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Towards Sub-Hertz Resolution Rotational Spectroscopy of a Single Molecular Ion ALEJANDRA COLLOPY, TARA FORTIER, National Institute of Standards and Technology Boulder, SCOTT DIDDAMS, DIETRICH LEIBFRIED, DAVID LEIBRANDT, National Institute of Standards and Technology Boulder, University of Colorado Boulder, CHIN-WEN CHOU, National Institute of Standards and Technology Boulder — We perform precision rotational spectroscopy and coherent quantum state manipulation [1] on a CaH^+ molecular ion. State preparation and readout are implemented through quantum logic operations on a co-trapped Ca^+ atomic ion. We coherently drive Raman transitions within or between rotational manifolds of the molecular ion with a 1051 nm fiber laser or a Ti:Sapph laser frequency comb, respectively. Completion of a certain molecular transition is heralded by a detectable state change of the Ca^+ ion. We currently achieve sub-100 Hz resolution of THz rotational transitions and anticipate achieving sub-Hz resolution by increasing the coherence of the frequency comb. A limitation of the accuracy of our rotational transition frequency measurements is the effect of the trap rf electric field. Such an electric field is unavoidable due to trap inhomogeneities and becomes more exaggerated for larger ion crystals. As a consequence of this rf field, we observe mixing of closely spaced (a few hundred Hz) states within rotational manifolds, as well as frequency shifts of rotational transitions. These shifts in turn allow us to derive a value of the molecular electric dipole moment. [1] C.-W. Chou et al. arXiv:1911.12808 (2019)

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