HL 39 Quantenpunkte und -drähte: Transporteigenschaften I

Zeit: Montag 10:00–12:15 Raum: TU P-N202

HL 39.1 Mo 10:00 TU P-N202

Nonmonotonic charge occupation in double dots — •Jürgen König[1] and Yuval Gefen[2] — [1]Institut für Theoretische Physik III, Ruhr-Universität Bochum, 44780 Bochum, Germany — [2]Department of Condensed Matter Physics, The Weizmann Institute of Science, 76100 Rehovot, Israel

We study the occupation of two electrostatically-coupled single-level quantum dots with spinless electrons as a function of gate voltage. While the total occupation of the double-dot system varies monotonically with gate voltage, we predict that the competition between tunneling and Coulomb interaction can give rise to a nonmonotonic filling of the individual quantum dots. This non-monotonicity is a signature of the correlated nature of the many-body wavefunction in the reduced Hilbert space of the dots. We identify two mechanisms for this nonmonotonic behavior, which are associated with changes in the spectral weights and the positions, respectively, of the excitation spectra of the individual quantum dots. An experimental setup to test these predictions is proposed.
[1] J. König and Y. Gefen, cond-mat/0408691.

HL 39.2 Mo 10:15 TU P-N202

Kondo effect versus spin blockade — •D. Kupidura[1], M. C. Rogge[1], R. J. Haug[1], and W. Wegscheider[2] — [1]Institut für Festkörperphysik, Universität Hannover, D-30167 Hannover — [2]Angewandte und Experimentelle Physik, Universität Regensburg, D-93040 Regensburg

We report a competition between Kondo effect and spin blockade in a lateral quantum dot defined by local anodic oxidation on a GaAs/AlGaAs-heterostructure. We observe magnetically induced chessboard patterns in the conductance of our system what suggests Kondo correlations between electronic spins in the leads and an unpaired spin within the quantum dot. Thus the dot forms a spin singlet with the leads. Additionally we observe a spin blockade phenomenon, which is correlated with a spin polarization of the 2-dimensional leads in a magnetic field. This polarization destroys the spin up/spin down superposition of the Kondo singlet. Thus along with the onset of this spin blockade we find a suppression of the Kondo effect.

HL 39.3 Mo 10:30 TU P-N202

Transport through a quantum dot spin valve — •Matthias Braun[1], Jürgen König[1], and Jan Martinek[2] — [1]Theoretische Physik III, Ruhr-Universität Bochum, D-44780 Bochum — [2]Institut für Theoretische Festkörperphysik, Universität Karlsruhe, D-76128 Karlsruhe

We develop a theory of spin-dependent transport through a single-level quantum dot with strong Coulomb interaction, weakly coupled to ferromagnetic leads [1]. The theory explicitly allows for non-collinear lead magnetizations, as well as an externally-applied magnetic field.

We derive generalized rate equations for the dot's occupation and accumulated spin and discuss the influence of the dot's spin on the conductance of the device. The Coulomb interaction, generates an intrinsic source of spin precession, leading to negative differential conductance as well as a nontrivial dependence of the conductance on the angle between the lead magnetizations [1,2]. In addition, the applied magnetic field gives rise to the Hanle effect. We propose schemes [3] to observe these different precession mechanisms in transport experiments, and show, how to utilize them to determine the spin lifetime in the quantum dot.

[1] Matthias Braun et al., cond-mat/0404455 (2004)
[2] J. König et al., Phys. Rev. Lett. 90, 166602 (2003)
[3] Matthias Braun et al., cond-mat/0411xxx (2004)

HL 39.4 Mo 10:45 TU P-N202

Investigation of tunneling rates in quantum dots using a quantum point contact — •M. C. Rogge[1], C. Fricke[1], B. Harke[1], R. J. Haug[1], and W. Wegscheider[2] — [1]Institut für Festkörperphysik, Universität Hannover, D-30167 Hannover — [2]Angewandte und Experimentelle Physik, Universität Regensburg, D-93040 Regensburg

