

Final Report to the U.S. DOE
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Abstract

This document presents an overview of the results of the DOE's support of experimental research into the structure and interactions of the negative ion of hydrogen conducted by the Department of Physics and Astronomy of the University of New Mexico at the Los Alamos National Laboratory. The work involves many collaborations with scientists from both institutions, as well as others. Although official DOE support for this work began in 1977, the experiment that led to it was done in 1971, near the time the 800 MeV linear accelerator at Los Alamos (LAMPF) first came on line. Until the mid nineties, the work was performed using the relativistic beam at LAMPF. The most recent results were obtained using the 35 keV injector beam for the Ground Test Accelerator at Los Alamos. A list of all published results from this work is presented.

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noncommittal as to which electron is which. Nowadays, it is fashionable to refer to such a description as a case of "entangled states".

The above discussion of the quantum mechanics of two electrons falls under the rubric of the Pauli exclusion principle. Early in my career I had dreams of testing this principle for small violations, and had looked briefly into the spectrum of He for possibilities that the ground state of He could ever be in a triplet state. Triplet states are strictly forbidden by the Pauli principle when the two electrons are in the same spatial state. Although this idea was abandoned, and I published nothing on it, I was primed to jump into a study of the other fundamental two-electron system, the negative ion of hydrogen, when the opportunity arose.

The opportunity began to arise in 1970 when the linear accelerator at Los Alamos, LAMPF, Los Alamos Meson Physics Facility, came on line. This accelerator produced beams, on alternate halves of its rf cycle, of protons and H^- ions at kinetic energies up to 800 MeV. At the time I was working with a group² interested in producing pulsed neutron beams at up to 800 MeV to do time-of flight studies of n on p production of pions. The energy of the neutron was measured by its time of flight, using scintillators viewed with photomultipliers. The best time resolution one could get was about a nanosecond, with such a system, and, for this reason it was necessary to know the "birth-time" of the neutron that well. Neutrons produced in short (nanosecond) bursts separated by hundreds of nanoseconds were therefore required, and we were faced with the problem of how this could best be done.

It occurred to me that with a pulsed laser fired into the H^- beam, which consisted of 1/4 nanosecond pulses separated by 5 nanosecond intervals, we ought to be able photodetach all the ions in a single micropulse. The resulting isolated H^0 pulse could be directed onto a neutron-producing target, e.g. a liquid deuterium target, giving us our desired isolated burst of neutrons with a very narrow pulse duration.

Since I knew very little about atomic physics, I asked my colleague, Charles Beckel, what he thought the cross section for photodetachment from H^- was. He thought 10^{-17} cm^2 would be about right. After a brief back of the envelope calculation, I concluded that with a pulsed Nd:glass laser we could do the trick, and we submitted a proposal to the LAMPF Program Advisory Committee to make such a beam.³ We were thinking in terms of what we called a "photon target", in which we filled the region between two parallel mirrors with a photon pulse by multiple reflections, and directed an H^- beam through it.

² Under the sponsorship of the predecessor of the DOE, ERDA, H. C. Bryant, B. D. Dieterle, C. P. Leavitt, and D. Wolfe, E (29-2)-3347, 7/73-9/76.

³ Our research proposal, "Solitary Micropulses by Photodetachment of the H^- Beam" (LAMPF proposal 52) by H. C. Bryant, spokesman, C. P. Leavitt, B. D. Dieterle, John Doe (we were planning to hire another UNM faculty member who turned out to be David Wolfe), Alan Paxton, and Paul Lovoi, was acknowledged received by Louis Rosen, Director of LAMPF, April 1, 1971, approved for accelerator development on July 28, 1971, and approved as a LAMPF experiment on May 9, 1973.

The Program Advisory Committee, evidently a conservative group, was not convinced from the calculations in our proposal that it would work, and instead of giving us valuable beam time at LAMPF to try it, recommended that we do a proof of principle at the vertical Van de Graaff at Los Alamos, which produced a DC 4 MeV H⁻ beam of 4 microamps. With student, Paul Lovoi, and colleague Gerald Ohlsen, we set up a demonstration experiment which bore out our predictions very well.

Unfortunately, by the time we had proven our method would work, another way of producing solitary pulses, although not as cleanly, was invented using a pulsed electrostatic deflector. Our method was never used for its intended purpose, although it did give us our first paper on the subject⁴. Furthermore, I began to think about the possible atomic physics that might be done with this method.

It was not widely understood that the negative hydrogen ion had any structure in its photodetachment continuum, although theoretical evidence of the doubly-excited shape resonance associated with the first excited state of hydrogen had already been advanced.⁵ So in 1972 when we turned in a proposal to LAMPF for beam time to study H⁻, resonances were not mentioned. Our principal goal was to make a precision measurement of the H⁻ binding energy some ten times better than existing measurements.⁶ A research proposal to the NSF to fund this effort, was, like the one for beam time, declined.⁷ It is interesting to note that unlike our first proposal to make a pulsed neutron beam, the referees felt the experiment would work; they just did not think it was worth the effort.⁸ Calculations of ground state energies of two-electron systems were universally thought to be more precise and reliable than any feasible measurement. With the wind thus taken out of our sails we turned to other things.

In the Spring of 1974, spurred by the remarkable dips demonstrated in the photodetachment from negative alkali ions by Lineberger et al⁹, we realized that we had a unique technique that would allow us to look for resonances in the vacuum ultraviolet photodetachment continuum of the H⁻ ion.¹⁰

⁴ H. C. Bryant, P. A. Lovoi and G. G. Ohlsen, *Phys Rev Letters* **27**, 1628 (1971)

⁵ H. S. Taylor and P. G. Burke, *Proc Phys Soc, London*, **92**, 336 (1967) and J. Macek, *op cit*, page 365.

⁶ "A Measurement of the Electron Affinity of H⁰", LAMPF Proposal 128, H. C. Bryant, spokesman, B. D. Dieterle, C. P. Leavitt, D. M. Wolfe, P. A. Lovoi, G. G. Ohlsen, P. A. M. Gram, August 22, 1972. The PAC declined this proposal on February 5, 1973. "I am sorry to inform you that the PAC does not feel the physics motivation for this experiment warrants the beam time requested. "I do feel that the technique suggested is novel and should be explored...", Louis Rosen, Director of LAMPF.

⁷ "Studies of the Laser-Photodetachment of Electrons from a Relativistic H⁻ Beam", Submitted to the Nuclear Physics Program of NSF on December 19, 1972. Proposed starting date June 1, 1973, \$107,892 for 24 months. NSF declined this proposal on June 5, 1973.

