Single-Shot Readout of Spin States in Si/SiGe Gated Quantum Dots

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Single-shot spin readout is an important resource for error-correction schemes involving quantum dot spin qubits. In this talk we review two recent experiments demonstrating single-shot readout of both one and two-electron spin states in Si/SiGe single and double quantum dots [1,2]. In both of these experiments, an energy difference between the two spin states of interest is used to generate spin-to-charge conversion, enabling the inference of the spin state of the system through the measurement of the charge occupation of the single or double dot. In the case of a single dot, we measure the one-electron spin-up and spin-down states. For the case of a double dot, we measure the two-electron spin-singlet and spin-triplet states. In each case, the single-shot measurement approach enables the extraction of T_1 relaxation times for the spin states involved.

We also show that the energy difference between the singlet and triplet states in a single Si/SiGe quantum dot can be tuned by controlling the gate voltages that define the device [3]. This tunability is useful for the manipulation of spin states in a newly proposed hybrid spin qubit [4].

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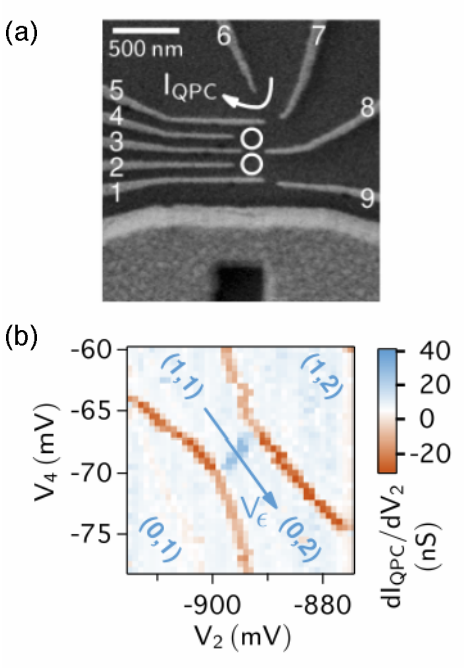

Fig. 1. (a) Scanning electron micrograph of a top-gated Si/SiGe double quantum dot. (b) Derivative of the current through a charge sensing quantum point contact, as labeled in panel (a). The electron occupations of the double quantum dot are superimposed on the data, and the detuning voltage V_ε is shown as the blue arrow. Reprinted with permission from Ref. [2]. Copyright (2012) by the American Physical Society.

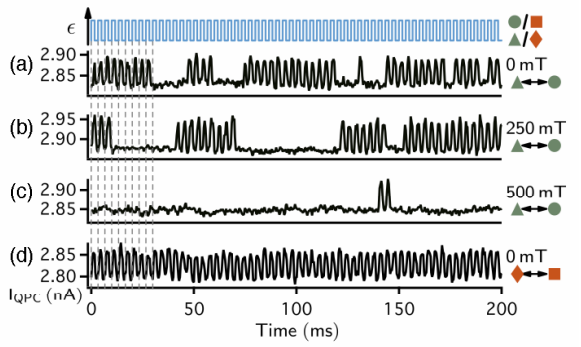

Fig. 2. (a,b,c,d) Measurement of the current I_{QPC} as a function of time in the presence of a pulsed gate voltage (shown at the top). Charge transitions from the charge state (1,1) to the charge state (0,2) are possible only for the singlet state S in (a,b,c). For (d), any spin state may tunnel. The measurements thus show repeated single shot readout of the spin state of the two-electron system for three different applied magnetic fields, labeled at the right. Panel (d) serves as a control, demonstrating that the expected tunneling events occur when spin selection rules do not prevent tunneling of the triplet state. Reprinted with permission from Ref. [2]. Copyright (2012) by the American Physical Society.