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Controlling a Singlet-Triplet Spin Qubit[1]

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An attractive candidate for a solid-state quantum bit is based on semiconductor quantum dots, which allow controlled coupling of one or more electrons, using rapidly switchable voltages applied to electrostatic gates [1]. Due to tight confinement and the high degree of isolation from the environment, spin relaxation times in quantum dots can approach millisecond timescales [2]. In this talk I will describe how fast electrical control of the exchange interaction can be used to coherently manipulate two-electron spin states [3]. By separating a spin singlet state on-chip, we measure an ensemble averaged spin dephasing time T_2^* of 10 ns, limited by the contact hyperfine interaction with the GaAs host nuclei. We develop quantum control techniques based on the exchange interaction to correct for hyperfine dephasing. Coherent spin state rotations are achieved, including spin SWAP. By using a spin-echo pulse sequence based on the exchange interaction we extend the spin coherence time, T_2 beyond 1.2 microseconds. The quantum control techniques demonstrated here are general and may be used to manipulate singlet-triplet spin qubits in carbon nanotubes, electrons on helium, and semiconducting nanowires.
In collaboration with A. C. Johnson, J. M. Taylor, E. A. Laird, A. Yacoby, M. D. Lukin, C. M. Marcus, M. P. Hanson, A. C. Gossard.

[1] J. R. Petta, A. C. Johnson, A. Yacoby, C. M. Marcus, A. C. Gossard, M. P. Hanson, Phys. Rev. B **72**, R161301 (2005).
[2] A. C. Johnson, J. R. Petta, J. M. Taylor, A. Yacoby, M. D. Lukin, C. M. Marcus, M. P. Hanson, A. C. Gossard, Nature **435**, 925 (2005).
[3] J. R. Petta, A. C. Johnson, J. M. Taylor, E. A. Laird, A. Yacoby, M. D. Lukin, C. M. Marcus, M. P. Hanson, A. C. Gossard, Science **309**, 2180 (2005).

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