DEVELOPMENT OF A FAST ION BEAM SPECTROMETER FOR MOLECULAR ION SPECTROSCOPY

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For over twenty years, the technique of velocity modulation spectroscopy[a] has been a workhorse method for the study of molecular ions, because it discriminates between the absorptions of ions and those of neutral molecules, which are many orders of magnitude more abundant in typical positive column plasmas. Using velocity modulation, it has been possible to study molecular ions as large as $C_2H_3^+$,[b] but the study of larger molecular ions such as CH_5^+ or $C_3H_3^+$ has been difficult due to the large partition functions of these molecules at the relatively high ($\sim$300 K) temperatures in these plasmas. Supersonically expanding plasmas can produce molecular ions at much lower temperatures, but to our knowledge no techniques have yet been developed to eliminate the absorptions of neutral molecules in these plasmas.

A promising alternative to these techniques is direct absorption spectroscopy of a fast ion beam, as pioneered by the Saykally group[c]. Molecular ions can be produced in a variety of plasma sources (including a supersonic expansion) and then extracted, accelerated, and focused using electrostatic ion optics. The resulting fast ion beam can then be turned 90° by an electrostatic quadrupole, allowed to drift through a field-free region, and then turned another 90° into a mass spectrometer. The beam in the drift region can be spectroscopically probed in a collinear configuration, which offers the advantages of a reasonable path length, a very narrow linewidth, and a mass-dependent Doppler splitting (when bidirectional radiation is employed). We will describe the development and commissioning of our ion beam system, which we call SCRIBES (Sensitive, Cooled, Resolved Ion BEam Spectroscopy). Spectroscopic studies with this instrument will be discussed in the following talk.

[a] S. K. Stephenson & R. J. Saykally, Chem. Rev. 105, 3220 (2005)
[b] M. W. Crofton, M.-F. Jagod, B. D. Rehfuss, & T. Oka, J. Chem. Phys. 91, 5139 (1989)
[c] J. V. Coe, J. C. Owrutsky, E. R. Keim, N. V. Agman, D. C. Hovde, & R. J. Saykally, J. Chem. Phys. 90, 3893 (1989)