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Sympathetic cooling, cold chemistry, and spectroscopy of CaH+ molecular ions

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Molecular ions exhibit a rich internal structure attributed to their vibrational and rotational degrees of freedom. However, at room temperature, the rotational energy level populations are widely distributed due to black body thermalization, and the numerous decay pathways make direct laser cooling of molecules challenging at best, and impossible at worst. Therefore, we aim to demonstrate a novel technique for the sympathetic cooling of molecular ions by first sympathetically Doppler cooling molecular ions (CaH^+) with co-trapped atomic ions (Ca^+) and then sympathetically cooling the internal degrees of freedom to the rovibrational ground state with neutral atoms (K) in a 3D MOT [1, 2]. This experimental setup also facilitates the study of chemical reactions between these species at a fundamental level. We have observed photon-mediated charge exchange between Ca^+ and K and characterized the reaction channels [3], and we have obtained preliminary evidence of charge exchange between CaH^+ and K. To demonstrate sympathetic internal cooling, it is essential to probe the internal state of the molecular ions. For this purpose and precision spectroscopy applications, we have employed Resonance Enhanced Multi-Photon Dissociation (REMPD) method to conduct vibronic and rovibronic spectroscopy of CaH^+ in previous studies [4], and our ongoing efforts involve extending this technique to rotational spectroscopy of CaH^+. The control over chemical reactions along with rotational spectroscopy will allow us to demonstrate sympathetic ground state cooling of CaH^+.

References:

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