Nanofabrication of singlet-triplet qubit in Si/SiGe quantum dots with integrated micromagnets

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Fabricating qubits composed of electrons in semiconductor quantum dots is a promising approach for the development of large scale quantum computer because of the approach's potential for scalability and for integrability with classical electronics. Electron beam lithography is used to pattern gates that can electrically confine a small number of electrons to within less than a hundred nanometers with controlled electron tunneling rates. The singlet-triplet (S-T_0) qubit, which consists of the $S_Z = 0$ subspace of two electrons, has attracted a great deal of attention. Coherent control of this qubit can be achieved by electrical gating only in the presence of a local magnetic field difference ΔB between two sides of the quantum dot. In this work, ΔB is generated from a proximal micromagnet, enabling much faster gate operation without introducing measurable ΔB noise, which is mainly due to nuclear spin fluctuations.

In this talk, I will present the operation and nanofabrication of the S-T_0 qubit in quantum dots in a silicon/silicon-germanium (Si/SiGe) heterostructure. Because the Si in the quantum well is ~95% nuclear spin zero, the quantum coherence time of this qubit is long (~0.35 μs). The two layers of electrostatic gates used to define the dots, and the micromagnets, rectangular thin films of cobalt, are both patterned by electron beam lithography. I will also present data demonstrating underdamped quantum oscillations around two different axes of the Bloch sphere, taking advantage of the beneficial properties of Si for maintaining quantum coherence, while simultaneously making use of the micromagnet for fast oscillations [1].

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[1] "Two-axis control of a singlet-triplet qubit with an integrated micromagnet." X. Wu, et al., *Proc. Natl. Acad. Sci.* **111**, 11938 (2014).