Kondo effect of a quantum dot in the mixed valence regime

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Quantum dots are high versatile and tunable devices and therefore give rise to the observation of many quantum effects in an controllable environment. Their investigation as magnetic impurities yielded the realization of an artificial Kondo system[1, 2, 3]. The Kondo effect describes the spin entanglement of a many-electron system, where a single localized spin on the quantum dot is screened by the delocalized electrons in the leads. A new ground state is formed with the binding energy T_K, the Kondo temperature.

We investigate the fingerprint of the Kondo effect, the so-called zero bias anomaly, in the regime of high tunnel coupling, where the coupling strength is comparable to the charging energy of the dot. Thus we enter the so-called mixed valence regime[1].

The sample consists of a two-dimensional electron system 37 nm below the surface. Using local anodic oxidation with an atomic force microscope a quantum dot with a diameter of about 150 nm is created[4]. Its energy level and tunnel coupling to the gates are controlled by three in-plane gates. Standard lock-in technique is used to perform transport measurements in a ^{3}He/^{4}He dilution refrigerator with a base temperature of about 20 mK.

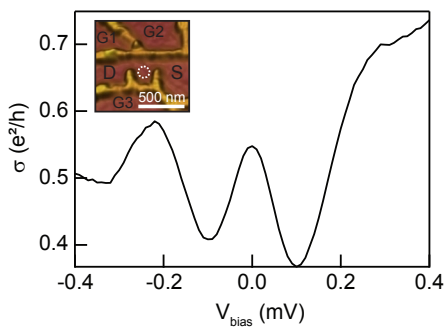

Figure 1: Differential conductance of the quantum dot as function of bias at $T = 20$ mK. Inset: AFM image of the sample.

The quantum dot is tuned into the mixed valence regime and the differential conductance is measured as function of bias and temperature. After subtraction of the background induced by broad Coulomb peaks we extract the Kondo temperature by analyzing the temperature dependence. Hence we fit results of numerical renormalization group calculations to the measurement data. The obtained Kondo temperatures are compared to values determined by investigating the width of the zero bias anomaly.

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