⁸ "This proposal is an example of an individual who realizes that an amusing experiment is possible but fails to ask the question, 'Will we learn anything?'," Anonymous referee for NSF.

⁹ Reported in *Physics Today*, March 1974 pages 18, 19. See also T. A. Peterson et al, *Phys Rev Letters* **32**, 189 (1974) and D. W. Norcross, *Phys Rev Letters* **32**, 192 (1974).

¹⁰ Discussions with D. Norcross, C. Lineberger, J. Slater and J. Cooper at JILA were most helpful and encouraging at this point.

submitted to the LAMPF PAC¹⁵ and a proposal for funding was submitted to ERDA.¹⁶ Our experimental run in March 1977 revealed much richer structure than had been anticipated, and so on June 3, 1977, we submitted a proposal for beam time to increase the energy range of our measurements.¹⁷ In October 1978, we submitted a proposal to look above the two-electron threshold¹⁸. Over the years the list of proposals and the subsequent experiments continued to grow.¹⁹, as we expanded the scope of our research using the relativistic beam. There seemed to be no end of new ideas for experiments.²⁰

¹⁵ "Stark Effect Quenching of Resonances in the Photodisintegration of the H- Ion", LAMPF Proposal 323. Submitted November 29, 1976, H. C. Bryant and P. A. M. Gram, Spokesmen, J. Donahue, C. P. Leavitt, H. Sharifian, H. Tootoonchi, D. M. Wolfe, M. A. Yates-Williams. Approved by PAC Jan 22, 1977

¹⁶ "The Photodetachment Spectrum of H-", Submitted to the U. S. Energy Research and Development Administration, January 28, 1977. Requested starting date: June 1, 1977. Amount requested \$82,727. The proposal was awarded \$60,000 for the first year May 18, 1977.

¹⁷ "Survey of Photodetachment Cross Section of H⁻ from Threshold to 15 eV and Its Dependence upon Electric Field." LAMPF Proposal 337, June 3, 1977, H. C. Bryant and P. A. M. Gram, Spokesmen. Donahue, J. C. Pratt, H. Sharifian, H. Tootoonchi, M. A. Yates-Williams. PAC recommended 336 hours of beam time with 168 hours of tune up, on August 11, 1977.

¹⁸ "Survey of the Single and Double Photodetachment Cross Section of the H⁻ Ion from 14 to 21.8 eV", LAMPF Proposal 449, October 2, 1978, H. C. Bryant and J. B. Donahue, Spokesmen, D. Clark, C. Frost, P. A. M. Gram, J. C. Pratt, W. Smith, M. A. Yates-Williams, Approved January 1979.

¹⁹ "A Study of the Effects of Very Strong Electric Fields on the Structure of the H- Ion", LAMPF Proposal 586, June 20, 1980, H. C. Bryant and P. A. M. Gram, Spokesmen, K. B. Butterfield, D. A. Clark, C. A. Frost, J. B. Donahue, M. E. Hamm, R. W. Hamm, W. W. Smith.

"Fundamental Experiments with Relativistic Hydrogen Atoms: Exploratory Work", LAMPF Proposal 587, June 20, 1980. W. W. Smith and J. B. Donahue, Spokesmen, H. C. Bryant, K. B. Butterfield, D. A. Clark, C. A. Frost, P. A. M. Gram, D. Hamilton, M. A. Hamm, R. W. Hamm.

"A Search for Long-Lived States of the H₋ Ion", LAMPF Proposal 588, June 20, 1980, D. A. Clark and H. C. Bryant, Spokesmen, K. B. Butterfield, J. B. Donahue, C. A. Frost, P. A. M. Gram, M. E. Hamm, R. W. Hamm, W. W. Smith.

"High Velocity Search for Small Deviations from Special Relativity", LAMPF Proposal 1074, June, 1987, D. W. MacArthur and J. B. Donahue, Spokesmen, H. C. Bryant, Stanley Cohen, J. L. Hall, P. G. Harris, J. N. Knudson, W. H. McCulla, A. H. Mohagheghi, T. D. Nichols, C. R. Quick, Jr, R. A. Reeder, R. K. Sander, W. W. Smith, J. E. Stewart, C. Y. Tang, V. Yuan.

"Photodetachment of H- near Threshold in an Electric Field, "An Atomic Interferometer", LAMPF Proposal 1075, June, 1987, H. C. Bryant, R. A. Reeder, Spokesmen, D. A. Clark, Stanley Cohen, J. B. Donahue, P. G. Harris, J. N. Knudson, D. W. MacArthur, W. H. McCulla, A. H. Mohagheghi, T. D. Nichols, C. R. Quick, Jr, R. K. Sander, W. W. Smith, J. E. Stewart, C. Y. Tang, V. Yuan. On September 14, 1987 this experiment was awarded 250 hours of beam time.

"Interaction of Relativistic H- Ions with Matter", LAMPF Proposal 1076, June, 1987, Randy Reeder, Amir Mohagheghi, C. R. Quick, Jr, Spokesman, H. C. Bryant, D. A. Clark, Stanley Cohen, J. B. Donahue, P. G. Harris, J. N. Knudson, D. W. MacArthur, W. H. McCulla, T. D. Nichols, R. K. Sander, W. W. Smith, J. E. Stewart, C. Y. Tang, V. Yuan.

"A Search for Spontaneous Electric Fields in Near-Luminal Frames", LAMPF Proposal 1077, June, 1987, H. C. Bryant and D. W. MacArthur, Spokesmen, D. A. Clark, Stanley Cohen, J. B. Donahue, P. G. Harris, J. N. Knudson, W. H. McCulla, A. H. Mohagheghi, T. D. Nichols, C. R. Quick, Jr, R. A. Reeder, R. K. Sander, W. W. Smith, J. E. Stewart, C. Y. Tang, V. Yuan. The PAC declined this proposal on Sept 14, 1987.

²⁰ "High Excitations and Double Escape in the Negative Hydrogen Ion", LAMPF Proposal 1121, July 8, 1988, Joey B. Donahue and Philip G. Harris, Spokesmen, H. C. Bryant, Stanley Cohen, D. A. Clark, J. N. Knudson, Duncan MacArthur, A. H. Mohagheghi, C. R. Quick, Jr, R. A. Reeder, R. K. Sander, W. W. Smith, J. E. Stewart, C. Y. Tang, V. Yuan

"Multiphoton Detachment of Electrons from the H- Ion", LAMPF Proposal 1127, July 8, 1988, C. R. Quick and H. C. Bryant, Spokesmen, D. A. Clark, Stanley Cohen, Joey B. Donahue, Philip G. Harris, J. N.

