Superconducting Spin Qubits in Hole Quantum Dots

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Hybrid systems comprising superconducting and semiconducting materials are promising architectures for quantum computing. Superconductors induce long-range interactions between the spin degrees of freedom of semiconducting quantum dots [1,2]. These interactions are widely anisotropic when the semiconductor material has strong spin-orbit interactions such as for holes in Ge or Si [3]. We show that this anisotropy is tunable and enables fast and high-fidelity two-qubit gates between singlet-triplet (ST) spin qubits [4]. Our design is immune to leakage of the quantum information into non-computational states and removes always-on interactions between the qubits, thus resolving key open challenges for these architectures. Our spin qubits do not require additional technologically-demanding components nor fine-tuning of parameters. They operate at low magnetic fields of a few milli Tesla and are fully compatible with superconductors. In realistic devices, we estimate infidelities below 10^{-3}.

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