HL 60: Quantum dots: Transport

Time: Wednesday 17:15–18:45 Location: EW 203

HL 60.1 Wed 17:15 EW 203

The Kondo resonance of a quantum dot in magnetic fields — •Alexander W. Heine[1], Daniel Tutuc[1], Gertrud Zwicknagl[2], and Rolf J. Haug[1] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover, 30167 Hannover, Germany — [2]Institut für Mathematische Physik, Technische Universität Braunschweig, 38106 Braunschweig, Germany

The fingerprint of the Kondo effect in quantum dots is a peak of enhanced conductance at zero bias, the so-called zero bias anomaly. We examine experimentally the influence of magnetic fields on this zero bias peak. The measurements were performed in an ^{3}He/^{4}He dilution refrigerator with a base temperature of about 20 mK. A magnetic field B up to 6 T was applied parallel as well as perpendicular to the sample surface.

In a perpendicular magnetic field we analyze the splitting of the Kondo resonance in the so-called Kondo chessboard. Here a decrease of the splitting width with increasing magnetic field is observed. The data is compared to numerical renormalization group calculations by Hewson et al.[1], which show the relation between the effective splitting of the zero bias anomaly and B/T_K. Thereby we can show, that the quantum Hall effect in the two-dimensional leads affects the Kondo temperature and therefore the splitting of the zero bias anomaly.

[1] Hewson et al., Phys. Rev. B 73, 045117 (2006)

HL 60.2 Wed 17:30 EW 203

Optical detection of single-electron tunneling dynamics in self assembled quantum dots — •Annika Kurzmann[1], Benjamin Merkel[1], Arne Ludwig[2], Andreas D. Wieck[2], Axel Lorke[1], and Martin Geller[1] — [1]Faculty of Physics and CENIDE, University of Duisburg-Essen, Lotharstr. 1, 47057 Duisburg, Germany — [2]Chair of Applied Solid State Physics, Ruhr-Universität Bochum, Universitätsstr. 150, 44780 Bochum, Germany

The tunneling dynamics of charge carriers into self-assembled quantum dots (QDs) have been studied using electrical measurements like transconductance spectroscopy. However, these techniques are still limited to measurements of an ensemble of QDs, i.e. the dynamics of single electron tunneling into a single QD has not been observed yet.

Here, for the first time, we demonstrate that we are able to study the electron tunneling between a single self-assembled QD and a 3D back contact, using resonance fluorescence as detection scheme. The QD is embedded in a diode structure, which allows controlled charging and discharging of the QD with single electron resolution. We apply voltage pulses to the top-gate contact and measure the resonance fluorescence signal, while electrons tunnel into or out of the QD. Using this new time-resolved measurement technique, we investigate the relation between the tunneling times into the QD and the chemical potential in the back gate. An even more detailed understanding of the tunneling processes between QDs and a charge carrier reservoir can be achieved by measuring the telegraph noise in the resonance fluorescence signal, when the states with occupation number 0 and 1 are degenerate.

HL 60.3 Wed 17:45 EW 203

All-electrical measurement of the spin-triplet relaxation time in self-assembled quantum dots — •A. Al-Ashouri[1], K. Eltrudis[1], A. Beckel[1], A. Ludwig[2], A. D. Wieck[2], A. Lorke[1], and M. Geller[1] — [1]Faculty of Physics and CENIDE, University of Duisburg-Essen, Lotharstraße 1, 47057 Duisburg, Germany — [2]Chair for Applied Solid State Physics, Ruhr-Universität Bochum, Universitätsstraße 150, 44780 Bochum, Germany

Devices for quantum computation require coherent access to qubits, which can be realized by a two level quantum system in quantum dots (QDs). Promising candidates for a suitable system include the excited spin triplet and its singlet ground state. A long lifetime is expected for an excited spin state, however, a desirable all-electrical read-out scheme for the qubit state has yet to be realized.