YAG harmonic with a tunable dye beam. We also did fixed frequency multiphoton measurements.

Our most striking results in these low energy beam measurements were the observations of the singlet D resonance in both negative hydrogen and negative deuterium. We were able to observe an isotope shift whose magnitude we could attribute directly to electron momentum correlation. Our result is 2.1 standard deviations from what is expected from theory. The ball is now in the theorists' court²², although the laws of statistics do not signal an irreconcilable discrepancy. As far as we know, this is the first measurement of electron correlation, explicitly. This work also demonstrated that with the use of multiphoton techniques, essentially all of the singlet resonances are experimentally assessable.

Finally, most recently we have returned to an earlier mystery, which, in part, has motivated our work. Why is not the shape resonance seen in stellar spectra? With my colleague and former student, Stanley Cohen, we have been searching through astrophysical archives, available on the internet, with spectra in the appropriate vacuum ultraviolet wavelength region. A report of our search so far was given at the APS Centennial Meeting in Atlanta and is cited among the list of publications.²³

We tried to publish all of our results over the years. These publications are attached, and we urge the reader to consult them for the details. Of course, not all significant work was published, sometimes because of some fatal flaw that made it scientifically unreliable, and sometimes because it got left behind in our zeal to uncover new results. My students, collaborators and I still carry much in their heads from this experience, and hopefully more will be written in the future.

The dissertations written by the students supported by these grants, a list of which also attached, give perhaps the best perspective, as well as the "nitty gritty", on this work for they speak with many voices, and often give a very clear idea of the human as well as scientific aspects of this endeavor. I dedicate this report to my students with the sincerest of thanks for coming along with me with courage, energy and enthusiasm on our various adventures into the unknown. My other coworkers are legion; to these capable colleagues, whose names I leave to be discerned as authors on the list of publications appended, I offer heartfelt thanks. Finally I thank the Division of Chemical Sciences, Office of Basic Energy Sciences, Office of Energy Research of the U. S. Department of Energy²⁴ for their support, and **especially** I wish to thank **Dr. J. V. Martinez**, Fundamental Interactions Branch, who with his wise counsel and even-handed encouragement, has been along for the entire journey. *Mil gracias, Joe!*

²² In a recent (June 17, 1999) email Prof. Shi-I Chu at the University of Kansas writes "Dr. K.T. Chung and I have performed some precision two-electron calculations for the case of two-photon detachment of H through the singlet D state etc. It appears that the results are in excellent agreement with your experimental data published in PRL 75, 2924 (1995)". We have just sent him our isotopic shift data from PRA 58,1889 (1998) with erratum PRA 59, 906 (1999), and it remains to be seen if he will confirm the discrepancy.

²³ "A Search for Doubly Excited States of Extraterrestrial H", Stanley Cohen and H. C. Bryant, Bull Amer Phys Soc 44, 1122 (1999), Centennial Meeting, Atlanta, GA, March 20-26, 1999.

²⁴ Georgia McClelland, Oakland Operations, thank you for your help and patience.

Publications Resulting from this Work

Publications in Refereed Journals

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Comments

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Invited Papers

"Photodetachment Studies on a Relativistic H^- Beam, Invited talk at Atomic Physics Gordon Conference, July 4-8, 1977, Wolfeboro, New Hampshire. Not published.

"Photodetachment Studies on a Relativistic H⁻ Beam," Invited paper (30 minutes), 9th Annual Meeting of the Division of Electron and Atomic Physics, Knoxville, Tennessee, 5-7 December 1977, Bull. Amer. Phys. Soc. **22**, 1 Dec. 1977, p. 1319. H. C. Bryant.

"Time-resolved Beam Energy Measurements at LAMPF," IEEE Transactions on Nuclear Science, Vol NS-26, No. 3, June 1979, pp. 3291-3293. Also paper presented at 1979 Particle Accelerator Conference, Accelerator Engineering and Technology, San Francisco, California, March 12-14, 1979, by D. W. Hudgings. H. C. Bryant, D. A. Clark, C. A. Frost, J. Donahue, D. W. Hudgings, M. McNaughton and M. A. Yates-Williams.

"Studies of H⁻ Resonances in an Electric Field," Invited Review Talk 3A2, XI International Conference on the Physics of Electronic and Atomic Collisions, 29 Aug.-4 Sept. 1979, Kyoto International Conference Hall, Kyoto, Japan. Published in book, **Electronic and Atomic Collisions**, N. Oda and K. Takayangi, eds., North Holland, 1980. H. C. Bryant.

"Atomic Physics with Relativistic Beams," invited lecture presented by H. C. Bryant at the 7th International Conference on Atomic Physics, Aug 4-8, 1980, Massachusetts Institute of Technology. Published in in book **Atomic Physics 7**, Kleppner and Pipkin, eds., North Holland. H. C. Bryant, K. B. Butterfield, D. A. Clark, C. A. Frost, J. B. Donahue, P. A. M. Gram, M. E. Hamm, R. W. Hamm, W. W. Smith.

"Photodetachment of Relativistic Ions," IEEE Transactions on Nuclear Science **28**, 1203 (1981) presented by J. B. Donahue at Conference on the Application of Accelerators in Research and Industry, Denton, Texas, Nov. 3-5, 1980. J. B. Donahue, P. A. M. Gram, M. E. Hamm, R. W. Hamm, H. C. Bryant, K. B. Butterfield, D. A. Clark, C. A. Frost, W. W. Smith.

"Photodetachment Spectroscopy of the H⁻ ion," invited talk at US-Mexico Joint Seminar on the Atomic Physics of Negative Ions, presented by H. C. Bryant, April 1-4, 1981, La Mansion, Galindo, Mexico. H. C. Bryant, K. B. Butterfield, D. A. Clark, J. B. Donahue, P. A. M. Gram, R. W. Hamm, W. W. Smith. Published in **Notas de fisica Vol. 5**, Instituto de fisica, UNAM, Mexico, pages 265-281, Ignacio Alvarez and Carmen Cisneros, editors.

"Atomic Physics with Relativistic Beams," Atomic Physics Program Contractors' Workshop, US DOE, Argonne, IL, April 1-2, 1981. Presented by D. A. Clark.

