

# DIVISION OF ATOMIC, MOLECULAR AND OPTICAL PHYSICS NEWSLETTER

A Division of The American Physical Society

April 2000

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## Message From the Chair

Steve Lundeen

Every January, the APS invites officers of all 34 APS Units (14 Divisions, 8 Topical Groups, 5 Forums, and 7 Sections) to meet at APS headquarters in College Park for a one day "Unit Convocation." This provides an opportunity for APS officers to address issues common to all units and for units to share their ideas and experiences.

In recent years, DAMOP has tried to have all its officers attend these meetings, which then can also function as a mid-year management meeting for DAMOP issues. After attending these meetings for three years, I can certainly claim to have a better appreciation of APS programs and goals. I am especially impressed with the progress that APS has made during this time in upgrading its public information function. Headed by Randy Atkins, APS/AIP now has a six-member team, which meets regularly and coordinates several activities with the common goal of communicating the excitement of physics more effectively to the press and the public. It's encouraging to see this movement at APS headquarters, because all during this time, the units have been constantly urged to do more in this direction, and I confess to some frustration at finding a way to do it. This year, for the first time, DAMOP has set up a Public Relations Committee, chaired by Bill Cooke of William and Mary, charged with formulating a strategy for increasing DAMOP's effectiveness in this area. Our task is made more manageable by the increased emphasis on this goal at APS headquarters. For example, any DAMOP member can email leads on newsworthy physics to "hotphysics@aps.org", and APS staff is now equipped to follow up. I hope that DAMOP's Public Relations committee can find ways to encourage a steady stream of these leads to APS, as well as other ways to get the word out. Of course, the good news is that AMO science is very exciting right now. There should be plenty of "hot physics" news coming out of the AMO community for the foreseeable future! One indication of that is found in the compilation of "Top Physics News Stories of 1999", compiled from the "Physics News Updates" distributed weekly by APS/AIP staff. Of the ten top physics stories of 1999, fully half of them were in AMO science (see the Dec. 10, 1999 Physics News Update for details). This is quite a remarkable statistic when you consider that DAMOP membership is only slightly more than 6% of the total APS membership. It is not, however, a surprising statistic to those familiar with the remarkable pace of recent progress in AMO science! Another indication of this is found in the program for our annual DAMOP meeting, coming up this June in Storrs, CT, which is available through the [www.aps.org](http://www.aps.org) web site. The very rapid development of entirely new areas of research such as quantum information processing and Bose-Einstein condensates has resulted in an exciting program that appears almost completely orthogonal to our program of even five years ago! And there is no sign that things are slowing down! This is truly an exciting time in AMO science!

In his remarks at this year's Unit Convocation, APS president James Langer emphasized that one of APS's primary goals is to maintain the health of the physics community in the US. Of course, this is a complex task, with many subplots. In this exciting time of rapid change, maintaining a healthy AMO science community is a particular challenge for DAMOP. Our single most important vehicle for this is our annual meeting. We strive to provide a program that educates and informs our members about the latest developments in our science, while at the same time providing an environment that helps to strengthen our ties as a community. Our 2000 meeting promises to meet this challenge and be one of our best meetings ever. I hope to see

every one of you there!

## **DAMOP 2000 WEBSITES**

Detailed information for the Storrs meeting, including electronic registration, is available at the two meeting websites:

<http://www.aps.org/meet/DAMOP00>

<http://www.ce.uconn.edu/damop2K>

## **The 7% SOLUTION: REGISTER YOUR EMAIL ADDRESS NOW!**

If you are part of the 7% of the DAMOP membership for whom we do not have an email address, please help us out by sending it to APS at [coa@aps.org](mailto:coa@aps.org). We are sending out more and more announcements solely by email, and hope to start voting by email in the near future.

## **GORDON RESEARCH CONFERENCE: MOLECULAR ELECTRONIC SPECTROSCOPY AND DYNAMICS**

This conference will be held at Colby Sawyer College, New London, New Hampshire July 30 - August 4, 2000. The scientific program will include 22 invited 40 minute talks arranged into the following sessions: Herzberg Session; From Atom- in-Molecule to Supercritical Fluids; Imaging and Control; Quantum Dots; A Little of This and A Little of That; Light Harvesting Antenna Systems; Time vs. Frequency Domains. In addition there will be four poster sessions. All attendees, especially graduate students and postdocs, are encouraged to present a poster. Grant applications are pending which would provide partial support (conference fee and travel) for early-career scientists who plan to present a poster. The invited speakers include: Ch. Jungen, F. Merkt, R. Lipson, W. Ketterle, A. Vilesov, T. Momose, J. Brennecke, C. Hayden, C. Blondel, P. Bucksbaum, S. Leone, J. Cao, U. Banin, M. Moskovits, P. McEuen, H.F. Davis, M. Gruebele, R. Van Grondelle, K. Schulten, S. Volker and D. Jonas. Visit the MES&D-GRC web site:

