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Heat bath algorithmic cooling using electron-nuclear spin ensemble in the solid state: characterization of the open quantum system control KYUNGDEOCK PARK, ROBABEH DARABAD, GUANRU FENG, STEPHANE LABRUYERE , JONATHAN BAUGH, Institute for Quantum Computing, University of Waterloo, RAYMOND LAFLAMME, Institute for Quantum Computing, University of Waterloo, Perimeter Institute for Theoretical Physics — The ability to perform multiple rounds of Quantum Error Correction (QEC) is an essential task for scalable quantum information processing, but experimental realizations of it are still in their infancy. Key requirements for QEC are high control fidelity and the ability to extract entropy from ancilla qubits. Nuclear Magnetic Resonance (NMR) quantum processors have demonstrated high control fidelity with up to 12 qubits. A remaining challenge is to prepare nearly pure ancilla qubits to enable QEC. Heat Bath Algorithmic Cooling (HBAC) is an efficient tool for extracting entropy from qubits that interact with a heat bath, allowing cooling below the bath temperature. For implementing HBAC with spins, a hyperfine coupled electron-nuclear system in a single crystal is more advantageous than conventional NMR systems since the electron, with higher polarization and faster relaxation, can act as a heat bath. We characterize 3 and 5 qubit spin systems in gamma-irradiated malonic acid and present simulation and experimental results of HBAC to benchmark our quantum control. Two control schemes are compared: electron nuclear double resonance and indirect control of nuclei via the anisotropic hyperfine interaction.

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