Time resolved control of electron tunnelling times and single-shot spin readout in a quantum dot.


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Since the first report of a few electron lateral quantum dot about 10 years ago [1], there has been much focus on the application of these systems as spin qubits. A crucial technique for read-out of spin qubits has been the time resolved charge detection. In particular, emphasis has been placed on the DiVincenzo criteria and their individual demonstration. A crucial technique for this research has been the time resolved charge detection. This enabled, for example, single-shot single spin read out by Elzerman et al [2]. Surprisingly, to our knowledge, this important scheme has not yet been reproduced.

In this paper we reproduce this Delft protocol for single-shot single spin readout on one quantum dot within a triple quantum dot device (Fig.1) in a GaAs-AlGaAs heterostructure with neighbouring quantum point contacts as charge detectors, and extract the $T_1$ values at different magnetic fields, e.g., $\sim$300µs at 10T (see Fig. 2).

To enable such investigations, it is important to extract and control the tunnel times for different device gate voltage settings. We achieve this using two techniques : (i) A statistical approach for which the chemical potential of the dot is aligned with the reservoirs and (ii) An averaged gate pulsing scheme in which the N=0 to N=1 to N=0 transitions are induced by pulses. The first approach results in tunnel in and out times being approximately equal whereas (ii) results in very different times for tunnelling in and out due to the energy dependence of the tunnel barriers. Experimental results are compared with calculated spin relaxation times due to phonons [3], nuclear spins and electrons in leads.

References
3. M.Florescu et al. Physica E 22, 41