<http://www.grc.uri.edu/programs/2000/molspec.html>. To apply to attend the MES&D-GRC, please fill out the email form at:

[app@grcmail.grc.uri.edu](mailto:app@grcmail.grc.uri.edu) or by mail from: Conference Application, Gordon Research Conferences, University of Rhode Island, P.O. Box 984, West Kingston, RI 02892- 0984 USA (401) 783-4011; (401) 783-7644 (FAX). The Conference Chair is Robert W. Field, Room 6-219, MIT, 77 Mass. Ave., Cambridge, MA 02139 (617) 253-1489 (VOX), (617) 253-7030 (FAX), [rwfield@mit.edu](mailto:rwfield@mit.edu).

## **CHANGES IN THE DOE AMO PROGRAM: A LETTER FROM PAT DEHMER**

We want to take this opportunity to tell you of a change in the

program management of the Atomic, Molecular, and Optical (AMO) Physics program at DOE. On December 26, 1999, Dr. Joseph V. Martinez accepted a position as Senior Advisor on Scientific Institutional Outreach within the Office of Science. Joe had been with the Chemical Sciences Division of the Office of Basic Energy Sciences (BES) for about 20 years of which more than 15 were spent as the Program Manager for the Atomic (now Atomic, Molecular and Optical) Physics program. In this position, Joe was a strong supporter and advocate for the AMO physics program, and we would like to take this opportunity to thank him for his years of service and dedication to the community.

We are pleased to announce that Dr. Eric Rohlfing will be the new Program Manager of the AMO Physics program. Eric received his undergraduate degree with honors and Phi Beta Kappa recognition from the University of Virginia and his Ph.D. degree from Princeton University where he worked with Professor Herschel Rabitz. Eric was a postdoctoral associate at both Exxon Corporate Research Science Laboratories and Los Alamos National Laboratory. At Exxon, he participated in early studies of metal and carbon atom clusters using pulsed molecular beam/laser vaporization techniques; at Los Alamos, he was involved in studies of the dynamics and spectroscopy of jet-cooled copper dimers and trimers. Eric was a Principal Member of the Technical Staff at Sandia National Laboratories' Combustion Research Facility for over 10 years where he led studies of the spectroscopy and dynamics of combustion-relevant small radicals and molecules such as vinoxy ( $C_2H_3O$ ) and  $C_3$ . For the past two years, Eric served on detail from Sandia National Laboratories to BES, where he assisted with both the Chemical Physics and the AMO Physics programs. Eric joined the staff of BES in July 1999 and since has been involved in both program management and development of an initiative for fourth-generation light sources. Eric has published more than 50 papers in the archival literature.

The AMO Physics program will continue as an important component of the BES research portfolio. The goals of the AMO Physics program are directed toward the fundamental study of reactivity at the highest level of detail. Continued strong interaction between experiment and theory is a hallmark of the program, one that is devoted to solving very fundamental questions concerning atomic and molecular properties, collisional processes, many-body effects, and atomic scale manipulation of matter. The interaction between atoms, molecules, ions, electrons, photons and electromagnetic fields remain as high priority areas of interest as the complete understanding of complex processes have been shown to require a fundamental understanding of the details of the process itself. These are exciting times in AMO physics. The advent of new tools, new phenomena, and improved sensitivities will allow significant advances to be made. We would like you to join us in thanking Joe for his years of service to the AMO program and in welcoming Eric.

