High Precision, Sensitive, Near-IR Spectroscopy in a Fast Ion Beam

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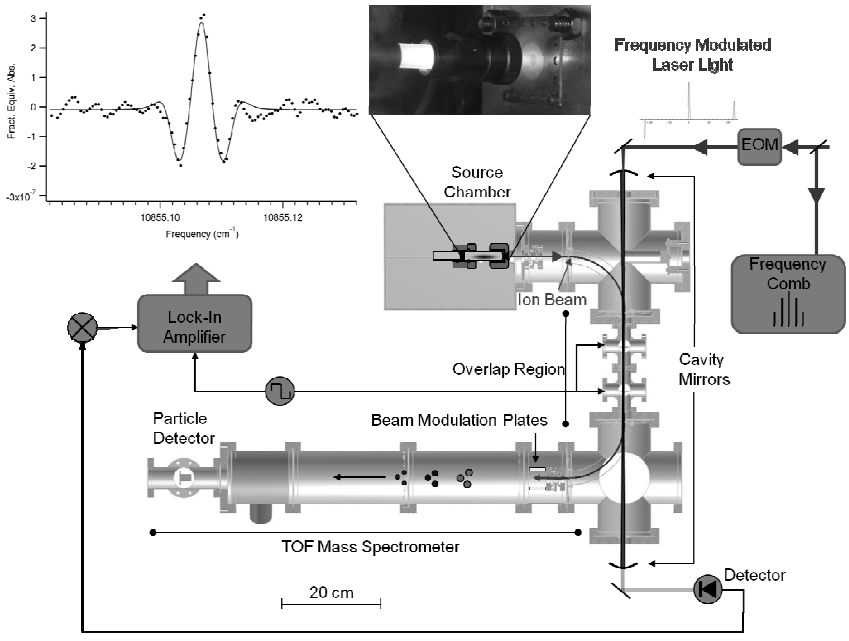
In the low temperatures and pressures of the interstellar medium (ISM), molecular ions play key roles as reactants and intermediates, as well as physical probes of the interstellar environment. As such, high resolution laboratory spectra of these ions aid in further understanding the chemistry and physics of the ISM. There are many challenges to high resolution molecular ion spectroscopy in the laboratory, though. To combat these challenges, we have built a fast ion beam spectrometer that possesses rigorous ion-neutral discrimination, high sensitivity and resolution, and mass identification capabilities. The primary components of the system are a cold cathode ion source, an electrostatic ion optical system for steering and focusing the extracted ion beam, an ion beam-laser overlap region where the spectroscopy takes place, and a time-of-flight mass spectrometer for mass studies of the ion beam. The spectra are obtained using a highly sensitive spectroscopic technique called Noise Immune Cavity Enhanced Optical Heterodyne Molecular Spectroscopy (NICE-OHMS). By calibrating the spectra with an optical frequency comb, line centers of transitions can be determined to <10 MHz. In the future, a supersonic expansion discharge source will take the place of the current cold cathode in order to create an ion beam with much lower rotational temperature.

We have recorded near-infrared rovibronic transitions of the 1-0 Meinel band of N_2^+ as a proof of concept of this setup. In addition to analyzing the lineshapes of the transitions, the line center of the $Q_{22}(14.5)$ line was determined to an accuracy of ~8 MHz. Presently, we are working to extend our ion beam spectroscopy to the study of mid-infrared vibrational transitions of other molecular ions using a Difference Frequency Generation (DFG) laser tunable from 2.8 to 4.8 μm.



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