Abstract Submitted
for the DAMOP20 Meeting of
The American Physical Society

Quantum sensing beyond the standard quantum limit with 2D arrays of trapped ions KEVIN GILMORE, MATTHEW AFFOLTER, ELENA JORDAN, NIST Boulder, ROBERT LEWIS-SWAN, DIEGO BARBERENA, ATHREYA SHANKAR, MURRAY HOLLAND, ANA MARIA REY, University of Colorado, Boulder, JOHN BOLLINGER, NIST Boulder — Quantum sensing protocols using trapped-ions can enable detection of weak electric fields (<1 nV/m) by sensing displacements surpassing the Standard Quantum Limit (SQL) the sensitivity achievable with a coherent state. We present experiments investigating the limits of electric field sensing via the excitation of the center-of-mass (COM) motion of 100s of ions in a 2D crystal. By coupling the mechanical motion of the ions to their spin states by way of an optical potential, the displacement of the ion crystal can be read out via the spin state. Recently, phase stabilization of this optical potential has improved the sensitivity by an order of magnitude. Probing on resonance with the COM mode provides the maximum sensitivity to electric fields. Using a scheme that cancels the thermal and zero-point motion ideally allows for detection of displacements ∼15 dB below the SQL. Currently, frequency fluctuations of the COM mode limit this sensitivity to ∼5 dB below the SQL. With future improvements, we predict electric field sensitivities of ∼1 nV/m. Electric fields of this size may be produced by dark matter candidates: 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: 27 Jan 2020 Electronic form version 1.4