Here we use time-resolved transconductance spectroscopy[1] to electrically prepare and detect the triplet state in self-assembled InAs QDs and find a long spin relaxation time in the order of μs. The investigated QDs are embedded in a GaAs\AlGaAs matrix using a heterostructure FET. They are coupled to a two dimensional electron gas (2DEG) via a tunneling barrier. The 2DEG is used as a charge reservoir as well as a sensitive detector for the electron states in the QDs. After initialization of the spin-triplet state we observe the electron emission during read-out and in this way are able to record the temporal decay of the triplet state. The long timescale for the decay promises future coherent manipulation of such a spin-qubit.

[1] A. Beckel et al., Phys. Rev. B **89**, 155430 (2014).

HL 60.4 Wed 18:00 EW 203

Stochastic resonance in electron counting — •Timo Wagner, Johannes Bayer, Eddy P. Rugeramigabo, and Rolf J. Haug — Institut für Festkörperphysik - Abteilung Nanostrukturen, Leibniz Universität Hannover, 30167 Hannover, Germany

We performed electron counting experiments on a double quantum dot (QD) as well as on a more advanced serial triple quantum dot structure. For both systems an adjacent quantum point contact (QPC) serves as sensitive charge detector to resolve time dependent single electron tunneling events. From the recorded time trace we extracted the waiting times for tunneling into and out of a quantum dot.

The two waiting time distributions reveal phase correlated oscillations. We identify those characteristic oscillations as stochastic resonance due to the superposition of a small harmonic signal and the bistable stochastic quantum dot signal. Further we studied and simulated the dependency of different system parameters on the resonance.

The quantum dots structures were defined by metallic topgates on a two dimensional electron gas on GaAs/AlGas. The measurements on the double quantum dot were performed in a He3 system at temperatures around 300mK and for the triple dot measurements we used a dilution refrigerator with base temperature around 20mK. Time resolved charge was archieved with a low noise DC setup.

HL 60.5 Wed 18:15 EW 203

Transport Measurements on a Triple Quantum Dot with Two Bias Voltages — •Monika Kotzian[1], Fernando Gallego Marcos[2], Gloria Platero[2], and Rolf J. Haug[1] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover, Appelstrasse 2, 30167 Hannover, Germany — [2]Instituto de Ciencia de Materiales, CSIC, Cantoblanco, 28049 Madrid, Spain

We present transport measurements on a lateral triple quantum dot with a star-like geometry [1] in dependence of two different bias voltages applied simultaneously. The structure is made with local anodic oxidation by AFM on a GaAs/AlGaAs heterostructure, the design allowing to simultaneously measure the conductance along two different paths with two quantum dots in each path. By controlling the potentials via the four gates of the device resonances of two and all three dots can be generated. [2,3] With one lead attached to each dot and using two of the leads as source contacts with two different bias voltages and one lead as a drain contact, novel possibilities arise to study the interaction between the transport paths. For characterization of the system and a better understanding of coupling effects and bias dependent behavior the transport near the triple dot resonance is simulated using the Born-Markov approximation.

[1] M. C. Rogge, R. J. Haug, Phys. Rev. B 77, 193306 (2008). [2] L. Gaudreau, et al., PRL 97, 036807 (2006). [3] M. C. Rogge, R. J. Haug, New Journal of Physics 11, 113037 (2009).

HL 60.6 Wed 18:30 EW 203

Electron Transport in a Quadruple Quantum Dot System — •Johannes Bayer, Timo Wagner, Eddy P. Rugeramigabo, and Rolf J. Haug — Institut für Festkörperphysik, Leibniz Universität Hannover

We successfully produced a tunable system of four tunnel-coupled quantum dots in series. The device was fabricated via electron beam lithography on an MBE-grown GaAs /AlGaAs heterostructure forming a 2DEG 110 nm beneath the surface with an electron density of $2.4 \cdot 10^{11}$ cm^{-2} and an electron mobility of $5.1 \cdot 10^5$ cm^2/Vs. We performed electronic transport measurements in a dilution refrigerator at a base temperature of about 10 mK. The quadruple quantum dot system (QQD) has been studied in terms of linear and nonlinear transport behavior. Additionally, two quantum point contacts are located near the quantum dots and used as sensitive charge detectors. We present a combination of transport measurements and charging diagrams in the many electron regime of the QQD.