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High-fidelity entangling gate for double-quantum-dot spin qubits

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Electron spins in semiconductors are promising qubits, because their long coherence times enable nearly a billion coherent quantum gate operations. However, developing a scalable high-fidelity two-qubit gate remains challenging. We discuss a new entangling gate between two double-quantum-dot spin qubits in GaAs, which uses a magnetic field gradient between the two dots in each qubit to suppress decoherence due to charge noise. When the magnetic gradient dominates the voltage-controlled exchange interaction between electrons, qubit coherence times increase by an order of magnitude. Using randomized benchmarking, we measure single-qubit gate fidelities of approximately 99%, and through self-consistent quantum measurement, state, and process tomography, we measure an entangling gate fidelity of 90%. In the future, operating double quantum dot spin qubits with large gradients in nuclear-spin-free materials, such as Si, should enable a two-qubit gate fidelity surpassing the threshold for fault tolerant quantum information processing.