Lawrence Berkeley National Laboratory
Recent Work

Title
HIGH ENERGY ATOMIC PHYSICS

Permalink
https://escholarship.org/uc/item/6pf670m2

Authors
Gould, H.
Claytor, N.
Misawa, S.

Publication Date
1988-07-01

eScholarship.org Powered by the California Digital Library
University of California

LBL-25535 c.2

Lawrence Berkeley Laboratory
UNIVERSITY OF CALIFORNIA

Materials & Chemical Sciences Division

To be presented at the DOE Atomic Physics Contractors' Meeting, Bethesda, MD, August 31–September 1, 1988

1988

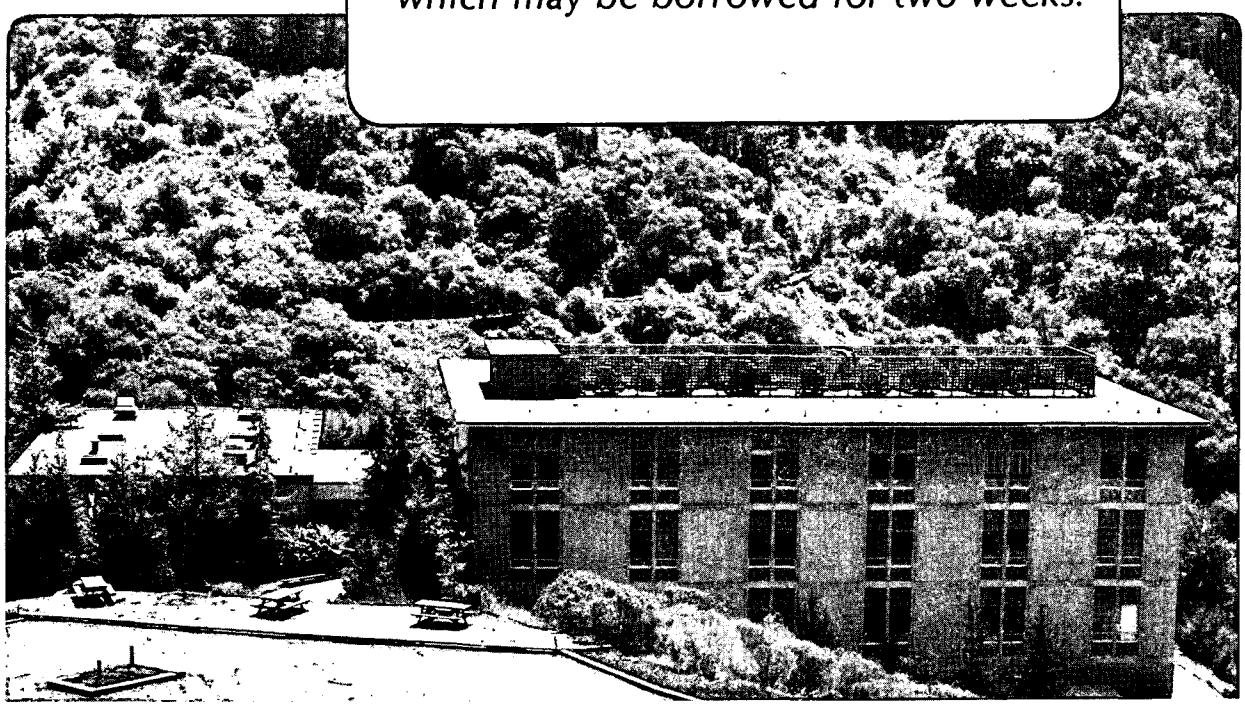
High Energy Atomic Physics

H. Gould, N. Claytor, S. Misawa, R. Mowat,
M. Prior, and J. Schweppe

July 1988

TWO-WEEK LOAN COPY

This is a Library Circulating Copy which may be borrowed for two weeks.



LBL-25535 c.2

Prepared for the U.S. Department of Energy under Contract Number DE-AC03-76SF00098.

DISCLAIMER

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor the Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or the Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or the Regents of the University of California.

HIGH ENERGY ATOMIC PHYSICS

Harvey Gould, Nelson Claytor, Shigeki Misawa, Richard Mowat†
Michael Prior, and John Schweppe

Materials and Chemical Sciences Research Division,
71 - 259, Lawrence Berkeley Laboratory,
University of California, Berkeley, CA 94720

INTRODUCTION

The goal of this program is to test quantum electrodynamics (QED) in very high atomic number (Z) ions and to understand atomic collisions of relativistic very high-Z ions. These are new areas of research which involve physics that is not accessible at lower energies or with lower Z ions. This research is conducted at the Lawrence Berkeley Laboratory's Bevalac, the world's only relativistic heavy ion accelerator. Recent results include the first measurement of the Lamb shift in a very high-Z atom (uranium, Z = 92) and the first measurement of electron impact ionization cross sections for very highly charged ions. Currently we are working on a precision measurement of the Lamb shift in lithiumlike uranium.

