Abstract Submitted
for the DPP13 Meeting of
The American Physical Society

First principle simulations of phonons and thermal excitations of ultra-cold non-neutral ion plasmas in Penning traps DOMINIC MEISER, Tech-X Corp., BRIAN C. SAWYER, JOESPH W. BRITTON, JOHN J. BOLLINGER, NIST — Ultra-cold ions in Penning traps are a powerful platform for research in strongly correlated plasmas, quantum information, quantum metrology, and simulation of complex many-body problems of condensed matter theory. Thermal excitations of the ion crystals play a central role in these experiments. On the one hand, the motion associated with them is a limiting factor for the performance of current experiments. Better cooling of the ions could pave the way to new experiments. On the other hand, phonons are instrumental in some of the quantum simulation experiments because they allow one to engineer specific effective interactions between the spins of different ions. To better understand the phonons and thermal excitations in ultra-cold ion crystals we have carried out first principles molecular dynamics simulations. These simulations include a microscopic model for the laser cooling in addition to the cyclotron motion, trapping potentials, and Coulomb interactions between pairs of ions. We present results from these simulations on the stationary properties of planar ion crystals, phonon spectra and phonon mode structures, temperature of the phonon modes, and the dynamics of rearrangements of ions in the crystal.

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Date submitted: 12 Jul 2013 Electronic form version 1.4