HL 88: Quantum Dots and Wires: Transport Properties IV (mainly Double Dots and Point Contacts)

Time: Thursday 16:30–18:15 Location: EW 202

HL 88.1 Thu 16:30 EW 202

A hybrid double-dot in silicon — •Miguel Fernando Gonzalez Zalba, Dominik Heiss, and Andrew Ferguson — Microelectronics Research Centre, Cavendish Laboratory, Cambridge, CB3 0HE, UK

We report electrical measurements of a single arsenic dopant atom in the tunnel-barrier of a silicon Single Electron Transistor (SET). As well as performing electrical characterization of the individual dopant, we study series electrical transport through the dopant and SET. We measure the triple points of this hybrid double dot system, using simulations to support our results, and show that we can tune the electrostatic coupling between the two sub-systems.

HL 88.2 Thu 16:45 EW 202

Spin Based Quantum Computation with Quantum Dots Including Micro-Magnet Technique — •Roland Brunner[1,2], Yun Suk Shin[2], Toshiaki Obata[3], Michel Pioro-Ladriere[4], Toshihiro Kubo[5], Koji Yoshida[3], Tomoyasu Taniyama[6], Yasuhiro Tokura[5], and Seigo Tarucha[3] — [1]Institute of Physics, Montanuniversitaet Leoben, 8700, Austria — [2]Quantum Spin Information Project, ICORP, Japan Science and Technology Agency, Atsugi-shi, Kanagawa, 243-0198, Japan — [3]Department of Applied Physics, University of Tokyo, Hongo, Bunkyo-ku, Tokyo, 113-8656, Japan — [4]Département de Physique, Université de Sherbrooke, Sherbrooke, Québec, J1K-2R1, Canada — [5]NTT Basic Research Laboratories, NTT Corporation, Atsugi-shi, Kanagawa, 243-0198, Japan — [6]Materials and Structures Laboratory, Tokyo Institute of Technology, 4259 Nagatsuta, Yokohama, 226-8503, Japan

Here, we present in a semiconductor double quantum dot, the realization of a two-qubit quantum gate. The approach is based on the combination of spin exchange control and on single spin rotations [1]. The all-electrical two-qubit quantum gate [1] is accomplished in an GaAs/AlGaAs double quantum dot with a novel split micro-magnet. The micro-magnet is used to generate an inhomogeneous magnetic field necessary for the manipulation of the single electron spin [2,3,4]. References: [1] Brunner et al. Phys. Rev. Lett. 107 146801 (2011). [2] Pioro-Ladrière, M. et al. Nature Physics 4, 776 (2008). [3] Obata, T. et al. Phys. Rev. B 81, 085317 (2010). [4] Y. Tokura et al. Phys. Rev. Lett. 96, 047202 (2006).

HL 88.3 Thu 17:00 EW 202

Magnetotransport in single and double quantum dots in the Kondo regime — •Alexander W. Heine, Daniel Tutuc, and Rolf J. Haug — Institut für Festkörperphysik, Leibniz Universität Hannover, D-30167 Hannover, Germany

We analyse the magnetotransport of quantum dots (QD) in the Kondo regime. The sample consists of two lateral QDs produced by local anodic oxidation on a GaAs/AlGaAs heterostructure, containing a two-dimensional electron system (2DES) 37 nm below the surface. Transport measurements on each single QD, and both QDs in parallel respectively, are performed in a ^{3}He/^{4}He dilution refrigerator with a base temperature of 20 mK, using standard lock-in technique. The QDs are separately tuned by six sidegates into the Kondo regime. A magnetic field applied perpendicular to the 2DES gives rise to the so-called *Kondo chessboard.* We investigate the QDs' non-linear transport properties in fields up to 5 T, as well as the temperature dependence of the linear conductance.

HL 88.4 Thu 17:15 EW 202

Magnetic focusing of ballistic photocurrents in mesoscopic circuits — Markus Stallhofer[1], •Christoph Kastl[1], Christoph Karnetzky[1], Dieter Schuh[3], Werner Wegscheider[4], Gerhard Abstreiter[1], Jörg Kotthaus[2], and Alexander Holleitner[1] — [1]Walter Schottky Institut and Physik-Department, TU München — [2]Fakultät für Physik and Center for NanoScience (CeNS), LMU München — [3]Institut für Experimentelle und Angewandte Physik, Universität Regensburg — [4]Laboratorium für Festkörperphysik, ETH Zürich, Switzerland

We exploit GaAs-based quantum point contacts (QPCs) as mesoscopic detectors for analyzing the flow of photogenerated electrons in a two-dimensional electron gas (2DEG) [1]. At moderate, perpendicularly applied magnetic fields, we resolve circular electron trajectories. We extract the cyclotron radius and the electron momentum of the photogenerated electrons at varying magnetic fields and irradiation intensities. The extracted values surprisingly exceed the ones derived from a single-particle cyclotron motion. With the help of Monte Carlo simulations, this deviation is related to the effects of electron-electron scattering on the propagation of the photo-excited electrons.
[1] K.-D. Hof et al., Nano Letters, 10, 3836 (2010).

