Abstract Submitted
for the DAMOP19 Meeting of
The American Physical Society

Quantum sensing with 2D arrays of trapped ions KEVIN GILMORE, MATTHEW AFFOLTER, ELENA JORDAN, JOHN BOLLINGER, NIST Boulder, ATHREYA SHANKAR, MURRAY HOLLAND, University of Colorado Boulder, ARGHAVAN SAFAVI-NAINI, University of Queensland — Quantum sensing protocols using trapped-ions can enable detection of extremely weak electric forces (<1 yN) and fields (<1 nV/m). We present experimental measurements that investigate the sensitivity with which weak electric fields can be detected through the excitation of the center-of-mass (COM) motion of a 2D ion crystal with 100s of ions. By coupling the mechanical motion of the ion crystal to the spin states of the ions by way of an optical potential, the displacement of the ion crystal can be read out via the spin state. Previous work demonstrated measurements of displacements as small as 50 pm, 40 times smaller than the ground-state wavefunction size. Recent experimental advancements – phase stabilization of the optical potential – have improved this sensitivity and will allow for using techniques such as spin squeezing and parametric amplification to make further improvements. Additionally, ground-state cooling via electromagnetically-induced transparency (EIT) enables performing these measurements resonantly with the COM mode (1.6 MHz) of the ion crystal, where we predict electric field sensitivities of ~1 nV/m or smaller. Electric fields of this size may be produced by some dark matter candidates. In particular, axion and hidden photon dark matter in the neV (MHz) regime has not been experimentally explored at this level.

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Date submitted: 30 Jan 2019 Electronic form version 1.4