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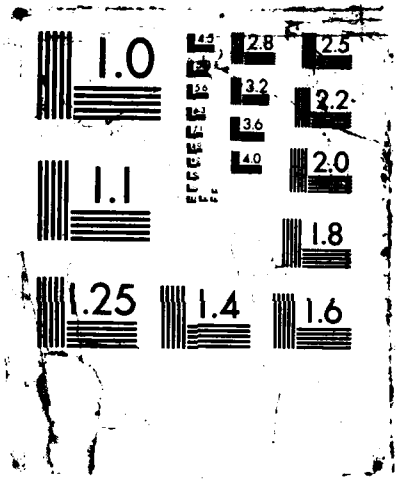
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A summary of research performed under AFOSR Contract No. F49620-86-C-0085 is given. The contract covered the period 1 July 1986 - 30 September 1987. The report describes measurements of ion-pair production cross sections for $He^*(2^{1,3}S)$-Li, Li-Cs, Li-Na, and Li-Na^*(3p) collisions at energies of several keV. Measurements of chemi-ionization cross sections for $He^*(2^{1,3}S)$-Li collisions are also mentioned. A method is described for exciting a fraction of the atoms in a Li vapor to the 2p resonance state using a dye laser. The fraction is determined by observing with the laser on and off the ion-pair production of Cl^- when a fast Cl beam collides with the vapor. Data have been taken, but not analyzed, for charge transfer in collisions of Li^- + Na(Na^*) and for ion-pair production involving the following species: $He^*(2^{1,3}S)$, Cs, Na, Na^*(3p), H, D, Li, and Li^*(2p).

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PROGRAM

The goal of the present program is to show the scientific feasibility of a new twist to an old approach for generating H^- and Li^- (as well as D^-, He^-, and O^-) beams. The H^- and Li^- will be the source of high energy (above ~ 1 MeV) H and Li beams. It is anticipated that this new scheme will result in more intense beams than the older method. The old method of producing negative ions begins with a source of positive ions to which two electrons are added by two charge-transfer (CT) processes. The processes occur in a vapor of ground-state (GS) atoms such as Sr or Cs. The new technique is basically the same except that the vapor consists of a mixture of GS and excited state atoms of Na or Li which is produced by laser excitation of the vapor. For Li^- production, for example, the first electron is added by CT in GS Na and the second by CT in excited Na. For H^-, both the first and second CT events could be in excited Na. We believe it is the second CT which favors the new approach and could increase negative ion production. The program is aimed at measuring cross sections and determining H^- and Li^- yields to ascertain which approach is best.

ACCOMPLISHMENTS

The research accomplished on Contract *F49620-86-C-0085 for the* period 1 July 1986 - 30 September 1987 is cited below.

1. We prepared a manuscript of our study of the associative and Penning ionization and the ion-pair production in the $He^*(2\,^{1,3}S)$-Li system. A paper has been published.

2. We completed studies of the reaction $Li + Cs \rightarrow Li^- + Cs^+$. This is the second of a three-step process which is advocated by some for production of Li beams of interest to the Air Force. Our cross-section measurements for this reaction will enable us to compare yields of Li^- using Cs with those employing laser excited Na, as suggested by us. A paper has been published on the Li-Cs reaction.

3. A beam-gas method was used to measure cross sections for ion-pair production of $Li^- + Na^+$ in collisions of Li-Na and Li-$Na^*(3p)$. The Li projectile energy range was from 1000 to 5500 eV. In this range the cross section for Li-$Na^*(3p)$ collisions was 10-200 times larger than that for Li-Na collisions. This is attributed to the laser excitation of Na. A paper has been published on the results.

4. A technique has been developed for exciting a fraction, f^*, of the atoms of a Li vapor into the 2p resonance state with a dye laser and measuring this fraction. The perfection of such a technique will allow us to assess the importance of a method of producing Li^- and $H^-(D^-)$ beams through the reactions $Na + Li^*(2p) \rightarrow Na^+ + Li^-$ and $H(D) + Li^*(2p) \rightarrow H^-(D^-) + Li^+$. The excitation of Li was accomplished by using a Coherent 599-21 dye laser pumped by an Innova 90-5 Ar ion laser to furnish radiation at 671 nm, the wavelength needed to excite Li from its 2s ground state to the resonance state. The Li vapor was generated in an existing cell equipped with a heating coil for vaporizing the Li and a thermocouple for measuring the cell temperature. Values of f^* approximating 0.1% were achieved. Such values will be sufficient to study the desired $Na-Li^*(2p)$ and $H(D)-Li^*(2p)$ reactions. The f^* were measured by passing a Cl beam through the cell and measuring the ion-pair production current of Cl^- with the laser on and off. The reactions are, thus, $Li(Li^*) + Cl \rightarrow Li^+ + Cl^-$. The value of $(1-f^*)$ is given by the ratio of the Cl^- current with the laser on to that with the laser off, because Cl^- is produced with ground-state Li but not with $Li^*(2p)$.

5. Some data have been taken for charge transfer in collisions of $Li^- + Na(Na^*(3p))$ and for ion-pair production in collisions of $He^*(2\,^{1,3}S) + Cs$, $He^*(2\,^{1,3}S) + Na(Na^*(3p))$, $H(D) + Na(Na^*(3p))$, and $H(D) + Li(Li^*(2p))$. The data have not been analyzed.

PUBLICATIONS

1. S. Y. Tang, D. P. Wang, and R. H. Neynaber, "Ion-Pair Production in Li-Cs Collisions," J. Phys. B19, L831 (1986).

2. S. Y. Tang, D. P. Wang, and R. H. Neynaber, "Ion-Pair Production and the Effect of Laser Excitation in Li-Na Collisions," J. Phys. B20, L85 (1987).

3. D. P. Wang, S. Y. Tang, and R. H. Neynaber, "Ion-Pair Production and the Effect of Laser Excitation in Na-Na Collisions," J. Phys. B20, 767 (1987).

4. D. P. Wang, S. Y. Tang, and R. H. Neynaber, "Ion-Pair Production and Chemi-ionization in Collisions of $He^*(2\,^{1,3}S)$ with Li," J. Phys. B20, 1527 (1987).

TALKS

1. D. P. Wang, S. Y. Tang, and R. H. Neynaber, "Chemi-ionization and Ion-Pair Production of $He^*(2\,^{1,3}S)$ with Li," Bull. Am. Phys. Soc. 31, 963 (1986).

2. S. Y. Tang, D. P. Wang, and R. H. Neynaber, "Ion-Pair Production in Li-Cs Collisions," Bull. Am. Phys. Soc. 32, 1168 (1987).

PARTICIPANTS

The participants in the research described above are Dr. R. H. Neynaber, Dr. S. Y. Tang, and Mr. D. P. Wang (graduate student).

USE OF RESULTS

The Air Force Weapons Laboratory at Kirtland Air Force Base, and, particularly, the Space Applications Group/AWYS, are interested in our results.

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