HL 88.5 Thu 17:30 EW 202

Ballistic photocurrents at the presence of electron-electron scattering — Markus Stallhofer[1], •Christoph Karnetzky[1], Marcel Brändlein[1], Christoph Kastl[1], Dieter Schuh[3], Werner Wegscheider[4], Jörg Kotthaus[2], and Alexander Holleitner[1] — [1]Walter Schottky Institut and Physik-Department, TU München — [2]Fakultät für Physik and Center for NanoScience (CeNS), LMU München — [3]Institut für Experimentelle und Angewandte Physik, Universität Regensburg — [4]Laboratorium für Festkörperphysik, ETH Zürich, Switzerland

We demonstrate that GaAs-based quantum point contacts (QPCs) can be employed to resolve the non-equilibrium dynamics of photogenerated charge carriers in a mesoscopic circuit [1]. To this end, electron-hole pairs are optically created in a two-dimensional electron gas (2DEG) and the resulting current through an adjacent QPC is measured as a function of the laser spot position. We particularly investigate the characteristic spatial decay length of the photocurrent as a function of the optical excitation power and the excitation energy. We identify two transport regimes, dominated either by the effects of electron-electron scattering or the formation of an optically induced Quasi-Fermi level.
[1] K.-D. Hof et al., Nano Letters, 10, 3836 (2010).

HL 88.6 Thu 17:45 EW 202

Metastable charge states in a few electron double quantum dot — •Daniel Biesinger[1], Martin Brühlmann[1], Christian Scheller[1], Dominik M. Zumbühl[1], Jeramy Zimmerman[2], and Art C. Gossard[2] — [1]Dep. of Physics, University of Basel, Switzerland — [2]Materials Dep., University of California, Santa Barbara, California, USA

We are presenting quantum transport experiments on a lateral GaAs double quantum dot in the few electron regime. Adjacent quantum dots are used as real-time charge sensors, allowing single-shot charge readout with ms rise time and sensitivities as large as $\delta g/g \sim 0.7$ per electron. The tunneling-rates of the double dot can easily be widely tuned. At low enough dot-lead tunneling rates detectable in real-time, a sharply defined diamond-shaped region centered between the (0,0) and the (1,1) triple points appears in the charge stability diagram, displaying metastable charge-state switching between (0,1) and (1,0) as a function of time. The diamond is repeatable and does not show hysteresis. The timescale of the switching-process depends strongly on the coupling to source and drain, while it appears independent of the inter-dot coupling. The bistability disappears at higher tunneling-rates, returning to the usual honeycomb structure, but is also seen for larger electron numbers, making it unlikely that it is caused by random impurities or charge traps in a device that otherwise displays excellent stability. Further, we can rule out co-tunneling, latching and charge-sensor back action effects. We are currently looking for a model, and are in particular considering Fermi edge singularity physics.

HL 88.7 Thu 18:00 EW 202

Large nuclear spin polarization in gate-defined quantum dots using a single-domain nanomagnet — •Gunnar Petersen[1], Eric A. Hoffmann[1], Dieter Schuh[2], Werner Wegscheider[2,3], and Stefan Ludwig[1] — [1]CeNS und Fakultät für Physik, Ludwig-Maximilians-Universität, München — [2]Institut für Angewandte und Experimentelle Physik, Universität Regensburg — [3]Solid State Physics Laboratory, ETH Zurich, Schweiz

Double quantum dots (QD) defined electrostatically in a two-dimensional electron system provide a versatile platform for investigating electron spin phenomena. In a GaAs based double QD system electrons are not completely isolated but weakly coupled to the host nuclei by hyperfine interaction. Such a coupling of electrons to a nuclear bath is common to a variety of material systems and gives rise to future applications in quantum information processing. For example, nuclear spins are a possible candidate for quantum memory[1]. Here we present experimental data demonstrating the manipulation of nuclear spins of the host material by hyperfine coupling to the electronic system. Nuclear polarization on the order of 50 percent is reached with the aid of a nanomagnet in the vicinity of the double QD. A phenomenological model is used to describe the dynamic build-up and decay of nuclear polarization. It provides a detailed understanding of the dynamic polarization process driven by electron-nuclear interaction.

[1] Morton, J. J. L. et al. Solid-state quantum memory using the (31)p nuclear spin. *Nature* **455**, 1085-1088 (2008).