HL 30 Quantum dots and wires: Transport properties II

Time: Wednesday 18:15–19:15 Room: HSZ 01

HL 30.1 Wed 18:15 HSZ 01

Tunnel-coupled one-dimensional electron systems
— •S.F. Fischer[1], G. Apetrii[1], U. Kunze[1], D. Schuh[2,3], and G. Abstreiter[3] — [1]Werkstoffe und Nanoelektronik, Ruhr-Universität Bochum, D-44780 Bochum — [2]Walter Schottky Institut,Technische Universität München, D-85748 Garching — [3]Angewandte u. Exp. Physik, Universität Regensburg, D-93040 Regensburg

Wave function mixing and splitting of degenerate one-dimensional (1D) energy levels are a direct outcome of tunnel coupling between 1D ballistic electron systems. We present the conductance and transconductance measurements of vertically stacked short electron wave guides fabricated from tunnel-coupled quantum wells in GaAs/AlGaAs heterostructures with atomic force microscope lithography [1]. Subsequent 1D subbands are populated by increasing a top gate voltage. The subladders of the top and bottom electron wave guides can be shifted relative to each other by application of a back gate voltage [2], magnetic fields or cooling under top gate bias [3]. Mode coupling is reflected by level anti-crossings. Large 1D-subband spacings (>10 meV) allow an unprecedented resolution in drain bias spectroscopy which proves as a powerful tool for the direct determination of splitting energies. Device operation above liquid helium temperature is demonstrated. In an outlook we compare vertically and laterally tunnel-coupled 1D electron systems.

[1] U. Kunze, *et al.*, Superlatt. Microstructures 31 (2002) 3.
[2] G. Apetrii, *et al.*,Physica E, in press.
[3] S.F. Fischer, *et al.*,Appl.Phys.Lett. 81 (2002) 2779.

HL 30.2 Wed 18:30 HSZ 01

Ballistic electron spectroscopy with a quantum dot — •Frank Hohls, M. Pepper, J. P. Griffith, G. Jones, and D. A. Ritchie — Cavendish Laboratory, University of Cambridge, UK

Non-equilibrium transport measurements can be used to characterise and analyze confined electron systems. However, if there is a strong interaction between electrons then the assumptions underlying these techniques should be modified. In order to investigate the energy spectrum with a method which measures the energies directly, we propose to use a quantum dot for the energy-selective detection of non-equilibrium ballistic electrons injected from a device under study into its drain lead. Here we study the feasibility of this ballistic electron spectroscopy. Our device consists of two quantum dots, one used to prepare ballistic electrons with a well defined excess energy and the other used to demonstrate their detection. We use magnetic field dependence to demonstrate the ballistic nature of the detector signal and show the energy selectivity for varying excess energy of the ballistic electron beam.

HL 30.3 Wed 18:45 HSZ 01

Prediction of a concrete two qubit quantum gate based on quantum wires — •Tobias Zibold[1], Andrea Bertoni[2], and Peter Vogl[1] — [1]Walter Schottky Institut, Technische Universität München, Am Coulombwall 3, 85748 Garching — [2]National Research Center S3, INFM-CNR, 41100 Modena, Italy

We predict a concrete semiconductor nanostructure for a two qubit quantum gate based on ballistic transport in quantum wires. The device allows controlled entanglement and its determination from DC I-V characteristics. In contrast to the majority of proposals that use charge or spin in closed systems such as quantum dots, our device is based on open system qubits [1]. This allows for an especially simple DC write-in and read-out process. The device consists of two vertically stacked GaAs/AlGaAs 2DEGs that are depleted by external gates to form a Mach-Zehnder interferometer for ballistic electrons in each of the two layers. Each of which represents a single qubit [2]. We show that the entanglement between the two interferometers leads to controlled dephasing and can be determined from their I-V characteristics. We further show that correlation measurements of the I-V characteristics of both interferometers can be used to distinguish this mechanism of dephasing from other sources thereof. To this end we have developed a Green's function method that allows us to calculate the ballistic current of the coupled system for a realistic, three-dimensional device structure. [1] G.B. Akguc et al., Phys. Rev. A 69, 042303 (2004). [2] A. Bertoni et al., Phys. Rev. Lett. 84, 5912 (2000).

HL 30.4 Wed 19:00 HSZ 01

Bias voltage controlled threshold hysteresis in GaAs/AlGaAs quantum-wire transistors with embedded InGaAs quantum dots — •Christian R. Müller, Lukas Worschech, and Alfred Forchel — Technische Physik, Universität Würzburg, Am Hubland, 97074 Würzburg, Germany

We have studied the threshold hysteresis of quantum-wires realized by electron beam lithography and wet chemical etching on the basis of a GaAs/AlGaAs heterostructure with InGaAs quantum dots in the AlGaAs spacer. Threshold shifts are due to charging and discharging of the quantum dots and can be controlled electrically by the side-gates. We have observed that the threshold hysteresis between up- and downsweeps of the side-gate voltage decreases with increasing bias voltage, and for a critical bias voltage the threshold hysteresis is suppressed. A change of the hysteresis sign was detected for bias voltages exceeding the critical bias voltage. As a result the memory function of the studied quantum-wire transistors can be inhibited electrically. We discuss the bias voltage dependent variation of the threshold hysteresis in terms of an interplay between the capacitive couplings of the quantum-wire, the quantum dots and the side-gates.