RECENT RESULTS

1. Electron Impact Ionization of U91+ - U88+ Measured by Channeling: We (N. Claytor, H. Gould, B. Feinberg [LBL], C.E. Bemis Jr., J. Gomez del Campo, C.A. Ludemann and C.R. Vane [ORNL]) have made the first measurements of electron impact ionization cross sections for very highly charged ions. We did this by channeling 407 MeV/nucleon U92+, U91+, U90+, U89+ and U88+ (bare uranium through berylliumlike uranium) along the <110> axis of 0.11 mm-thick and 0.37 mm-thick Si single crystals. For channeled ions, we observe a large reduction in the probability for ionization and a reduction in the probability for electron capture. We are able to determine the fraction of incident ions which channel and the density of electrons along the path of the ions which channel. We use these determinations to interpret our ionization data to yield cross sections for electron impact ionization. Electron impact cross sections for hydrogenlike - berylliumlike uranium by 220 keV electrons (the energy of the electrons seen in the rest frame of the 407 MeV/nucleon uranium) have been obtained and compared with theory. A manuscript is being prepared for publication.

† Physics Dept., North Carolina State University, P.O. Box 8202, Raleigh, NC 27695.

2. Charge States of Relativistic Uranium: We have measured (see publication number 2) the charge state distributions of 105- 220-, 430-, and 955-MeV/amu uranium ions in solid targets. The initial charge states used were bare, one-, two-, three-, nine-, and 24- electrons so that single and multiple ionization of K-, L-, and M- shell electrons and electron capture into bare ions and ions having full or partially filled K- and L- shells could be observed. For electron capture some disagreement with theory is found at the lower energies. Measured equilibrium charge states are compared with models both with and without excited state effects. Excited state effects are less important for relativistic uranium than for any other ion.

WORK IN PROGRESS

We are currently constructing an experiment whose goal is a measurement of the $2\,^2P_{1/2}$ - $2\,^2S_{1/2}$ splitting in lithiumlike uranium to a few parts in 10^4. Recent advances in the theory of few-electron high-Z atoms[1] will make it possible to interpret such a measurement as a test of quantum electrodynamics at the 0.1% level.

The measurement will be made using a soft x-ray, multichannel Doppler tuned spectrometer in which the $\approx$ 280 ev photons from the $2\,^2P_{1/2} \rightarrow 2\,^2S_{1/2}$ transition in lithiumlike uranium will be compared with the carbon K-edge in polypropylene. The multichannel feature is obtained by using position sensitive x-ray detectors. A prototype detector, based on the design of Huddle and Mowat[2] has been constructed and operated.

RECENT PUBLICATIONS

1. N. Claytor, "Channeling of Relativistic Uranium" in "Proceedings of the 8th High Energy Heavy Ion Study" edited by J.W. Harris and G.J. Wozniak, (Lawrence Berkeley Laboratory Publication LBL-245780, CONF-8711116, UC-34C, 1988), pp 481-489.

2. R. Anholt W.E. Meyerhof, X-X Xu, H. Gould, B. Feinberg, R.J. McDonald, H.E. Wegner and P. Thieberger, "Atomic collisions with relativistic heavy ions. VIII Charge-state studies of relativistic uranium ions." Phys. Rev. A36, 1586 (1987), LBL-22699.

1. W.R. Johnson, S.A. Blundell, and J. Sapirstein, Phys. Rev. A37, 2764 (1988); I. Lindgren, Phys. Rev. A31, 1273 (1985); G.W.F. Drake, "Theoretical energies for the n=1 and 2 states of the helium isoelectronic sequence up to Z=100", submitted to the Canadian Journal of Physics; P. Indelicato, Nucl. Instrm. Meth. B31, 14 (1988); G. Soff and P.J. Mohr, "Vacuum Polarization in a Strong Coulomb potential", to be published.

2. J.R. Huddle and J.R. Mowat, Nucl. Instrm. Meth. 202, 343 (1982).

3. W.E. Meyerhof, R. Anholt, X-X Xu, H. Gould, B. Feinberg, R.J. McDonald, H.E. Wegner and P. Thieberger, "Multiple Ionization in Relativistic Heavy-Ion Atom Collisions" Phys. Rev. (rapid communications) A35, 1967 (1987), LBL-22186.

4. C.T. Munger and H. Gould, "Tests of Quantum Electrodynamics in Few-Electron Very High-Z Ions" Physica Scripta 36, 476 (1987), LBL-21855

5. C.T. Munger and H. Gould, "Lamb shift in Heliumlike Uranium (U^{90+})" Phys. Rev. Lett. 57, 2927, 1986. LBL- 21996.

6. R. Anholt and H. Gould, "Relativistic Heavy-Ion-Atom Collisions," in "Advances in Atomic and Molecular Physics," edited by D. Bates and B. Bederson, (Academic, Orlando, 1986), pp. 315 - 385. LBL-20661.

This work was supported by the Director: Office of Energy Research, Office of Basic Energy Science, Chemical Sciences Division; of the U.S. Department of Energy under contract No. DE AC03 76SF00098.

LAWRENCE BERKELEY LABORATORY
TECHNICAL INFORMATION DEPARTMENT
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA 94720