We present transport measurements on a coupled system including a quantum dot and a quantum point contact. We use a GaAs/AlGaAs heterostructure containing a two-dimensional electron system (2DES) 34 nm below the surface. The device is built using an atomic force microscope (AFM) for lithography. The lateral quantum dot and the quantum point contact are defined using local anodic oxidation (LAO). We investigate our device in a 3He/4He dilution refrigerator. We measure the transport through the quantum dot and at the same time use the quantum point contact as a charge detector. Thus we can still observe charge fluctuations on the dot in a regime, where the current through the dot is too low for transport measurements. In this regime we were able to investigate and compare the tunneling rates to source and drain leads. Thus we were able to find a symmetry line, on which the tunneling rates to both leads are equal. Keeping the tunneling rates symmetric, we were able to detect the change in charge induced by exited dot states in nonlinear measurements.

HL 39.5 Mo 11:00 TU P-N202

Investigation of spin blockade in a quantum dot using a quantum point contact as a charge detector — •C. Fricke[1], M. C. Rogge[1], B. Harke[1], F. Hohls[1], R. J. Haug[1], and W. Wegscheider[2] — [1]Institut für Festkörperphysik, Universität Hannover, D-30167 Hannover — [2]Angewandte und Experimentelle Physik, Universität Regensburg, D-93040 Regensburg

We show transport measurements in high magnetic field on a coupled system including a quantum dot and a quantum point contact. We use a GaAs/AlGaAs heterostructure containing a two-dimensional electron system (2DES) 34 nm below the surface. The lateral quantum dot and the quantum point contact (QPC) are defined by an atomic force microscope (AFM) using the local anodic oxidation (LAO). We perform our measurements in a 3He/4He dilution refrigerator with a superconductive magnet. Transport through the quantum dot and the quantum point contact are measured at the same time. We thereby use the QPC as a charge detector. Thus we can observe charge fluctuations on the dot with high sensitivity, even when the current through the dot is too low for transport measurements. At high magnetic field we observe spin blockade on the dot. In this regime charge redistributions due to the magnetic field lead to a change in the effective charge detected by the QPC.

HL 39.6 Mo 11:15 TU P-N202

Single electron quantum dots — •Daniel Schröer[1], Andreas K. Hüttel[1], Stefan Ludwig[1], Jörg P. Kotthaus[1], and Karl Eberl[2] — [1]CeNS und Sektion Physik, LMU München, Germany — [2]MPI f. Festkörperforschung, Stuttgart, Germany

We create lateral quantum dots by depleting the two-dimensional electron system of an AlGaAs/GaAs heterostructure using lithographically defined gold gates. An advantage of this lateral approach is the flexibility in number and geometry of leads and gates. Multiple quantum dots can be coupled capacitively or via tunnel barriers. The interdot coupling strengths and the number of electrons per dot are tunable by means of gate voltages. Here, we present measurements on a unique gate design that allows the definition of either a single or a double quantum dot in the few electron limit. By gradually adjusting the gate voltages, we observe a smooth transition from a single dot to a double dot. We quantify the decreasing interdot tunnel coupling using low frequency transport spectroscopy for one and two electrons. The electron number is verified with an additional quantum point contact. Further on, indications of Kondo effect and higher order tunneling processes are investigated in both the single and double dot regime.

HL 39.7 Mo 11:30 TU P-N202

Electrostatically defined single gate quantum dots — •C. Rössler[1], A. K. Hüttel[1], S. Ludwig[1], J. P. Kotthaus[1], and W. Wegscheider[2] — [1]CeNS und Department für Physik der LMU, 80539 München — [2]Institut für Angewandte und Experimentelle Physik, Universität Regensburg, 93040 Regensburg

We perform transport measurements on quantum dots (QD) defined by means of negatively biased gate electrodes on top of a AlGaAs/GaAs heterostructure. The two–dimensional electron gas (2DEG) is only 37 nm below the surface of our δ–doped sample. Conductance measurements in the Coulomb blockade regime, for example on a QD defined by three gates, are strongly affected by temporal charge fluctuations. Our layout contains one complex shaped gate. If biased sufficiently, it divides the 2DEG into two electrically isolated areas. At lower bias voltage, the geometry of this gate results in a QD beneath it, even if all other gates are grounded. This has been reproduced on three different samples. Strikingly, the transport properties of the single gate dot are undisturbed by the fluctuations. We investigate this QD in its few electron limit. The coupling to the leads depends strongly on the gate voltage which is the only control parameter. In the regime of strong coupling, we observe Kondo signatures and investigate its temperature and magnetic field dependencies.

