formalism is applied.

[1] V. Ya. Prinz et al., Physica E 6 (2000) 828-831
[2] O. G. Schmidt, K. Eberl, Nature 410 (2001) 168

HL 7.4 Fr 11:30 TU P-N226

Influence of N on the electron transport in (Ga,In)(N,As) probed by magnetotransport under hydrostatic pressure — •J. Teubert, P.J. Klar, W. Heimbrodt, K. Volz, and W. Stolz — Department of Physics and Material Sciences Center, Philipps-University of Marburg, Germany

Incorporation of small amounts of nitrogen into GaAs and (Ga,In)As results in considerable changes of the electronic properties of these materials. Whereas the optical properties are already extensively studied, there is only little knowledge about the effects of nitrogen incorporation onto the electronic transport behaviour of these III-V alloys. Magnetoresistance (MR) and Hall measurements at temperatures between 2 and 280 K and fields up to 10 T show large negative MR effects for n-type samples whereas p-type samples behave like conventional III-V alloys. We present first magnetotransport measurements under hydrostatic pressure up to 20 kbar for n-type (Ga,In)(N,As) samples. All the results can be explained qualitatively by the energetic and spatial disorder effects induced by N in the conduction band.

HL 7.5 Fr 11:45 TU P-N226

Admitances of quantum MIS (metal-insulator-semiconductor)-type structures — •Paul Racec[1,2] and Ulrich Wulf[3,1] — [1]IHP/BTU Joint Lab, Postfach 101344, 03013 Cottbus, Germany — [2]National Institute of Materials Physics, PO Box MG-7, 077125 Bucharest Magurele, Romania — [3]Brandenburgische Technische Universität Cottbus, Fakultät 1, Postfach 101344, 03013 Cottbus, Germany

We perform calculations of the charge-charge corelation function in open quantum nanostructures in the frame of random phase approximation. We use single particle wave-functions obtained in a separate static Hartee calculations. Full quantum-mechanical expressions for admitances of MIS (metal-insulator-semiconductor)-type nanostructures are given. The turnover frequency in the capacitance is associated with the lifetime of a quasi-bound state. Qualitative comparison with experimental data is also provided.

HL 7.6 Fr 12:00 TU P-N226

Quantenpunktelektronen als kontrollierbare Streuzentren für 2D-Elektronengase — •Marco Russ[1], Axel Lorke[1], Dirk Reuter[2] und Andreas D. Wieck[2] — [1]Laboratorium für Festkörperphysik, Universität Duisburg-Essen, Lotharstr. 1, 47048 Duisburg — [2]Angewandte Festkörperphysik, Ruhr-Universität Bochum, Universitätsstr. 150, 44780 Bochum

AlGaAs-Heterostrukturen, die in einem geringen Abstand ein zweidimensionales Elektronengas und eine Lage selbstorganisierter InAs-Quantenpunkte enthalten, zeigen neben der grundsätzlich verringerten Beweglichkeit einige Besonderheiten in ihren Transporteigenschaften, deren Ursache noch nicht vollständig geklärt ist. Selbstorganisierte Quantenpunkte beeinflussen ihre Umgebung nicht nur durch strukturelle Effekte (Verspannung), sondern auch durch Wechselwirkungen mit den eingeschlossenen Elektronen, deren Zahl im Experiment in situ steuerbar ist. Hier werden Messungen im Temperaturbereich von 230mK-4,2K für verschiedene Dot-2DEG-Abstände vorgestellt, die eine Trennung dieser beiden Streumechanismen erlauben und quantitativ den Einfluss zusätzlicher Ladungen in der Quantenpunktschicht auf die Transporteigenschaften des zweidimensionalen Elektronengases beschreiben. Die Ergebnisse lassen sich unter der Annahme einer linearen Abhängigkeit der Beweglichkeit des 2DEG von der Ladung in der Quantenpunktschicht modellieren, für 6 Elektronen pro Quantenpunkt ergibt sich eine ladungsinduzierte Verringerung der Beweglichkeit von etwa 10%.

HL 7.7 Fr 12:15 TU P-N226

High frequency operation of monolithic GaAs/AlGaAs three terminal junctions — •Christian R. Müller, Lukas Worschech, Daniela Spanheimer, and Alfred Forchel — Technische Physik, Universität Würzburg, 97074 Würzburg

Non-linear transport characteristics of monolithic GaAs/AlGaAs three terminal junctions with junction lengths down to a few 10 nm were studied at room temperature and time dependent voltage variations up to 50 GHz. It is found that with increasing bias voltage applied to one branch, voltage sweeps at the other branch lead to a transistor operation with high gain up to $d\Delta V_{Out}/dV_g \sim 30$. We relate this novel type of operation to an accumulation of electrons in the junction in the strong non-linear regime, which in turn enhances the capactive coupling of the branches. The interplay of electron injection and gating leads to a pronounced peak in the input characteristics. We have studied the high frequency output of the device. Rectification of the input signal is still observed at frequencies up to 20 GHz.

HL 7.8 Fr 12:30 TU P-N226

Intrinsic feedback controlled bistability in an electron Y-branch switch — •David Hartmann, Lukas Worschech, Stefan Lang, Stephan Reitzenstein, and Alfred Forchel — Technische Physik, Universität Würzburg, 97074 Würzburg

Electron Y-branch switches (YBSs) controlled by four independent side-gates have been realized by electron beam lithography and wet etching in a modulation doped GaAs/AlGaAs heterostructure. Asymmetric gate bias allows the study of field effect in YBSs with only one branch exploited as swept gate controlling the channel between the other branch and the stem. Close to the onset limit of gate-current threshold the YBS shows an intrinsic pronounced switching bistability with no need of any external feedback. The input current-voltage characteristics can be tuned to a reversed and a non-reversed response with gain. We will discuss the role of different gate bias on the switching bistability. Different applications as nanoelectronic Schmitt-Trigger and complementary switching device are proposed and demonstrated.

HL 7.9 Fr 12:45 TU P-N226

Separating X-valley electrons in AlAs using quantum point contacts — •F. Erfurth, J. Moser, M. Bichler, D. Schuh, G. Abstreiter, and M. Grayson — Walter Schottky Institut, TU-Muenchen, 85748 Garching

We demonstrate the fabrication of one-dimensional (1D) AlAs electron systems used to distinguish between electrons from different conduction band valleys. Split gates are used to create a quantum point contact (QPC) by depleting two-dimensional (2D) electrons in a 15 nm wide quantum well ($n = 3\times10^{11}$ cm^{-2}, $\mu = 5.8$ m^2/Vs). In AlAs, the conduction band X-valley mass is anisotropic ($m_x = 0.19m_0$, $m_y = 1.1m_0$) and doubly degenerate. This degeneracy can be broken at a QPC depending on the QPC alignment relative to the crystal axes. The lateral confinement causes splitting into distinct mass subbands, and by shifting the 1D Fermi level, electrons from a specific valley can be selectively transmitted.

In our experiments we first use a magnetic field to break the valley degeneracy. At the quantum Hall filling factors of $\nu = 2$, $B = 6$ T we are able to separate edge channels into one transmitted valley and one reflected valley channel. At $\nu = 3$, $B = 4$ T ($\nu = 4$, $B = 3$ T) all three (four) channels of alternating valleys can be successively separated. This demonstrates the first successful use of 1D constrictions to distinguish between electrons from different valleys.