Spin-Resolved Single-Electron-Tunneling and Local Density of States Fluctuations in High Magnetic Fields

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Spin-polarized electronic transport has attracted wide interest with respect to future applications like spin transistors or spin valves. In this context spin relaxation and coherence play an important role. In our work, we present spin-resolved measurements of single electron tunneling via an individual localized state in double-barrier resonant tunneling devices.

The experiment was performed with a highly asymmetric double barrier resonant tunneling device grown by molecular beam epitaxy on n^+-type GaAs substrate. The heterostructure consists of a 10 nm wide GaAs quantum well sandwiched between two $Al_{0.3}Ga_{0.7}As$-tunneling barriers of 5 and 8 nm. The contacts are formed by 0.5 µm thick GaAs layers highly doped with Si up to $4\cdot10^{17}$ cm^{-3} and separated from the active region by 7 nm thin spacer layers of undoped GaAs. We carried out DC measurements of the I-V-characteristics in a dilution refrigerator at 20 mK base temperature in high magnetic fields up to 22 T.

In our experiment, we were able to measure the transport spectrum of a single localized state. We observed *spin splitting* of ground and excited states in our transport spectra. Fig. 1 shows a typical spectrum. The I-V curves were measured in the non-charging bias direction, that means we expected a single-particle spectrum. Clearly one observes spin splitting of the quantum levels. A comparison of different peaks yields the same effective g-factor $|g^*|=0.24$. We have analyzed the fluctuation pattern of the local density of states of the emitter[1] in the lowest Landau band for *different* peaks. We have evaluated a strong cross-correlation between the two fluctuation patterns of the local density of states. This indicates that both quantum levels belong to the same spectrometer scanning the local disorder of the emitter.

Moreover, we measured the temperature dependence of our sample for different magnetic fields. Additionally, in some samples we observed and analyzed in detail distorted Fock-Darwin spectra of single localized states with broken circular symmetry. The spectra exhibit lifted degeneracies and anticrossings. They were also studied with respect to different configurations of the magnetic field relative to the tunneling current.

References

[1] P. König., T. Schmidt, and R.J. Haug, Europhys. Lett. **54**, 495 (2001).

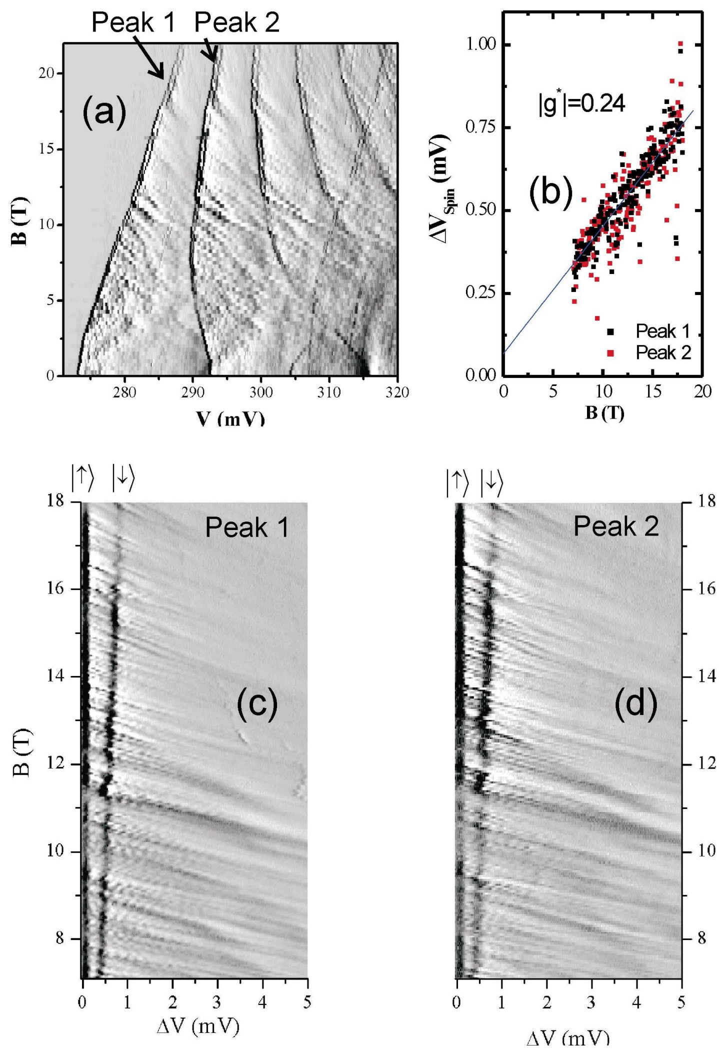

Fig. 1(a) shows a typical transport spectrum with the voltage-axis as the energy-scale of our system. The black lines indicate the evolution of the quantum levels with magnetic fields. For high magnetic fields one recognizes a fan-like formation of traces, which are the N=0 Landau–levels of our electron-system perpendicular to the magnetic field. Additionally, at high magnetic fields we find a Zeeman-splitting of our spin-degenerate quantum levels. In Fig. 1(b) we plotted the spin splitting voltage ΔV versus magnetic field for the first two peaks and extracted for both an effective g-factor $|g^*|=0.24$ according to a linear fit (straight line) assuming $\Delta V= g^*\mu_B B$. We present in Fig. 1(c) and (d) the contour plots of the differential conductance versus magnetic field and bias voltage, but in contradiction to Fig. 1 (a) we have aligned the map G(V,B) to the position of the spin-up component of the first (Fig. 1(c)) and second (Fig. 1(d)) conductance peak, which indicates the Fermi level of the emitter. We observe fluctuations in the differential conductance with a negative slope in the magnetic field, which we attribute to the fluctuations of the local density of states of the emitter[1].