HL 39.8 Mo 11:45 TU P-N202

Spektroskopie von Vielteilchen-Wellenfunktionen in selbstorganisierten InAs-Quantenpunkten — •Oliver Wibbelhoff[1], A. Lorke[1] und D. Reuter[2] — [1]Laboratorium für Festkörperphysik, Universität Duisburg-Essen, Lotharstr. 17, D-47048 Duisburg, Germany — [2]Lehrstuhl für angewandte Festkörperphysik, Ruhr-Universität Bochum, Universitätsstr. 150, D-44780 Bochum, Germany

Wir verwenden frequenzabhängige Kapazitäts-Spannungs-Spektroskopie um die Tunnelwahrscheinlichkeit von Elektronen in Quantenpunkten zu messen, die in eine Feldeffekt-Transistor-Heterostruktur [1] eingebettet sind. Der Wechselspannungsfrequenz folgend, tunneln die Elektronen zwischen den selbstorganisierten InAs-Quantenpunkten und einem hoch dotierten Rückkontakt hin und her. Eine zusätzliche Gleichspannung ermöglicht es eine Anzahl von 0 - 6 Elektronen in die InAs-Insel zu laden. Durch Anlegen eines zur Tunnelrichtung senkrechten Magnetfeldes und Messung des resultierenden Tunnelstroms kann der Impuls der tunnelnden Elektronen variiert und so die Aufenthaltswahrscheinlichkeiten im k-Raum ausgetastet werden [2]. Für die niedrigsten Energiezustände zeigt sich eine gute Übereinstimmung mit dem Modell eines harmonischen Potenzials, sowie eine Formanisotropie der Inseln entlang der <110> Kristallachsen. Die Vielteilchen-Wellenfunktionen der höherenergetischen Zustände zeigen eine Feinstruktur, die auf komplexe elektronische Wechselwirkungen hinweist.

[1] H. Drexler et al., Phys. Rev. Lett. 73, 2252 (1994).
[2] A. Patanè et al., Phys. Rev. B 65, 165308 (2002).

HL 39.9 Mo 12:00 TU P-N202

Spektroskopie an Quantenringen — •Chr. Notthoff[1], A. Lorke[1], O.S. Wibbelhoff[1] und D. Reuter[2] — [1]Festkörperphysik, Universität Duisburg-Essen, Lotharstraße 1, 47048 Duisburg — [2]Angewandte Festkörperphysik, Ruhr-Universität Bochum, Universitätsstr. 150, 44780 Bochum

Die Dispersion der Eigenzustände von Elektronen und Exzitonen im Einschlußpotential von selbstorganisierten InAs-Quantenringen in einer GaAs-Matrix werden mittels Kapazitäts-Spannungs- und Photolumineszenz-Spektroskopie unter dem Einfluß eines äußeren Magnetfeldes untersucht.

Die Quantenringe sind in einer MISFET-Struktur eingebettet, um sie der Kapazitäts-Spannungs-Spektroskopie zugänglich zu machen. Im Gegensatz zu der diamagnetischen Dispersion der Elektroneneigenenergien in Quantenpunkten zeigen Quantenringproben eine Struktur in der Dispersion der Elektroneneigenenergien, die auf einen Übergang der Drehimpulsquantenzahl der Elektronenwellenfunktion mit wachsendem Feld hinweist. Durch den Vergleich der experimentell bestimmten Magnetfeldabhängikeit mit numerischen Modellrechnungen kann der elektronische Radius der Quantenringe bestimmt und mit dem aus AFM-Messungen ermittelten Radius verglichen werden.

Die Dispersion der Exzitonen im Magnetfeld wurde mittels Photolumineszenz-Spektroskopie bestimmt. Hier zeigt sich ebenfalls eine Struktur in der Dispersion, was für nicht geladene Exzitonen zunächst nicht zu erwarten ist, jedoch durch polarisierte Exzitonen erklärt werden kann.