Electron Spins in Few-Electron Lateral Quantum Dots

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We report on the realization of a few-electron double quantum dot (DQD) defined in a two-dimensional electron gas by means of surface gates on top of a GaAs/AlGaAs heterostructure. Quantum point contacts (QPCs) placed in the vicinity of the DQD serve as charge detectors. These enable determination of the number of electrons on the DQD, as shown in Fig.1. This number can be reduced to (0,0) while still allowing transport measurements through the DQD [1].

In a N=2 single QD, we observe the singlet to triplet ground state transition as a function of perpendicular magnetic field by large-bias spectroscopy (Fig. 2). High frequency pulse experiments (transient current spectroscopy) from excited triplet to the singlet ground state at 1.25 T reveal long spin relaxation times (T_1>5 μs).

Spin-qubit read-out schemes and ESR experiments are proposed that will give a bound on the decoherence time T_2 of a coherent superposition of the spin-up and spin-down state [2]. The experiments so far demonstrate that this quantum dot circuit can serve as a good starting point for a scalable spin-qubit system.

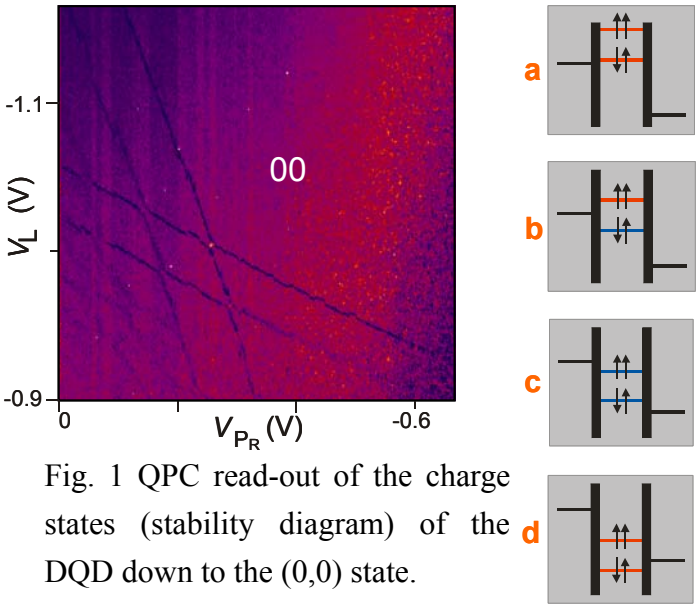

Fig. 1 QPC read-out of the charge states (stability diagram) of the DQD down to the (0,0) state.

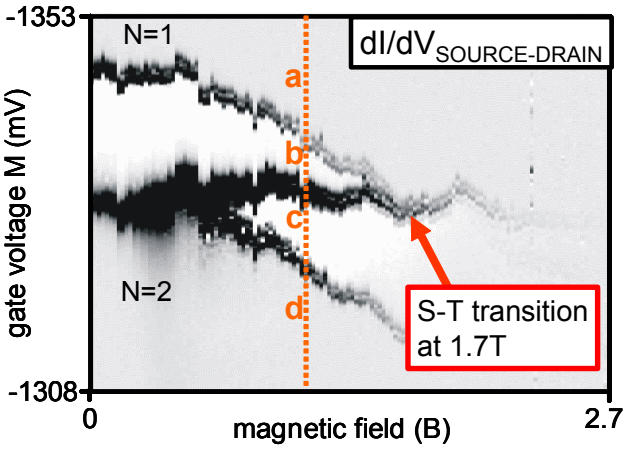

Fig. 2 Singlet-triplet transition in a N=2 single QD as a function of perpendicular magnetic field as observed by large-bias spectroscopy (V_{sd}=750 μV).

[1] J. M. Elzerman, R. Hanson, J. S. Greidanus, L. H. Willems van Beveren, S. De Franceschi, L. M. K. Vandersypen, S. Tarucha and L. P. Kouwenhoven, cond-mat/0212489 (2002)

[2] L. M. K. Vandersypen, R. Hanson, L. H. Willems van Beveren, J. M. Elzerman, J. S. Greidanus, S. De Franceschi, and L. P. Kouwenhoven, cond-mat/0207059, (2002)