PROGRESS REPORT
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"Relativistic Atomic Beam Spectroscopy"
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This year major advances have been made in three areas: high-lying, doubly-excited resonance states in the H^- , the interaction of relativistic H^- ions with thin carbon foils and multiphoton photodetachment. We plan to pursue these studies further.

I. High-lying, doubly-excited resonance states

We have carefully studied four series of doubly-excited resonances in H^- photodetachment. Our energy resolution was 8 meV with an absolute uncertainty in the energy scale of 1 meV. Figure 1 displays partial photodetachment cross sections for H^- into $H^-(n)$: a: $n \geq 4$, b: $n \geq 5$, c: $n \geq 6$, d: $n \geq 7$. At least three resonances can be clearly seen converging on each of the thresholds $n=5, 6, 7$ and 8.

Remarkably, the energies of these resonances can be modeled mathematically by a simple quantum-defect formula.¹

Fig. 1. High-lying resonances in the $1P$ continuum of H^- .

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These experiments were the subject of a Ph.D. dissertation² by P.G. Harris which won the Louis Rosen Prize for the best dissertation at LAMPF in the previous year.

A proof of principle of a two laser beam extension of these measurements was completed this summer at LAMPF.

II. Interactions with thin carbon foils

The results of the passage of H^- ions, for beam energies ranging from 226 MeV to 800 MeV, through thin carbon foils, ranging in thickness from $14 \mu\text{g}/\text{cm}^2$ to $300 \mu\text{g}/\text{cm}^2$, have been studied. The physics is particularly interesting because the interaction times can be as small as 0.2 fs, a time range which, outside of individual atomic collisions, has not been previously investigated. Even the shortest laser pulses are many femtoseconds.

An electron spectrometer was used to field-ionize selectively H^- Rydberg states emerging from the foil for n values ranging between 9 and 17. The yields of low lying ($n=1$ to 5) hydrogen states were measured using a Doppler-tuned Nd:YAG beam to excite transitions to a Rydberg state which subsequently was field-ionized in the electron spectrometer and detected.

With the help of our Hungarian collaborators (Péter Kálman, Technical University Budapest, and János Bergou, now at Hunter College) much progress has been made with the theoretical understanding

The possibility of making very thin crystalline foils for further studies is being investigated by Károly Rózsa (Hungarian Academy of Science).

The foil studies were the subject of a Ph.D. dissertation³ by Amir Mohagheghi which was completed in early summer 1990.

III. Multiphoton photodetachment

Multiphoton measurements are especially difficult as the dependence on laser irradiance is very sensitive. Also, since the laser beam must be focused very tightly, beam overlap uncertainties present formidable problems. Nevertheless, we have some preliminary results using linearly polarized light for photon multiplicities ranging for 2 to 5, which we are currently attempting to compare with recent theoretical predictions.⁴

IV. Recent Refereed Publications

"Observation of Multiphoton Detachment of the H^- Ion", C.Y. Tang, P.G. Harris, A.H. Mohagheghi, H.C. Bryant, C.R. Quick, J.B. Donahue, R.A. Reeder, Stanley Cohen, W.W. Smith, J.E. Stewart, Phys. Rev. A., 39, 6068 (1989) (Rapid Communications.)

"Further Studies of H^- Photodetachment in Electric Fields", P.G. Harris, H.C. Bryant, A.H. Mohagheghi, C.Tang, J.B. Donahue, C.R. Quick, R.A. Reeder, S. Cohen, W.W. Smith, J.E. Stewart, C. Johnson. Phys. Rev. A. 41, 5968 (1990).

"Measurement and Reduction of Momentum Spread in the LAMPF LINAC Beam", P.G. Harris, H.C. Bryant, A.H. Mohagheghi, R.A. Reeder, C.Y. Tang, J.B. Donahue, C.R. Quick, D.C. Rislove, H. Sharifian, H. Tootoonchi, T.C. Altman. Nuclear Instruments and Methods A, 292, 254-258 (1990).

"Excitation of atoms passing through a TEM_{00} Gaussian laser beam at relativistic velocities", C.R. Quick, H.C. Bryant, Journal of the Optical Society of America B, 7, 708-714 (1990).

"Observations of High-Lying Resonances in the H^- Ion", P.G. Harris, H.C. Bryant, A.H. Mohagheghi, R.A. Reeder, H. Sharifian, C.Y. Tang, J.B. Donahue, C.R. Quick, D.C. Rislove, W.W. Smith, J.E. Stewart. Phys. Rev. Letters 65, 309 (1990).

V. References

1. H.R. Sadeghpour and Chris H. Greene, Phys. Rev. Letters, 65, 313 (90).
2. P.G. Harris, LA-11843-T Los Alamos Report 1990.
3. Amir Mohagheghi, Los Alamos Report, to be published.
4. C.Y. Tang, et al., Invited paper, International Conference on Multiphoton Processes ICOMPV, 9/24-28/1990, Paris.

VI. Other Group Publications

"Interaction of Relativistic H^- Ions With Thin Foils", A.H. Mohagheghi, H.C. Bryant, P.G. Harris, C.Y. Tang, C.R. Quick, R.A. Reeder, W.W. Smith, and J.E. Stewart, APS Spring Meeting in Washington, DC (1990), Post Deadline Paper.

"Multiphoton Detachment of Electrons from H^- " C.Y. Tang, H.C. Bryant, P.G. Harris, A.H. Mohagheghi, R.A. Reeder, H. Tootoonchi, C.R. Quick, S. Cohen, J.B. Donahue, H. Sharifian, W.W. Smith, J.E. Stewart. Bull. Amer. Phys. So., 35, 1150 (1990) BX35.

"Observation of High-Lying Resonances in the H^- Ion", P.G. Harris, H.C. Bryant, A.H. Mohagheghi, R.A. Reeder, H. Tootoonchi, C.Y. Tang, C.R. Quick, Stanley Cohen, H. Sharifian, W.W. Smith. Bull. Amer. Phys. Soc. 35, 1163 (1990) DX12.

VII. Talks by H.C. Bryant

Colloquium: Department of Physics, University of Wyoming, Laramie "Recent advances in the physics of the H^- Ion", February 27, 1990.

" H^- as a Quantum Mechanical Interferometer". Invited talk at the Foundations of Quantum Mechanics Workshop, Santa Fe, NM, May 29, 1990.

Seminar: Tungsram Factory, (GE) Budapest, "Atomic Physics at the Linear Accelerator at Los Alamos", June 6, 1990, 10:00 am.

Colloquium: University of Szeged, Szeged, Hungary. "The Physics of the H^- Ion". June 7, 1990.

Lecture: Institut für Experimentalphysik, Technische Universität Graz, Petergasse 16, "Experiments with 800 MeV H^- Ions", June 22, 1990, 3:30 pm.

"Recent Results for HIRAB", Invited talk at the 24th LAMPF Users Group Meeting, LANL, August 14, 1990.

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