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A description of charge-transfer studies of HCl+ in Xe using a mergingbeams technique is given. The work was performed under the Grant No. AFOSR-80-0244. Absolute and relative cross sections were obtained for collision energies from 0.01 to 870eV.

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LOW-ENERGY ATOMIC COLLISIONS

FINAL SCIENTIFIC REPORT FOR PERIOD

1 June 1980 - 30 September 1980

Grant No. AFOSR-80-0244

Sponsored By

Air Force Office of Scientific Research

Principal Investigator: Dr. R. H. Neynaber
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AFOSR Project Monitor: Dr. Ralph E. Kelley

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31 October 1980

The goal of this experimental program was to study selected chemi-ionization and ion-molecule reactions by merging-beams techniques to better understand the dynamics of such collisions and to provide data to assist in the formulation of theory. The relative energy of the reactants for these studies was varied from threshold to 10 or 20 eV.

These studies give a clearer picture of the role played by the kinetic and internal energy of reactants at low relative energies. This is important for the development of advanced Air Force systems that require communication through either a naturally or artificially ionized atmosphere, for the development of propulsion systems for the Air Force, and for advancing the technology of lasers.

ACCOMPLISHMENTS

During the four-month period of the present grant, absolute and relative cross sections Q were obtained for the charge-transfer reaction $HCl^+ + Xe \rightarrow HCl + Xe^+$. The reactants and products are in their ground electronic states, but HCl^+ and HCl may be vibrationally and rotationally excited. The studies were made by a merging-beams technique for a relative kinetic energy W of the reactants from nominally 0.01 to 870 eV. Relative Q and lab-energy distributions of Xe^+ indicate that (a) near-resonant charge transfer preceded by a capture, or orbiting, collision occurs for $0.01 \leq W \lesssim 0.6$ eV, (b) near-resonant charge transfer without capture occurs for $0.6 \lesssim W \lesssim 200$ eV, and (c) non-resonant charge transfer is dominant for $W \gtrsim 400$ eV. The near-resonant charge transfer is apparently fostered by the matching of electronic-vibrational-rotational energy levels of the entrance and exit channels. This results in the conversion of internal energy of HCl^+ into internal energy of HCl.

A paper has been written and submitted for publication (see below) on the study described above. In addition, the subject will be presented at the 12th Annual Meeting of the Division of Electron and Atomic Physics of the American Physical Society (see below).

PAPERS AND TALKS

Published Papers

R. H. Neynaber and S. Y. Tang, "Charge Transfer of HCl^+ in Xe," submitted to Physical Review for publication.

Talks

R. H. Neynaber and S. Y. Tang, "Charge Transfer of HCl^+ in Xe," to be presented at 12th Annual Meeting of the Division of Electron and Atomic Physics, University of Southern California, 1-3 December 1980.

PERSONNEL

R. H. Neynaber and S. Y. Tang have conducted the research for this contract.

USE OF RESULTS

Ion-molecule reactions such as charge-transfer are useful, for example, in the development of laser technology and in understanding atmospheric, nuclear weapons, and fusion reactor effects.

The charge-transfer studies for HCl^+ in Xe are relevant to the development of XeCl lasers. These lasers operate in the blue-green region of the visible

spectrum and are useful, for example, to certain naval operations. Researchers such as L. Champagne and L. Palumbo at the Naval Research Laboratory are trying to develop a XeCl laser. The charge-transfer reaction represents a loss mechanism for Xe, which otherwise could be used to generate the desired excimer $XeCl^*$.

It is interesting to note, as described above, that internal energy of HCl^+ is converted into internal energy of HCl by the charge-transfer reaction. The excited HCl can then dissociatively recombine with electrons to form Cl^-, i.e., $HCl^* + e \rightarrow H + Cl^-$. This would explain the observation of Cl^- in the laser medium by developers of the XeCl laser.