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Achieving Single-Molecule Spectroscopy with Fast State Regeneration[1] VINCENT CARRAT, MARK G. KOKISH, BRIAN C ODOM, Northwestern University — Single atomic or molecular ions provide well-isolated systems suitable for high-precision spectroscopy, but require a large number of measurements in order to probe fundamental physics. However, this drawback can be mitigated by implementing high repetition rates using fast optical state preparation techniques. These techniques are available for atomic ions, but remain a challenge to implement for molecules. Following our previous demonstration of optical rovibrational cooling, we report our progress toward demonstrating fast rovibrational spectroscopy of a single AlH^+ ion. Adapting the recipe from quantum logic spectroscopy, we co-trap a single AlH^+ ion alongside a Ba^+ ion. Ba^+ serves as a coolant ion for ground motional state preparation and a means to detect the internal state of AlH^+. The internal state of AlH^+ can be transferred to Ba^+ through a series of momentum kicks induced by multiple absorption events, a process made possible by the highly diagonal Franck-Condon factors in AlH^+. After state readout, AlH^+ can then be returned to its ground rovibrational state via optical pumping for the next measurement. Since we are relying on fast optical manipulations, we aim to reach a repetition rate of at least several Hertz.

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