Single-Shot Readout of Singlet-Triplet Qubit States in a Si/SiGe Double Quantum Dot

Jon R. Prance[1], Zhan Shi[1], C. B. Simmons[1], D. E. Savage[1], M. G. Lagally[1], L. R. Schreiber[2], L. M. K. Vandersypen[2], Mark Friesen[1], Robert Joynt[1], S. N. Coppersmith[1], and M. A. Eriksson[1]

[1] University of Wisconsin-Madison, Madison, Wisconsin 53706, USA
[2] Kavli Institute of Nanoscience, TU Delft, Lorentzweg 1, 2628 CJ Delft, The Netherlands

The spin singlet and triplet states of a two-electron double quantum dot form the basis for a logical qubit that combines fast manipulation and a spin readout mechanism. In this talk we present measurements demonstrating single-shot readout of the two-electron spin states in a Si/SiGe double quantum dot [1]. The readout is achieved by using Pauli spin blockade to perform spin-to-charge conversion, and by measuring the charge state of the double dot in real time with a nearby quantum-point-contact charge sensor.

Using single-shot spin readout, we investigate the lifetimes of the two-electron spin states as a function of magnetic field. A statistical analysis of repeated single-shot measurements allows us to extract the rates of multiple relaxation processes simultaneously. At zero magnetic field we find that the four spin states (the singlet and three triplets) all have lifetimes of ~10ms. As the magnetic field increases, the lifetimes of the singlet state and the T_0 triplet state are unchanged, whereas the lifetime of the spin-polarized T_- triplet increases, reaching 3 seconds at 1T.

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References:

[1] J. R. Prance, et al., *"Single-Shot Measurement of Triplet- Singlet Relaxation in a Si/SiGe Double Quantum Dot,"* Phys. Rev. Lett. **108**, 046808 (2012). http://lanl.arxiv.org/abs/1010.5828

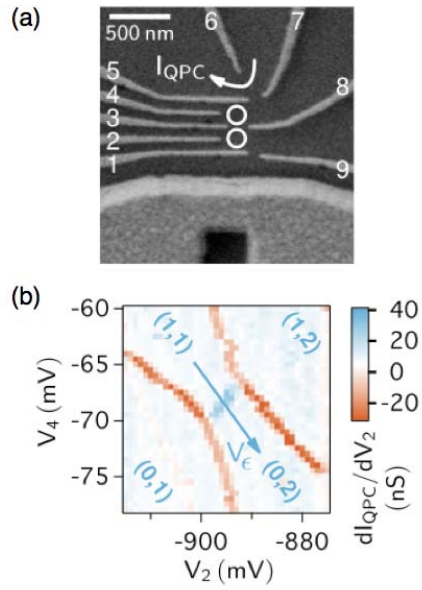

Figure 1. (a) Scanning electron micrograph image of a Si/SiGe double quantum dot. (b) Charge stability diagram of the double dot, detected my measuring the current I_{QPC} through the nearby quantum-point-contact charge sensor. The labels (n,m) denote regions in phase space where the upper dot contains *n* electrons, and the lower dot contains *m* electrons. The arrow labeled V_ε indicates the detuning axis, along which the energy levels on the two dots change in opposite senses. Reprinted with permission from Ref. [1]. Copyright (2012) by the American Physical Society.

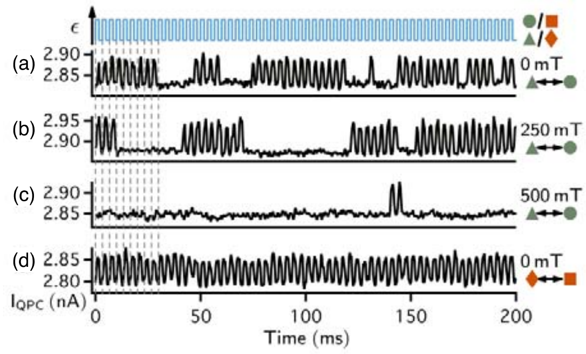

Figure 2. (a,b,c,d) Measurement of the current through the charge sensing quantum point contact as a function of time while a pulsed gate voltage is applied, as shown at the top. Charge transitions from the (1,1) charge state to the (0,2) charge state are possible only for the singlet state S in panels (a,b,c). In (d), either spin state may tunnel. The measurements thus show repeated, single shot readout of the spin state of the two-electron system. As the applied, in-plane magnetic field increases, the time the system spends in the triplet state increases, indicating slower T_- to S relaxation. Panel (d) serves as a control, demonstrating that the expected tunneling events occur anytime spin selection rules do not prevent tunneling of the triplet state. Reprinted with permission from Ref. [1]. Copyright (2012) by the American Physical Society.