"Recent Progress on Two-Electron Photodetachment of H⁻," invited talk at "Electron Scattering from Atoms and Atomic Ions," (a Satellite Symposium of the 1981 ICPEAC), NASA Goddard Space Flight Center, Greenbelt, MD 20771, July 23-24, 1981, presented by C. A. Frost. H. C. Bryant, K. B. Butterfield, D. A. Clark, J. B. Donahue, P. A. M. Gram, R. W. Hamm, W. W. Smith.

"Transverse diffusion of mass-identified ions in their parent gases," Invited paper presented by H. C. Bryant, published in **Proceedings of the 3rd International Swarm Seminar**, Innsbruck, Aug. 5-6, 1983 (Editors: W. Lindinger, H. Villinger and W. Federer). H. C. Bryant, G. Sejkora, P. Girstmair, M. Hesche, N. Duric, T. D. Mark. See also dissertation by Martin Hesche, "Experimentale Untersuchungen und Theoretische Analysen Diffusionskoeffizienten von Ionen in Gasen." 1985. I was one of his mentors at the University of Innsbruck, Austria. His advisor was Prof. Dr. T. Märk.

"Atomic Physics Near the Speed of Light," Invited Lecture (45 minutes) at **Symposium on Atomic and Surface Physics**, Maria Alm, Salzburg Jan. 29-Feb. 4, 1984 (not published). H. C. Bryant.

"Atomic Physics with Relativistic Beams," 25 minute lecture at U. S. DOE Atomic Physics Program Contractor's Meeting, April 26-27, 1984. National Bureau of Standards, Gaithersburg, MD. Abstract in NBS "Program and Abstracts", Atomic Physics Program Contractor's Workshop. H. C. Bryant.

"Observations of the Response of Near-Luminal H^0 and H^- Atoms to Magnetic Fields," 20 minute invited talk at Workshop on Atomic Spectra and Collisions in External Fields, National Bureau of Standards, Gaithersburg, Maryland, Oct. 22, 23, 1984. Published as a chapter in the book: **Atomic Excitation and Recombination in External Fields**, edited by M. H. Nayfeh and C. W. Clark. Gordon & Breach (1985), Chapter entitled "Simple Atomic Systems in Strong Electric Fields" by W. W. Smith, C. Harvey, J. E. Stewart, H. C. Bryant, K. B. Butterfield, D. A. Clark, J. B. Donahue, P. A. M. Gram, D. MacArthur, G. Comtet and T. Bergeman.

"Laser Photodetachment Studies of the H^- Ion in Strong Electric Fields," 30 minute presentation at **Lasers '84** (The Seventh International Conference on Lasers and Applications), San Francisco, Nov. 26-30, 1984. H. C. Bryant.

"Laser Spectroscopy with Relativistic Beams," invited paper (30 min), **International Laser Science Conference**, Dallas, Texas, Nov 18-22, 1985 (Session MJ). H. C. Bryant.

"Near Luminal H^- in Strong Fields," invited lecture, **International Symposium Atoms in Strong Fields**, Hotel Am Badersee, Grainau, FRG, Sept. 5-9, 1988. H. C. Bryant.

"The Spectroscopy of H^- ," 40 minute lecture at the **Workshop on Long Range Forces in Few Body Systems**, Vancouver, BC, Canada 28-30 June 1989. H. C. Bryant.

"Laser Spectroscopy of Relativistic Beams of H^- and H^0 : Observation of Electron Detachment from H^- by Multiphoton Absorption," **NICOLS '89** (New Hampshire, June 1989, presented by W. Smith). W. W. Smith, C. R. Quick, Jr., J. B. Donahue, S. Cohen, C. Y. Tang, P. G. Harris, A. H. Mohagheghi, H. C. Bryant, R. A. Reeder, H. Toutouchi, J. E. Stewart, H. Sharifian.

"Observation of Excited H^0 Atoms Produced by Relativistic H^- Ions in Carbon Foils," XVI ICPEAC "Hot Topic", July 31, 1989. NY (20 minutes), presented by H. C. Bryant, Published in book: **The Physics of Electronic and Atomic Collisions** (AIP Conference Proceedings 205). A. Dalgarno et al., eds. p. 487-491 (1990). A. H. Mohagheghi, P. G. Harris, C. Y. Tang, H. C. Bryant (presented paper), J. B. Donahue, C. R. Quick, R. A. Reeder, H. Sharifian, W. W. Smith, J. E. Stewart, H. Toutouchi, T. C. Altman, D. C. Rislove.

"Relativistic Hydrogen Systems," invited talk, Xth Atomic Physics Program Workshop, US DOE, Lawrence Berkeley Lab, Berkeley, CA, November 9, 1989, (9:45-10:10 am).

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

"Recent Results from HIRAB," invited talk at the 24th LAMPF Users Group Meeting, Los Alamos National Laboratory, August 14, 1990.

"Multiphoton Studies on a Relativistic Beam of H^- Ions," invited lecture, **International Conference on Multiphoton Processes (ICOMP V)**, Sept. 24-28, 1990. Paris, France. Published in in book **Multiphoton Processes** edited by G. Mainfray and P. Agostini. Service de

Physique des Atomes et des Surfaces, Centre d'Etudes de Saclay, 91191 Gif-sur-Yvette Cedex. 1990. pp. 69-78. C. Y. Tang, H. C. Bryant (presented paper), P. G. Harris, A. H. Mohagheghi, R. A. Reeder, H. Sharifian, H. Toutouchi, C. R. Quick, J. B. Donahue, Stanley Cohen, W. W. Smith.

"Relativistic Atomic Beam Spectroscopy," Invited lecture, XI DOE Atomic Physics Program Contractor's Workshop, November 15-16, 1990. (Sheraton Old Town) UNM and Sandia National Labs. (H. C. Bryant and Arlee Smith, organizers).

"Photodetachment of the H^- Ion," Invited paper at **11th International Conference on the Application of Accelerators in Research and Industry**. C. R. Quick, Jr. (presented paper), J. B. Donahue, Stanley Cohen, H. C. Bryant, C. Y. Tang, P. G. Harris, A. H. Mohagheghi, R. A. Reeder, H. Sharifian, H. Toutouchi, W. W. Smith, 5-8 November, 1990. Published in book of invited papers.

