Coherence and Coupling of Two-Electron-Spin Qubits in GaAs

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Semiconductor spin qubits are promising candidates for quantum computation because of their slow decoherence and potential for scalability. All fundamental single qubit operations have been demonstrated for GaAs based spin qubits, but they suffer from decoherence due to hyperfine coupling to nuclear spins. We have developed effective techniques to mitigate this decoherence channel for two-electron spin qubits in double quantum dots.

By repeatedly inverting the qubit in a way that decouples its evolution from the fluctuations of the nuclear spin bath, its coherence time can be extended to more than 200 μs, two orders of magnitude longer than previously shown. Alternatively, operating the qubit as a feedback loop that controls the nuclear bath also enhances the coherence time and enables universal single qubit control with greatly improved gate fidelities.

Having achieved good single qubit control, a fundamental milestone toward quantum information processing is to couple qubits in order to generate entangling gates. We demonstrate a protocol to implement two-qubit gates using the Coulomb interaction between adjacent double dots while decoupling both qubits from slow electrical fluctuations. Preliminary results indicate that Bell states can be created with sufficient fidelity to demonstrate entanglement.

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