Zeeman splitting and spin relaxation in a one-electron quantum dot

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We have measured the relaxation time, T_1, between Zeeman-resolved spin levels of a single electron confined in a GaAs/AlGaAs quantum dot. In a magnetic field, applied parallel to the 2-Dimensional Electron Gas in which the quantum dot is defined, the orbital states split due to Zeeman energy. At large fields the g-factor shows clear deviation from the bulk GaAs value of -0.44. By applying short pulses we can populate the excited spin state with one electron and monitor relaxation between the Zeeman sublevels. We find a lower bound for the spin relaxation time T_1 of 50 μs. The real T_1 may in fact be much longer than this lower bound. Even when the dot is subject to a continuous charge measurement, we find no clear decay of the excited spin state within our experimental time window. This indicates the promising potential of a single electron spin as a quantum bit.

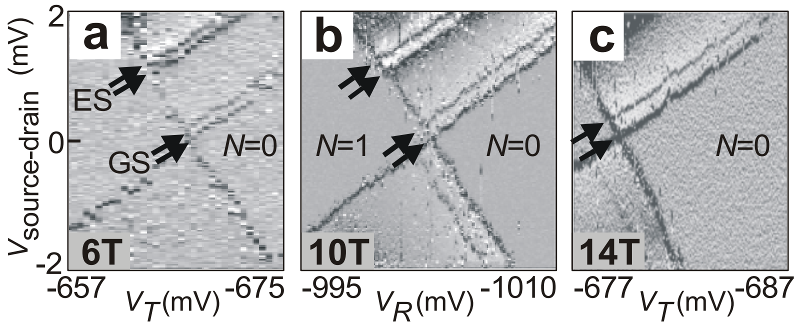

Fig. 1. dI/dV$_{source-drain}$ vs. V$_{source-drain}$ and gate voltage around the 0-to-1-electron transition at B = 6 T, 10 T, and 14 T showing the Zeeman splitting of the orbital ground state (GS) and excited state (ES).

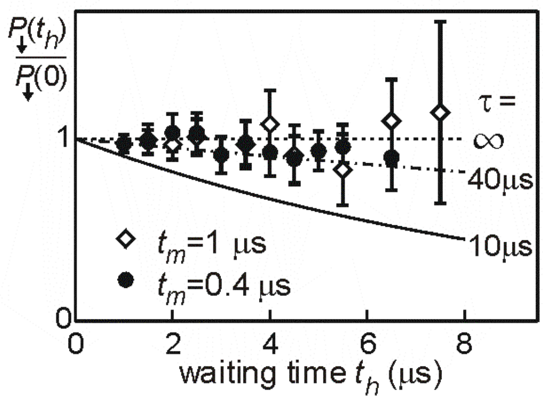

Fig. 2. Normalized probability that the electron spin did not relax from the spin-excited state, spin down, to the spin ground state, spin up vs. waiting time (B = 7.5 T). Data sets with different pulse settings are shown. The decay is clearly very slow.