Abstract Submitted
for the DAMOP19 Meeting of
The American Physical Society

Quantum simulations and force sensing experiments with 2D arrays of hundreds of trapped ions M. AFFOLTER, K.A. GILMORE, J.E. JORDAN, J.J. BOLLINGER, NIST - Boulder, A. SHANKAR, A. SAFAVI-NAINI, R.J. LEWIS-SWAN, A.M. REY, M. HOLLAND, JILA, NIST, U. Colorado — We summarize recent experimental work with 2D arrays of hundreds of trapped $^9Be^+$ ions stored in a Penning trap. The goal of this work is quantum simulations and sensing with large trapped ion crystals. For improved sensing and simulation fidelity, electromagnetically induced transparency (EIT) cooling has recently been implemented[1], with near ground state cooling observed for all the drumhead modes. Future experiments will investigate extending EIT cooling to 3D crystal arrays. We will also discuss recent improvements in the phase stability of the spin dependent, optical-dipole force, which enables new phase-coherent force sensing protocols, and the reduction of spontaneous emission in quantum simulation through parametric amplification. Preliminary force sensing experiments carried out with an rf tickle far from the axial center-of-mass (COM) mode show a single measurement enhancement of 2 over previous work[2]. On resonance with the COM mode, the projected electric field sensitivity is < 0.5 (nV/m)/$\sqrt{\text{Hz}}$, providing opportunities to search for dark matter such as axions and hidden photons.

[1]J.E. Jordan et al., https://arxiv.org/abs/1809.06346.
[2]K.A. Gilmore et al., Phy. Rev. Lett. **161**, 263602 (2017)

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Date submitted: 30 Jan 2019 Electronic form version 1.4