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STATE-TO-STATE ION-MOLECULE REACTION DYNAMICS AT THERMAL ENERGIES

Our application for the DURIP equipment grant was motivated by our need for a tunable UV pulsed laser source. Under our current research grant (AFOSR 89-0264) we are currently conducting three independent inquiries concerning the formation and reaction of molecular ions in the gas phase. In addition to our existing laser resources that we are applying to this work, we required an additional intense, narrow bandwidth source of tunable ultraviolet radiation. Spectra-Physics, as part of a package deal, agreed to sell us such a laser system for a system price of \$71,000, which we purchased using the DURIP equipment grant. This system has been shown to deliver over 30mJ per pulse of tunable light at 280 nm with a bandwidth as small as .08 wavenumbers. As another part of the package deal, Spectra-Physics agreed to work with us on the upgrade of our WEX-1 wavelength extension unit to accommodate a BBO crystal. This upgrade, when completed, will extend the wavelength range over which we can generate greater than 3 mJ per pulse to wavelengths as short as 200 nm. This part of the package will cost not more than \$7000.

The main goal of our research is to study the internal state dependence of ion-molecule reactions, and to determine the internal states of the various product channels. For this we require the ability to make state selected molecular ions. The technique of choice is resonance enhanced multiphoton ionization (REMPI). By choosing the frequency of our ionizing radiation, we are able to select the spin-orbit, vibrational and even rotational state distributions. This gives us the ability to study

what degrees of motion in the molecular ion enhance or inhibit reaction with neutral molecules. Naturally, we must be able to measure the internal state distribution of the ions formed by REMPI to pursue this goal.

We have been exploring two new methods to measure ion state distributions. The first is high resolution photoelectron kinetic energy spectroscopy. We have developed a technique to measure to a high degree of accuracy the energy and spatial distribution of photoelectrons ejected in the REMPI process. The energy analysis of the electrons directly gives us the leftover energy that resides on the newly formed ions. We have been able to measure rotational (as well as vibrational and spin-orbit) state distributions with this method. In addition, the measurement of the angular dependence of the ejection of photoelectrons has allowed us to examine the angular momentum transfer associated with the ionization process¹. This information presents us with the opportunity to test models of molecular ionization and will help develop our ability to predict *a priori* the rotational distribution of ions formed by REMPI. The photoelectron spectroscopy requires two independently tunable sources of ultraviolet radiation. The equipment acquired through this grant has greatly expanded our capability to study fundamental ionization dynamics.

In addition to the photoelectron spectroscopy, we are now conducting two color ionize/probe experiments. The first color effects a multiphoton ionization of HBr, creating HBr^+ in a selected vibrational/spin-orbit state. The second color probes the state distribution of the ions via laser induced fluorescence after a variable time delay. This allows the study of collisional relaxation and charge

transfer². Again, this experiment requires two independently tunable ultraviolet sources.

These experiments have been made possible by the acquisition of an additional source of tunable ultraviolet radiation. Under the continuing support of the Air Force Office of Scientific Research we will continue to apply our new equipment to study multiphoton ionization and ion molecule reactions.

¹ S. W. Allendorf, D. J. Leahy, D. C. Jacobs, and R. N. Zare, J. Chem. Phys., **91**, 2216 (1989)

² J. Xie and R. N. Zare, Chem. Phys. Lett., **159**, 399 (1989)

Publication Work	
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