Repetitive Readout of a Single Electronic Spin via Quantum Logic with Nuclear Spin Ancillae

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Abstract

Robust measurement of single quantum bits plays a key role in the realization of quantum computation and communication as well as in quantum metrology and sensing. We have implemented a method for the improved readout of single electronic spin qubits in solid-state systems. The method makes use of quantum logic operations on a system consisting of a single electronic spin and several proximal nuclear spin ancillae in order to repetitively readout the state of the electronic spin. Using coherent manipulation of a single nitrogen vacancy center in room-temperature diamond, full quantum control of an electronic-nuclear system consisting of up to three spins was achieved. We took advantage of a single nuclear-spin memory in order to obtain a 10-fold enhancement in the signal amplitude of the electronic spin readout. We also present a two-level, concatenated procedure to improve the readout by use of a pair of nuclear spin ancillae, an important step toward the realization of robust quantum information processors using electronic- and nuclear-spin qubits. Our technique can be used to improve the sensitivity and speed of spin-based nanoscale diamond magnetometers.