CONTINUOUS SUPERSONIC EXPANSION DISCHARGE SOURCE FOR HIGH-PRECISION MID-INFRARED SPECTROSCOPY OF COLD MOLECULAR IONS

COURTNEY TALICSKA, MICHAEL PORAMBO, Department of Chemistry, University of Illinois at Urbana-Champaign, Urbana, IL, USA; BENJAMIN J. McCALL, Departments of Chemistry and Astronomy, University of Illinois at Urbana-Champaign, Urbana, IL, USA.

The low temperatures and pressures of the interstellar medium provide an ideal environment for gas phase ion-neutral reactions that play an essential role in the chemistry of the universe. High-precision laboratory spectra of molecular ions are necessary to facilitate new astronomical discoveries and provide a deeper understanding of interstellar chemistry, but forming ions in measurable quantities in the laboratory has proved challenging. Even when cryogenically cooled, the high temperatures and pressures of typical discharge cells lead to diluted and congested spectra from which extracting chemical information is difficult. Here we overcome this challenge by coupling an electric discharge to a continuous supersonic expansion source to form ions cooled to low temperatures. The ion production abilities of the source have been demonstrated previously as ion densities on the order of $10^{10}$-10$^{12}$ cm$^{-3}$ have been observed for H$_3^+$. With a smaller rotational constant and the expectation that it will be formed with comparable densities, HN$_2^+$ is used as a reliable measure of the cooling abilities of the source. Ions are probed through the use of a widely tunable mid-infrared (3-5 μm) spectrometer based on light formed by difference frequency generation and noise-immune cavity-enhanced optical heterodyne molecular spectroscopy (NICE-OHMS). To improve the sensitivity of the instrument the discharge is electrically modulated and the signal is fed into a lock-in amplifier before being recorded by a custom data acquisition program. Rovibrational transitions of H$_3^+$ and HN$_2^+$ have been recorded, giving rotational temperatures of 80-120 K and 35-40 K, respectively. With verification that the source is producing rotationally cold ions, we move toward the study of primary ions of more astronomical significance, including H$_2$CO$^+$.