"High-Lying Resonances in H^- ," P.G. Harris (presented paper) H. C. Bryant, A. H. Mohagheghi, C. Y. Tang, J. B. Donahue, C. R. Quick, R. A. Reeder, H. Sharifian, W. W. Smith, J. E. Stewart, H. Toutouchi, T. C. Altman, D. C. Rislove. H^- Workshop, UNM, January 1990.

"Multiphoton Detachment of Electrons from H^- ." C. Y. Tang (presented paper), C. R. Quick, H. C. Bryant, S. Cohen, J. B. Donahue, P. G. Harris, A. H. Mohagheghi, R. A. Reeder, H. Sharifian, W. W. Smith, J. E. Stewart, H. Toutouchi. Ibid.

"Interaction of Relativistic H^- Ions with Thin Foils," A. H. Mohagheghi (presented paper), H. C. Bryant, P. G. Harris, R. A. Reeder, H. Tootoonchi, C. Y. Tang, C. R. Quick, Stanley Cohen, H. Sharifian, W. W. Smith, J. E. Stewart. Ibid.

"Atomic Physics at the SSC," H. C. Bryant. Invited Lecture at the **Third U.S.-Mexico Atomic and Molecular Physics Symposium**, Hotel Hacienda Cocoyoc, Mexico. March 13-16, 1991. Published as chapter in book **Atomic and Molecular Physics**, C. Cisneros, T. J. Morgan and I. Alvarez, Eds. World Scientific, 1991 pp. 253-265.

"A Survey of Doubly-Excited Resonances in the H^- Photodetachment Continua," **1991 Atomic Physics Gordon Conference**, July 1-5, 1991, Brewster Academy, Wolfeboro, New Hampshire.

"Some simple aspects of H^- resonances in electric fields," **Workshop on Autoionizing Resonances in Electric Fields**, Boulder, Colorado (JILA). August 5-8, 1991. (40 minutes).

"Progress in H^- Spectroscopy," H. C. Bryant, (30 minutes) **44th Annual Gaseous Electronics Conference**, 22-25 October, 1991, Albuquerque, NM.

"Progress in the Study of H^- ," (40 minutes) **Workshop on New Developments and Challenges in Two-Electron Atoms and Ions**, JILA, Boulder, CO, July 22, 1992.

"Atomic Physics at Fermilab," H.C. Bryant, (40 minutes) Proceedings 400 MeV Beam International Conference, Fermilab, October 24-27, 1993, Carol Johnstone, Editor. FNAL, Batavia, IL

"Modeling Multiphoton Measurements on H^- ," H. C. Bryant, Invited Lecture at the **Fourth U.S.-Mexico Atomic and Molecular Physics Symposium**, Hotel Antigua Hacienda de Galindo, San Juan del Rio, Queretaro, Mexico. December 7-10, 1994,. Published with coauthor E. P.

MacKerrow as chapter in book **Atomic and Molecular Physics**, I. Alvarez, C. Cisneros, and T. J. Morgan, Eds., 1995, World Scientific Publishing Company. ISBN: 981-02-2370-6

"H⁻ Spectroscopy", H. C. Bryant, (30 minutes), XVI Atomic Physics Program Contractors' Workshop of the Department of Energy, Office of Basic Energy Sciences, Division of Chemical Sciences, Nov 4, 1995, San Antonio, Texas. Published in Book of Abstracts, p53-56.

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"Studies of H⁻ Resonances in an Electric Field," H. C. Bryant, Pages 145-160, in **Electronic and Atomic Collisions** (Kyoto XI ICEAC 1979), N. Oda and K. Takayangi, eds., North Holland, 1980, (ISBN 0-444-854-7)..

"Atomic Physics with Relativistic Beams," H. C. Bryant, K. B. Butterfield, D. A. Clark, C. A. Frost, J. B. Donahue, P. A. M. Gram, M. E. Hamm, R. W. Hamm, W. W. Smith, Pages 29-63, in **Atomic Physics 7**, Kleppner and Pipkin, eds., Plenum Press, NY and London, 1981, (ISBN 0-306-40650-0)

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"Simple Atomic Systems in Strong Electric Fields" by W. W. Smith, C. Harvey, J. E. Stewart, H. C. Bryant, K. B. Butterfield, D. A. Clark, J. B. Donahue, P. A. M. Gram, D. MacArthur, G. Comtet and T. Bergeman, in **Atomic Excitation and Recombination in External Fields**, edited by M. H. Nayfeh and C. W. Clark. Gordon & Breach, 1985

"An Atomic Interferometer," H. C. Bryant, in **Atomic Spectra and Collisions in External Fields**, K. T. Taylor, M. H. Nayfeh and C. W. Clark, eds, Plenum Press, New York and London, 1989. pp 177-185, (ISBN 0-306-43147-5)

"Observation of Excited H⁰ Atoms Produced by Relativistic H⁻ Ions in Carbon Foils," A. H. Mohagheghi, P. G. Harris, C. Y. Tang, H. C. Bryant, J. B. Donahue, C. R. Quick, R. A. Reeder, H. Sharifian, W. W. Smith, J. E. Stewart, H. Toutouchi, T. C. Altman, D. C. Rislove, in **The Physics of Electronic and Atomic Collisions** (AIP Conference Proceedings 205). A. Dalgarno et al., eds, p. 487-491, 1990. (ISBN 0-88318-390-0)

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"Atomic Physics at the SSC," H. C. Bryant, Chapter VI.4 in **Atomic and Molecular Physics**, C. Cisneros, T. J. Morgan and I. Alvarez, eds. World Scientific, 1991 pp. 253-265. (ISBN 981-02-0843-X)

"Modeling Multiphoton Measurements on H⁻", H. C. Bryant and E. P. MacKerrow in **Atomic and Molecular Physics**, I. Alvarez, C. Cisneros, and T. J. Morgan, eds., 1995, World Scientific Publishing Company, pp. 144-163. Drawing on page vii by HCB. (ISBN: 981-02-2370-6)

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"Relativistic Neutral Hydrogen Beams", H. C. Bryant and Edward P. MacKerrow, Chapter 8, p. 181-212, in AIP Press Instrumentation Series: **Accelerator-Based Atomic Physics Techniques and Applications**, editors S.M. Shafroth and J.C. Austin (Univ of NC at Chapel Hill) 1997, (ISBN 1-56396-484-8)

ABSTRACTS OF CONTRIBUTED PAPERS

"Observation of Resonances in the Photodetachment Cross Section of the H^- Ion Near 11 eV," presented by H. Tootoonchi at the Southwest Regional Conference for Astronomy and Astrophysics, May 22-23, 1977, Austin, Texas. J. Donahue, P. A. M. Gram, J. C. Pratt, M. A. Yates-Williams, H. Tootoonchi, H. Sharifian, H. C. Bryant. Published in proceedings.

