Abstract Submitted
for the DAMOP15 Meeting of
The American Physical Society

Reversing Molecular Ion Formation for Quantum Simulations in a Coulomb Crystal of Be^+ Ions BRIAN SAWYER, JUSTIN BOHNET[1], JOSEPH BRITTON, JOHN BOLLINGER, Time and Frequency Div., NIST, Boulder, CO 80305 — For more than a decade, the internal states of cold, trapped atomic ions have been used as qubits for quantum logic operations. Penning traps allow for confinement and manipulation of very large ion crystals (>> 100) in 1D, 2D, or 3D configurations. Quantum simulation experiments with 2D crystals in Penning traps rely on engineered couplings between Be^+ internal spin and collective ion motion perpendicular to the crystal plane. High-fidelity quantum logic operations require precise knowledge of the crystal mode structure, but mode eigenfrequencies and eigenvectors can shift over time as impurity hydride ions (i.e. BeH^+) are formed in the crystal via chemistry with background H_2 molecules in the vacuum chamber. To mitigate this, we have demonstrated [1] a single-photon photodissociation scheme for BeH^+ that efficiently recovers Be^+ ions within the crystal. A commercial excimer laser operating at 157 nm provides the photodissociation light, and we note that a 193 nm excimer should efficiently recover Mg^+ and Al^+ from their respective hydride species, making this technique applicable to a wide range of ion species used in quantum information experiments.

[1] B.C. Sawyer et al., Phys. Rev. A 91, 011401(R) (2015).

[1]supported by a NIST-NRC Fellowship

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Date submitted: 30 Jan 2015 Electronic form version 1.4