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Toward Nondestructive Single-Molecule Spectroscopy via Photon Recoil Readout[1] MARK KOKISH, VINCENT CARRAT, BRIAN ODOM, Northwestern Univ — Spectroscopy of rovibrational transitions in molecules can uniquely provide tighter constraints on the time variation of the proton-to-electron mass ratio. However, ultra-high precision spectroscopy requires control over each molecular degree of freedom. Here we present our progress toward developing a complete blueprint for manipulating the external and internal motion of a single aluminum monohydride cation (AlH^+). We have previously exploited the molecule's small vibrational branching ratios to achieve rovibrational ground state preparation via optical pumping. This property can be used again to perform nondestructive state readout. After preparing AlH^+ and a co-trapped Ba^+ ion in the ion trap's motional ground state via optical pumping, the Ba^+ acts as a sensitive detector to molecular motion. Such motion can be induced via repeated molecular photon recoil events, contingent upon absorption out of the molecule's ground vibrational state. This photon recoil readout conveniently makes possible nondestructive rovibrational spectroscopy to a metastable vibrational excited state. The initial conditions can then quickly be regenerated using optical methods.

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