"Preliminary Results of a Measurement of the H^- Photodetachment Cross Section in the Continuum Region," presented by H. Sharifian at the Southwest Regional Conference for Astronomy and Astrophysics, May 22-23, 1977, Austin, Texas. H. C. Bryant, J. Donahue, P. A. M. Gram, J. C. Pratt, M. A. Yates-Williams, H. Tootoonchi and H. Sharifian. Published in proceedings.

"The Effect of Electric and Magnetic Fields Upon Resonances in the H^- Photodetachment Cross Section," presented by P. A. M. Gram at the International Conference on Multiphoton Processes, Rochester, June 6-9, 1977. H. C. Bryant, J. C. Pratt, M. A. Yates-Williams, J. Donahue, H. Sharifian, H. Tootoonchi.

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"Survey of Resonance Region in the H^- Photodetachment Cross Section," presented by M. E. Hamm, paper AF10, Bull. Amer. Phys. Soc. 24, 561 (1979). M. E. Hamm, J. Donahue, P. A. M. Gram, J. C. Pratt, M. A. Yates-Williams, H. C. Bryant, D. A. Clark, C. A. Frost, H. Sharifian, H. Tootoonchi, W. W. Smith.

"Energy Measurements of the H^- Beam at LAMPF," presented by D. A. Clark, paper HM11, Bull. Amer. Phys. Soc. 24, 670 (1979). D. A. Clark, H. C. Bryant, C. A. Frost, J. Donahue, P. A. M. Gram, M. E. Hamm, D. W. Hudgings, M. McNaughton, J. C. Pratt, M. A. Yates-Williams, W. W. Smith.

"Stepwise Laser Photodetachment of $H(1s)$ via the Lyman Series using the Relativistic Doppler Shift," presented by W. W. Smith, paper BB3, Bull. Amer. Phys. Soc. 24, 1174 (1979). D. A. Clark, W. W. Smith, J. B. Donahue, H. C. Bryant, C. A. Frost, P. A. M. Gram, M. Hamm, R. W. Hamm, J. C. Pratt.

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"On the Role of HC(OH₂)₂⁺ in Interstellar Molecular Synthesis." H. Villinger, A. Saxer, E. E. Ferguson, W. Lindinger, H. C. Bryant, **3rd International Swarm Seminar Proceedings**, pp. 127-131. Eds. W. Lindinger, H. Villinger, W. Federer, Innsbruck, Austria, Aug. 3-5, 1983.

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"A Mystery Revisited: The H⁻ shape resonance in strong electric fields," paper presented at Symposium on Atomic and Surface Physics, Maria Alm, Salzburg, Jan. 29-Feb. 4, 1984. H. C. Bryant, K. B. Butterfield, C. J. Harvey, D. A. Clark, J. B. Donahue, P. A. M. Gram, D. MacArthur, W. W. Smith. Abstract published in **SASP '84 Contributions** p. 50-55.

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"Observation of the Stark Effect in Hydrogen ($n=4$) up to 3 MV/cm by Relativistic Beam Techniques," Ninth International Conference on Atomic Physics, Seattle, Washington, July 23-27, 1984, paper B27. T. Bergeman, C. Harvey, K. B. Butterfield, G. Comtet, H. C. Bryant, D. A. Clark, P. A. M. Gram, D. MacArthur, M. Davis, J. B. Donahue, and W. W. Smith. Published in proceedings.

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"Electron Correlation and Stark Quenching in the H^- Ion," H. C. Bryant, C. J. Harvey, J. E. Stewart, K. B. Butterfield, D. A. Clark, J. B. Donahue, P. A. M. Gram, D. W. MacArthur, V. Yuan, G. Comtet, W. W. Smith. Contributed paper SASP'86. Bundessportschule Obertraun, Austria, 9-15 Feb. 1986. Published in SASP '86 (Symposium on Atomic and Surface Physics) F. Howorka, W. Lindinger and T. D. Märk, Eds.) page 86.

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"A Brief Report on the 'Physics of the H⁻ Ion' Workshop," Honglie Fang and H. C. Bryant, submitted to **Acta Optica Sinica**. (Do not have reference)

"New Light on a Dark Ion," H. C. Bryant and C. H. Greene, p. 15-16, **Physics News in 1991**, American Institute of Physics, New York, 1991, Phillip F. Schewe, Ed.

"Egy Cowboykalapos Amerikai Akitudja, Ki Volt Selényi Pál," Beszélgetés Howard C. Bryant, Fizikussal. Interview in Hungarian Magazine, **Természet Világa**, August, 1993.

"Hooked on Resonances," by Sherry Robinson (Profile interview, with drawings by HCB), **Quantum** 13, 1, Spring 1996, Research and Scholarship at the University of New Mexico,

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"Relativistic Beams," joint Department of Physics-JILA colloquium, U. of Colorado, Boulder, CO, Fall 1980.

"Atomic Physics with Relativistic Beams," and "Why the Sea is Boiling Hot: Salt Gradient Solar Ponds," two colloquia presented at the Department of Physics and College of Engineering, The University of Wyoming, Laramie, WY, Feb. 10, 1981.

"H⁻ in Strong Electric Fields: Experimental Results," one hour lecture at workshop "The Physics of the H⁻ Ion", Los Alamos, NM, Nov. 12-13, 1981.

Colloquium: Institut fur Atomphysik, U. Innsbruck "Atomic Physics Near the Speed of Light," Oct. 7, 1982.

Lecture Series U. Innsbruck: 7 lectures "Photoelectric Processes in Simple Atoms," Fall 1982.

Lecture Series U. Innsbruck: 5 lectures "The Vector Potential and the Origin of Forces," Fall 1982.

Colloquium: Max-Planck-Institut fur Quanten Optik, Garching, West Germany, Dec. 8, 1982. "Experimental Spectroscopic Studies of the H⁻ Ion at Relativistic Velocities."

Colloquium for the Institut fur Experimental Physik, Canisianum, U. of Innsbruck, Innsbruck, Austria, March 10, 1983, "Outdoor drift tube: the physics of the salt-gradient solar pond."

Colloquium for the Physics Department, University of Kragujevac, Kragujevac, Yugoslavia, March 31, 1983, "The origin of the electromagnetic force."

