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Dipolar and Dipole-Phonon Quantum Logic with Sympathetically Cooled Molecular Ions MICHAEL MILLS, GRANT MITTS, HAO WU, ELIZABETH WEST, CHRISTIAN SCHNEIDER, ERIC HUDSON, University of California, Los Angeles — We discuss new ideas for quantum logic using both dipole-dipole and dipole-phonon interactions between sympathetically cooled molecular ions and summarize our experimental efforts in realizing these quantum logic schemes. Rather than coupling qubits by their shared motion, we explore the prospect of using the dipole-dipole interaction between molecular ions. A static polarizing electric field can facilitate this dipole-dipole interaction in neutrals, but in an ion trap the time-averaged electric field experienced by an ion is zero. Instead, by creating a superposition of opposite-parity eigenstates, the time-dependent polarization mediates a dipole-dipole interaction. The use of such oscillating dipole moments dynamically decouples the dipoles from laboratory electric fields, including those of the ion trap. As such, this technique is relatively insensitive to anomalous heating in ion traps. Additionally, we consider the coupling of a dipole moment of a polar molecular ion with the phonon modes of a Coulomb crystal. When the transition frequency between two dipole states is similar to the normal mode frequencies in an ion trap, the interaction between dipole and phonons become important. This interaction can be utilized in a number of promising applications.

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