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Sisyphus cooling of Trapped Ions as a Route to Experiments in the Quantum Regime PAUL C HALJAN, SARA EJTEMAEE, Simon Fraser University — In a linear rf Paul trap, relaxing the transverse confinement can lead laser-cooled trapped ions to undergo a symmetrybreaking structural transition from a linear to a 2-D zigzag configuration. We are interested in exploring the dynamics near the linear-zigzag transition at ultralow temperatures, corresponding to a few quanta or less of thermal energy in the vibrations of the trapped ion crystal. In weaker traps, as in our case, the Lamb-Dicke limit is not strongly fulfilled through Doppler cooling, and Raman sideband cooling of the vibrational modes starting from Doppler temperatures becomes challenging. To resolve this, we have implemented 3-D Sisyphus cooling based on a polarization gradient field as an intermediate step to achieving near ground-state cooling of trapped Ytterbium ions. We have compared the performance of the polarization-gradient cooling of a single trapped ion to simulations, and have extended the technique to cool crystals of a few ions. We find Sisyphus cooling, which has so far not been widely used with trapped ions, to be a simple, robust technique that simultaneously cools all of the vibrational modes to well below the Doppler limit, and paves the way towards our experiments in the quantum regime.

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