Colloquium for the Physics Department, University of Belgrade, Belgrade, Yugoslavia, April 1, 1983, "Atomic Physics near the speed of light."

Colloquium for the Institut fur Experimental Physik, University of Freiburg, Germany, April 23, 1983, "Atomic Physics near the speed of light."

Seminar for the Physics Department at the Universite Degli Studi, Povo, Trient, Italy, May 7, 1983, "Atomic Physics near the speed of light."

Colloquium for UNM Physics and Astronomy Department, March 2, 1984, "Atomic Spectroscopy Near the Speed of Light."

"Atomic Physics with Relativistic Beams," talk to Physics Division (1 hour), Los Alamos National Lab, MP 215, Nov. 8, 1984.

Colloquium for UNM Physics and Astronomy Department, January 25, 1985 "Progress in Understanding Simple Atoms."

The University of New Mexico 30th Annual Faculty Research Lecture

April 1, 1985, Physics Lecture Hall, The University of New Mexico, 8p.m.

"A Physicist's Journal: from the Glory to the Two-electron Ion."

"Physics with relativistic beams," talk to Amer. Phys. Soc. SDI Study Committee 11:30-12:00
May 24, 1985 at AT Div. Los Alamos National Lab, Los Alamos, NM, TA-53,MPF-6,
Room 302.

Sandia Colloquium, Sandia National Laboratory, Albuquerque, N.M., 9-10 a.m. 13 Sept., 1985,
"Tweedle Dee and Tweedle Dum Near the Speed of Light," (on film, transcript also
available).

Seminar: Los Alamos National Laboratory, Conference Room TA3, Bldg. 215, Rm 281, 1 pm,
July 16, 1986, "Photodetachment Study of H⁻ ions at Relativistic Velocities."

Colloquium: Dept. of Physics and Atmospheric Science, Drexel University, Philadelphia, 1 pm,
May 4, 1987, Disque Hall, Room 12-919, "Experimental Verifications of Special
Relativity."

Bag Lunch Seminar: MP Division Auditorium, 12 noon June 8, 1987, "A New Test of Special
Relativity."

Seminar: "Relativity Tests at LAMPF," Rutherford Laboratory, Chilton, Didcot England 29 July
1987.

Talk: "Photon Interactions with H⁻," Los Alamos National Lab, TA 35-127, A101, 2:30 PM,
Feb. 3, 1988.

Series of 5 Lectures given at The Los Alamos Summer School in Atomic Physics:

July 25-29, 1988: 10:30-12 UNM Campus, Los Alamos

1. What good is relativity?
2. The Structure of the H⁻ Ion.
3. Photodetachment of H⁻.
4. Effects of Fields: The Tale of Two Resonances.
5. The Atomic Interferometer and Beam Me Up, Scotty!

Colloquium: Dept. of Physics and JILA, University of Colorado, Boulder, CO, Oct 5, 1988,
"Atomic Physics Near the Speed of Light."

Talk: "H⁻ Physics at HIRAB," to Neutral Particle Beam Sensing and Control Panel (SDI), J.A.
Schafer and Associates, Albuquerque, NM, April 17, 1989.

Series of 3 Lectures given at the 1989 Los Alamos Theoretical Atomic Physics Summer School, July 18, 19, 20, 1989:

1. What good is relativity?
2. The Structure of the H^- Ion.
3. Effects of Fields.

Seminar: "Observations of atoms in strong fields," UNM, 20 September 1989.

Colloquium: Hungarian Academy of Sciences, Budapest. October 25, 1989, 2 pm. "An Atomic Interferometer."

Colloquium: Institute of Nuclear Research "Atomki", Debrecen, Hungary, October 26, 2: pm
"An Atomic Interferometer."

"Concluding Remarks," H^- Workshop, Albuquerque, NM, Jan 9, 10, 11, 1990. (Organizer) on January 11, 1990.

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

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

Seminar: Tungstam Factory, 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.

Radio Talk Show: Magyar Radio, Budapest, "Science in America," broadcast 6/17/90 and 6/19/90.

Journal Club: Discussion of D.J. Pegg, et al., "Partial cross sections for the photodetachment of metastable He," Phys. Rev. Letters 64, 278 (90), Feb. 20, 1990, 12:30.

Series of 3 lectures given at the 1990 Los Alamos Theoretical Atomic Physics Summer School, July 24, 26, 27, 1990. Essentially a repeat of those given in 1989.

Invited talk: Twenty-Fourth LAMPF Users Group Meeting, LAMPF Auditorium, Los Alamos, "Recent Results from HIRAB," 9:50-10:20 am, August 14, 1990.

Seminar: Cal Tech, Pasadena, CA. "Relativistic Atomic Physics," November 9, 1990.

Colloquium: University of Texas, Arlington, TX "Relativistic Atomic Physics," Nov. 28, 1990.

Colloquium: UNM, Department of Physics, "Relativistic Atomic Physics," December 7, 1990.

Colloquium: New Mexico State University, Department of Physics, "Relativistic Atomic Physics," January 31, 1991.

Colloquium: Rice University, Department of Physics, Houston; "Atomic Physics Near the Speed of Light," February 7, 1991.

Presentation of Expression of Interest, Super-Conducting Super Collider Laboratory, "Relativistic Atomic Physics at the SSC," EOI-17, June 14, 1991, Dallas, TX.

Talk: Society of Physics Students, UNM, Albuquerque, NM, "Tweedle Dee and Tweedle Dum near the speed of light," November 22, 1991, 2:30-3:30.

Colloquium: New York University, Department of Physics, New York; "Atomic Physics Near the Speed of Light," December 5, 1991.

Seminar: "Atomic Physics at the SSC," Los Alamos National Lab, Nuclear and Particle Physics (NP²), February 14, 1992. Otowi Building.

Seminar: The Autonomous University of Mexico (UNAM), "H⁻Spectroscopy," March 18, 1992, Cuernavaca, Morelos, Mexico.

Guest Teacher: Science Summer School for Navajo Children, Ganado, AZ, "What is Light?" July 6, 1992.

Series of 4 Lectures given at the Los Alamos AMO Summer School, July 27-31, 1992

1. Relativistic Beams.
2. The H⁻ Ion.
3. The effects of electric fields.
4. Multiphoton spectroscopy.

Native American Science Teachers, August 10, 1992, Regener Hall, UNM, "Physics Demonstration Equipment."

LAMPF PAC (Program Advisory Committee), August 19, 1992, Los Alamos, NM, "The Future of Hirab (High Resolution Atomic Beam) Facility for Atomic Physics," 1 hour.

