Seminars

Gauge theory of spin-orbit coupling in quantum dots

V. Fal'ko

Physics Department, Lancaster University, Lancaster, LA1 4YB, UK

Spin-orbit coupling (SO) is a relativistic phenomenon which gives rise to the spin relaxation of electrons diffusing through disordered semiconductor structures and also transforms their weak localisation into anti-localisation. In this talk, it will be shown that the effect of spin-orbit coupling on spin relaxation of carriers and their quantum transport properties is dramatically reduced by the geometrical confinement of orbital electron motion. The proposed analytical description of SO coupling in lateral semiconductor dots is based upon a non-Abelian gauge transformation, which eliminates the SO coupling in the lowest order. The theory based upon such a gauge transformation method enables one to give a complete analytical treatment of spectral and quantum transport problems in dots [1,2], to classify relevant symmetry classes and to characterise crossovers between them explaining the observed in Refs. [3,4] magneto-resistance behaviour of chaotic dots.

[1] I.L. Aleiner and V.I. Fal'ko, Phys. Rev. Lett. 87, 256801 (2001)
[2] J.H. Cremers, P.W. Brouwer, V.I. Fal'ko, Phys. Rev. B 68, 125329 (2003)
[3] J.A. Folk, S.R. Patel, K.M. Birnbaum, C.M. Marcus, C.I. Duruz, J.Harris, Phys. Rev. Lett. 86, 2102 (2001)
[4] D.M. Zumbhl, J.B. Miller, C.M. Marcus, K. Campman, and A.C. Gossard, Phys. Rev. Lett. 89, 276803 (2002)

Coulomb drag in double layers in a magnetic field.

Igor Gornyi

Institut fuer Nanotechnologie, Forschungszentrum Karlsruhe

The Coulomb drag between two electron layers is an important tool to investigate the inter-electron interaction, inelastic scattering, and particle-hole asymmetry. Recent experiments on Coulomb drag in the quantum Hall regime have yielded a number of surprises. The most striking observations are that the Coulomb drag can become negative in high Landau levels and that its temperature dependence is non-monotonous. We develop a theory of Coulomb drag in a strong magnetic fields explaining these puzzling experiments. It is shown that the drag in high Landau levels is an interplay of two contributions arising from different sources of particle-hole asymmetry, namely the curvature of the zero-field electron dispersion and the Landau-level quantization of the density of states.

Transport through quantum rings and dots.

R. Haug

Abteilung Nanostrukturen, Institut fuer Festkoerperphysik, Universitaet Hannover, Germany

In the talk different experiments studying single-electron tunnelling through small semiconducting quantum rings and dots will be discussed. The devices are prepared by combinations of electron-beam lithography and direct writing with an atomic force microscope. Self-assembled quantum dots are also used in the experiments. Transport spectroscopy with special emphasis on interference, interaction and spin effects will be presented.

Multiple scattering of cold atoms in disordered optical potentials with long-range correlations

Cord Mueller

Universitaet Bayreuth, Germany

We study multiple scattering of matter waves by a disordered optical potential in two and in three dimensions. In contrast to point-like impurities encountered in electron scattering, the fluctuations of an optical speckle pattern exhibit long-range correlations. We set up a diagrammatic Green's function approach and calculate ensemble-averaged propagators in the weak scattering regime. An analytical expression for the average Green's function allows to discuss the elastic scattering mean free path as a function of experimentally relevant parameters. The transport mean free path that enters the diffusion constant is calculated analytically from the single-scattering vertex showing strongly anisotropic scattering.

Quantum statistics of non-equilibrium Fermi gases.

Boris Muzykantskii

University of Warwick

We describe the Riemann-Hilbert (RH) approach to computing the response of a Fermi gas to a time-dependent perturbation. The method is non-perturbative, quite general and has the appealing feature of working directly with scattering amplitudes defined at the Fermi surface rather than with the bare Hamiltonian.