HL 29 Transport properties II

Time: Wednesday 17:00–18:15 Room: HSZ 01

HL 29.1 Wed 17:00 HSZ 01

Magnetotransport in solids with spin splitting of the energy spectrum — •Nikita Averkiev, M.M. Glazov, N.I. Sablina, and S.A. Tarasenko — A.F.Ioffe Physico-Technical Institute, 194021 St.Petersburg, Russia

Spin-dependent and transport phenomena are the topical fields of solid state physics. The electron spin can be used in the future quantum computers and other information processing devices. Study of the conductivity oscillations (Shubnikov-de Haas effect) gives an unique opportunity to investigate the fundamental properties of condensed matter and structure characterization. In this presentation we analyze the magnetotransport in low-dimensional structures where the spin dynamics becomes important and determines the pattern of the Shubnikov-de Haas oscillations. Both cases: (i) zero-field spin splitting and (ii) Zeeman effect in external field are studied in detail. We show that in the first case the pattern of magnetooscillations depends drastically on the ratio between spin-orbit terms caused by structure and bulk inversion asymmetry. Depending on this ratio, the spectrum of the Shubnikov-de Haas oscillations contains one, two, or three harmonics. Such a behavior is caused by the magnetic breakdown between the spin branches. Zeeman splitting, that becomes pronounced in tilted magnetic field, can result in suppression of the main harmonic and appearance of the oscillations at double frequency. The effects described open new possibilities to investigate the fine energy structure of low-dimensional conducting systems.

HL 29.2 Wed 17:15 HSZ 01

Direct observation of the Aharonov-Casher phase — •Markus König, Anna Tschetschetkin, Volkmar Hock, Matthias Schäfer, Charles R. Becker, Hartmut Buhmann, and Laurens W. Molenkamp — Physikalisches Institut (EP 3), Universität Würzburg, Am Hubland, 97074 Würzburg, Germany

Since its prediction in the 1980s, the concept of geometric phases has aroused much interest. One special case of a geometric phase is the Aharonov-Casher (AC) phase [1], which is acquired by a particle with a magnetic moment, which moves around an electric field. Nitta et al. [2] stated that the existence of the AC phase affects the transmission probability in ring shaped devices with spin-orbit coupling.

Apart from the Aharonov-Bohm (AB) effect, there has been no direct observation of any other phase related effects in a solid state system. So far, only some additional structures in the Fourier transform have been interpreted as indirect evidence of the geometric phase.

We present experimental results obtained on HgTe quantum well based ring structures, which have been used to study AB type conductance oscillations as a function of Rashba spin-orbit splitting energy. Nonmonotonic phase changes were observed, indicating that an additional phase factor modifies the electron wave function. We associate these observations with the Aharonov-Casher effect. This interpretation is confirmed by numerical calculations.

[1] Y. Aharonov and A. Casher, Phys. Rev. Lett. 53, 319 (1984). [2] J. Nitta, F. E. Meijer, and H. Takayanagi, Appl. Phys. Lett. 75, 695 (1999).

HL 29.3 Wed 17:30 HSZ 01

Ballistic rectification in single and cascaded nanoscale cross junctions — •Michael Knop[1], Ulrich Wieser[1], Ulrich Kunze[1], Dirk Reuter[2], and Andreas D. Wieck[2] — [1]Werkstoffe und Nanoelektronik, Ruhr-Universität Bochum, D-44780 Bochum — [2]Angewandte Festkörperphysik, Ruhr-Universität Bochum, D-44780 Bochum

Ballistic rectification is demonstrated in a nanoscale four-terminal Ψ-shaped semiconductor cross junction consisting of a straight voltage stem and current-injecting branches [1]. The devices are fabricated from a high mobility GaAs/AlGaAs-heterostructure by use of a mix-and-match process combining low-energy electron-beam lithography on negative-tone resist calixarene with standard photo lithography [2]. According to a simple billiard-like picture the rectifying effect relies on the pure inertial ballistic motion of the electrons through the junction. Rectification is obtained up to temperatures of $T = 125$ K. A possible remedy for the low rectification efficiency $\eta = V_{out}/|V_{in}| \approx 3\%$ of a single device is a cascade of identical rectifier stages. DC transport-measurements on a cascade of two rectifier stages show the expected enhancement of the output voltage compared to a single rectifier.

[1] M. Knop *et al.*, Physica E (accepted)
[2] M. Knop *et al.*, Semicond. Sci. Technol. **20**, 814 (2005)

HL 29.4 Wed 17:45 HSZ 01

In-plane electron tunneling between two one-dimensional — •Jean-Laurent Deborde[1], Saskia F. Fischer[1], Ulrich Kunze[1], Dirk Reuter[2], and Andreas D. Wieck[2] — [1]Werkstoffe und Nanoelektronik, Ruhr-Universität Bochum, Germany — [2]Angewandte Festkörperphysik, Ruhr-Universität Bochum, Germany

Recently, we have introduced a lateral one-dimensional (1D) to two-dimensional (2D) tunneling structure whose thin leaking potential barrier [1] was prepared by means of atomic-force microscope lithography [2]. This gate-voltage controlled device enables to probe the 1D density of states by the tunneling conductance. In the present work, we apply the same lithography technique to produce an in-plane 1D-to-1D tunneling device. The samples are fabricated on a high-mobility GaAs/AlGaAs heterostructure. The device consists of two adjacent 1D waveguides (115 nm and 120 nm wide, both 430 nm long) separated by a thin 50 nm wide and 10 nm deep groove. A Schottky-gate is deposited on top of the device in order to control the transmission through the barrier as well as the electron density inside the waveguides. At 4.2 K, each quantum wire shows conductance quantization as characteristic of 1D transport. Energy subband separations of both waveguides are investigated from the conductance under dc drain voltage. The application of a dc bias across the barrier shows signatures of tunnel coupling between the 1D subbands in the two quantum wires.

[1] J.-L. Deborde *et al.*, EP2DS-16 2005, Physica E (in press)
[2] U. Kunze, Supperlatt. Microstruct. **31**, 3 (2002)

HL 29.5 Wed 18:00 HSZ 01

Fano resonances in transport through open quantum systems — •Roxana Racec[1,2] and Ulrich Wulf[1,3] — [1]Technische Universität Cottbus, Fakultät 1, Postfach 101344, 03013 Cottbus, Germany — [2]University of Bucharest, Faculty of Physics, PO Box MG-11, 077125 Bucharest Magurele, Romania — [3]IHP/BTU Joint Lab, Postfach 101344, 03013 Cottbus, Germany

We develop a theory for the measured Fano resonances in the conductance of a quantum dot strongly coupled to the leads. A nonseparable potential is considered which assures for the channel mixing. Our central result is that there is a single, well-defined resonant transmission channel even in presence of channel coupling. This resonant channel is associated with a single pole of the S-matrix. In addition, there is a background part of the S-matrix arising from poles other than the resonant one. It can be shown that this constant part of the S-matrix can be split in one part which interferes coherently with the resonant channel (coherent background) and a noncoherent part (noncoherent background). The interplay between the coherent background and the resonant channel determines the single asymmetry parameter seen in the experiment. The noncoherent background part of the S-matrix results in a noncoherent constant contribution to the conductance which is also seen in the experiment.