Tulane University Quantum Group and Physics Colloquium, November 16, 1992, New Orleans, LA, "Experiments with H⁻ at LAMPF and around the World".

General Seminar, Louisiana State University, November 17, 1992, Baton Rouge, LA, "The Photoabsorption Spectrum of H⁻."

Colloquium: Department of Physics, University of Nevada, Reno, "The Spectroscopy of H⁻", February 11, 1993

Colloquium: MP Division, LANL, Los Alamos 3:45 pm, March 10, 1993. "The Spectroscopy of H⁻: Tweedle Dum and Tweedle Dee near the Speed of Light."

Seminar: Eötvös Lorand University, H-1088 Budapest Puskin u. 5-7, March 18, 1993. "Atomic Physics Near the Speed of Light."

Colloquium: FERMILAB, Batavia, IL, April 21, 1993. "H⁻ Beams and Lasers: Atomic Physics Near the Speed of Light."

"Research on the Physics and Technology of Hydrogen Beams at Los Alamos," H.C. Bryant, Brief Topics session of IDEA DAY #1, LAMPF Auditorium, LANL 6/10/93.

Guest Lecturer: Science and Math Summer School for Navajo Children, Fort Defiance Middle School, Sohatso, AZ, July 17, 18 1993.

Lectures: "H⁻ Physics," Los Alamos AMO Summer School, July 23-25, 1993.

Presentation: "Plans for H⁻ Spectroscopy at Fermilab," 400 MeV Beam Workshop, Fermilab, Batavia, IL 60510. October 24-27, 1993. (member of Organizing Committee for Workshop).

Seminar: Physik Department der Technischen Universität München, Theoretische Physik, March 18, 1994, "Atomic Physics Near the Speed of Light: The Spectroscopy of the H⁻ Ion."

Lectures: "H⁻ Physics," Los Alamos AMO Summer School, July 5-8, 1994.

Seminar: "Nu Seminar" Physics and Astronomy, UNM, "H⁻ Spectroscopy", 12-1 pm, Sept. 14, 1994.

Talk: Sertoma Club, Fiesta Restaurant, Montgomery and Carlisle, March 2, 1995 12-1 pm. "Tweedle Dee and Tweedle Dum at near the speed of light".

Guest Lecturer: Science and Math Summer School for Navajo Children, Fort Defiance Middle School, Sohatso, AZ, June 13, 1995.

Lectures: "H⁻ Physics," Los Alamos AMO Summer School, June 26-30, 1995.

Illustrated Talk, "A Bird's Eye View of Color", H. C. Bryant, to the Mesilla Valley Audubon Society, Las Cruces, NM, 7 pm, Dona Ana Community College, Feb. 21, 1996.

Lectures: "A Bird's Eye View of Color Vision" June 18 10:15- 11:15 am, and "Tweedle Dee and Tweedle Dum at near the Speed of Light", June 20 10:15- 11:15 am. H. C. Bryant, Los Alamos AMO Summer School, Los Alamos Branch Campus, 1996

Seminar: "The spectroscopy of the H⁻ ion", H. C. Bryant, Dec 10, 1996, 10 am, room 120, bldg 400, Phillips Lab, Albuquerque, NM

Colloquium: "Recent Advances in H⁻ Spectroscopy", July 15, 1997, Max Born Institute, Berlin, Germany.

Colloquium: "Recent Advances in H⁻ Spectroscopy", July 17, 1997, Technical University of Munich, Garching, Germany

Seminar: "Color Vision in Birds", November 4, 1997, Department of Physics, Brigham Young University, Provo, Utah

Colloquium: "Recent Advances in H⁻ Spectroscopy", November 5, 1997, Department of Physics, Brigham Young University, Provo, Utah

Colloquium: "Experimental Studies of a Quantum-Mechanical Three-Body Problem", August 28, 1998, Room 184, Physics and Astronomy Bldg., 4:00 pm, UNM

Ph.D. DISSERTATIONS Completed under the DOE auspices

Cholam-Hosseini Tootoonchi Sarraf, 1977

"Study of resonances Near 11 eV in the Photodetachment Cross Section of H⁻ Ion."

Mohamad Hassan Sharifian-Attar, 1977

"Measurement of the H⁻ Photodetachment Cross Section in the Continuum Region from 1.5 to 10.5 eV."

Charles Alan Frost, 1981

"Measurements of Threshold Behavior for One- and Two-Electron Photodetachment from the H⁻ Ion."

LA-8976-T UC-34c. Sept. 1981

Kenneth B. Butterfield, 1984

"Stark Broadening of H⁻ Resonances in Large Electric Fields."

LA-10149-T UC-34, June 1984

Stanley Cohen, 1986

"The Response of the ¹P^o Resonance Near $n = 3$ in the H⁻ Continuum to External Electric Fields."

LA-10726-T UC-34a. May 1986

James Edward Stewart, 1987

"Effects of Electric Fields on the Photodetachment Cross Section of the H⁻ Ion Near Threshold." LA-11152-T UC-34 Dec. 1987

Philip G. Harris, 1990

"Observations of High-Lying Resonances in the H⁻ Ion."

LA-11843-T UC-413 May 1990

Amir H. Mohagheghi, 1990

"Interaction of Relativistic H⁻ Ions with Thin Foils."

LA-11925-T UC-411 Sept. 1990

Thomas David Nichols, 1991

"Measurement of Intensity-Dependent Rates of Above-Threshold Ionization (ATI) of Atomic Hydrogen at 248 nm."

LA-12060-T UC-700, April, 1991 (Dr. George Kyrala was his Los Alamos advisor)

Chen Yau Tang, 1992

"Multiquanta Photodetachment from the H⁻ Ion."

LA-12254-T UC-414 March 1992

Monica Halka, 1993

"Partial Cross Sections in H⁻ Photodetachment."

LA-12533-T UC-410 April 1993

Edward P. MacKerrow, 1995

"Measurement of Two and Three Photon Absorption by the H⁻ Ion", May 1995

Philip Brian Keating, 1996

"Interactions of Relativistic H⁻ Ions with Matter and Fields", May 1996

Mark Shannon Gulley, 1997

"Non-resonant Two-photon Detachment of H⁻ Ions with 1.165 eV Photons", July, 1997

Daniel Rislove, 1997

"Characterization of the ¹D^e Doubly-Excited Resonance in Negative Hydrogen and Negative Deuterium Ions", December 1997.