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Toward dipole-phonon quantum logic with optimized sideband cooling

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The dipole-phonon interaction (DPI) between the permanent dipole of a diatomic molecular ion and the secular oscillation of the ion chain manifests as a Jaynes-Cummings-type interaction. When combined with quantum logic, this interaction can enable state preparation and measurement of quantum information encoded within a molecular ion [1,2]. Here, we report on our progress toward observing the DPI with a CaO+-Ca+ ion chain. To that end, we have demonstrated sympathetic sideband cooling to the ground state of motion and preservation of the motional state after adiabatic ramping of the secular frequency, which are both necessary prerequisites for the search for the DPI [3]. Moreover, we outline an experimental plan for observing the interaction despite low qubit subspace population at room temperature. Additionally, to improve the efficiency of the search for the DPI, we implement a comparative analysis of continuous and optimized pulsed sideband cooling and demonstrate the results experimentally with a Ca ion [4].

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