Quantum state control and precision spectroscopy of single molecular ions

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Over the past decades, atoms are trapped and laser cooled to near zero temperature, minimizing the motional effects in spectroscopy. Internal states of atoms can be coherently manipulated and prepared in pure quantum states, including entangled states that are impactful in quantum information processing, sensing, and metrology. This talk will describe the effort of the Ion Storage group at NIST in bringing molecular ions to equal footings with atoms in terms of state control and spectroscopic precision. The project builds on laser cooling and trapping techniques, frequency comb technology, and quantum-logic spectroscopy protocols nowadays routinely employed in cold-atom research and trapped ion optical clocks. That enables demonstrations, on single molecular ions, of coherent quantum state manipulation [1], nondestructive state detection [1-3], rotational [4, 5] and vibrational [6] spectroscopy with better than part-per-trillion resolution, and quantum entanglement [7]. The group is exploring new opportunities in physics and chemistry offered by the richer structure and broader species selections in molecules.

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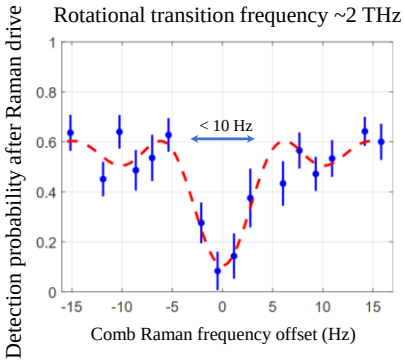

Fig.1. High-resolution rotational spectrum of CaH^+.

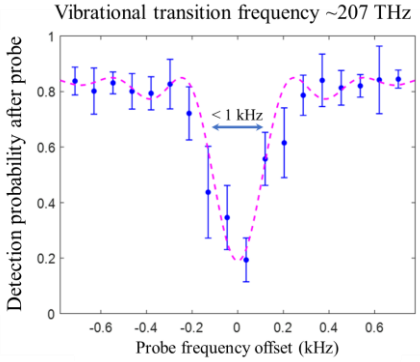

Fig.2. High-resolution vibrational spectrum of CaH^+.

References

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