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Prospects for laser cooling hundreds of ions using electromagnetically induced transparency in a Penning trap[1] ATHREYA SHANKAR, JILA Boulder, ELENA JORDAN, KEVIN GILMORE, NIST Boulder, ARGHAVAN SAFAVI-NAINI, JILA Boulder, JOHN J. BOLLINGER, NIST Boulder, MURRAY HOLLAND, JILA Boulder — The NIST Penning trap, with its ability to control planar crystals of tens to hundreds of ions, is a versatile quantum simulator to understand the dynamics of spin-boson and spin-spin models as well as to prepare and study ground states of exotic Hamiltonians. The combination of the trap potential and the inter-ion Coulomb interactions leads to coupled normal modes of motion, that can be used to engineer long-range spin-spin interactions. Thermal motion of the ions adversely affects the fidelity of state preparation protocols, and also degrades the quality of the dynamics under study. Laser cooling using electromagnetically induced transparency (EIT cooling) is attractive as an efficient way to quickly cool the transverse normal modes to near ground-state occupations before implementing quantum simulation protocols. We investigate the efficiency of EIT cooling of ions in the NIST Penning trap, accounting for the $\mathbf{E} \times \mathbf{B}$ drift-induced rotation of the ions as well as the complications arising from the simultaneous cooling of multiple normal modes. We show that, in spite of these challenges, the large bandwidth of transverse normal modes (hundreds of kilohertz), can be cooled to near ground-state occupations with cooling times of a few hundred microseconds.

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