Approaching ideal visibility in singlet-triplet qubit operations using energy selective tunneling-based Hamiltonian estimation

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Abstract

We report energy-selective tunneling readout-based Hamiltonian parameter estimation of a two-electron spin qubit in a GaAs quantum dot array. Optimization of readout fidelity enables a single-shot measurement time of 16 μs on average, with adaptive initialization and efficient qubit frequency estimation based on real-time Bayesian inference. By triggering the operation sequence conditional on the frequency detected in the probe step, we observed a 40-fold increase in coherence time without resorting to dynamic nuclear polarization. We also demonstrate active frequency feedback with quantum oscillation visibility, single-shot measurement fidelity, and state initialization fidelity up to 97.7%, 99%, and over 99.7%, respectively. By pushing the sensitivity of the energy-selective tunneling-based spin-to-charge conversion to the limit, the technique is useful for advanced quantum control protocols such as

error mitigation schemes, where fast qubit parameter calibration with a large signal-to-noise ratio is crucial.

Keywords : Spin qubit, Energy-selective tunneling readout, GaAs quantum dot

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