Patricia Dehmer

## DAMOP 2000 SYMPOSIA/INVITED SPEAKERS

- Plenary and Awards Session. Waymouth, Happer.
- New Applications of Atomic, Molecular and Optical Science in Medicine. Murnick, Yodh, Chupp, Wilson.
- Implementation of Quantum Information Processing. Deutsch, Polzik, Sackett, Ye.
- Atoms and Molecules in Intense Laser Fields. Bucksbaum, Gibson, Noordam, Villeneuve.
- Focus Session: Cold Atomic Collisions and Precision Intermolecular Potentials. Williams.
- Focus Session: Alignment of Molecules in Intense Laser Fields. Corkum.
- Focus Session: Theory of Bose-Einstein Condensates. Holland. Collective Effects in Rydberg Matter. Holmlid, Killian, Raithel, Eyler.
- Recent Progress in Quantum Optics. Orozco, Bali, Scully, Meystre.
- Ultracold Molecules. Julienne, Ensher, Heinzen, Meijer.
- Physics Results from Ion Storage Rings. Stoehlker, Andersen, Djurić, Müller.
- Applications of Ion Imaging in AMO Science. Chandler, Suits, Cocke, Cline.
- Late-Breaking Progress in AMO Science. Moshhammer, Wieman, Kuga, Haugen.
- Gerhard Herzberg's Legacy in AMO Physics. Stoicheff, Oka, Merer, Jungen.
- New Results with Ultracold Quantum Gases. Hau, Ketterle, Jin, Helmerson.

## CALL FOR BROIDA PRIZE NOMINATIONS

The Broida Prize Committee will meet this year to select a recipient for 2001. Last year's winner was Terry Miller of the Ohio State University. The members of the committee are: W.E.Moerner (chair; wmoerner@leland.Stanford.EDU), Bill Stwalley, Joe Dehmer, Terry Miller, and Hanna Reisler. Please contact one of them to put forward nominations for this Prize.

## RIS-2000 TO BE HELD IN KNOXVILLE

The Tenth International Symposium on Resonance Ionization Spectroscopy and Its Applications, RIS-2000, will be held in Knoxville, Tennessee, October 8-13, 2000. The meeting announcement, related information, and registration forms can be found on the Web at <http://www.phys.utk.edu/RIS2000.html>. Additional information can be obtained by contacting Dr. James E. Parks:

James E. Parks  
401 Nielsen Physics Building

The University of Tennessee  
Knoxville, TN 37996-1200  
email: jeparks@utk.edu  
Tel: 865-974-8952  
Fax: 865-974-7843

The conference includes an introductory course on RIS, along with sessions addressing basic principles of RIS, new directions and applications, and cross-disciplinary research. Conference topics include: Atomic Ionization Spectroscopy, Molecular Ionization Spectroscopy, Photoelectron Spectroscopy, Ultra-Fast Laser Spectroscopy, Clusters, New Laser Developments, Surface Analysis and General Applications.

## THESIS PRIZE AND UNDERGRADUATE RESEARCH SYMPOSIA

Once again, the work presented by our young researchers promises to provide two of the most exciting symposia at the Storrs meeting! As usual, the competition to become finalists for these sessions was fierce. The programs are as follows:

### Thesis Prize Session

Mark Baertschy - Electron-Impact Ionization of Hydrogen (University of California, Davis).

Jungsang Kim - Single Photonics: Generation and Detection of Heralded Single Photons (Stanford).

Charles Sackett - Dynamics of Bose-Einstein Condensation in  $^7\text{Li}$  (Rice).

Dan Stamper-Kurn - Peeking and Poking at a New Quantum Fluid: Studies of Gaseous Bose-Einstein Condensates in Magnetic and Optical Traps (MIT).

James Williams - Topological States in a Dilute Bose-Einstein Condensate (JILA).

Undergraduate Research Symposia (Undergraduate Underlined)  
Efficient Population Transfer in a Multi-Level Atom - G. Chern, A.-T. Nguyen, D. Budker, M. Zolotarev (University of California - Berkeley).

Non-linear dynamics of relativistic particles: How good is the classical phase space approach? - P.J. Peverly, Q. Su, R. Grobe (Illinois State University).

State-Selective Quantum Beat Spectroscopy by Using Time-Resolved, Two-Color Resonant Four-Wave Mixing - Edina Sarajlic, Elizabeth F. McCormack (Bryn Mawr College).

Polarization of  $^{129}\text{Xe}$  with Applications to Medical Imaging and

Precision Measurements - Samuel Stavis, Mark Rosenberry, Jonathan Zerger, Rosen Matt, Kevin Coulter, Timothy Chupp (University of Michigan).

Pressure Dependence of Excitation Cross Sections for Resonant Levels of Rare Gases - Michael D. Stewart, J. Ethan Chilton, Chun C. Lin (University of Wisconsin-Madison).

## **CONGRATULATIONS TO NEW DAMOP APS FELLOWS!**

We are proud to announce and to congratulate the following new DAMOP Fellows of the American Physical Society. They were elected late last year by the DAMOP Fellowship Committee. Their certificates will be presented at the Banquet at the 2000 Storrs meeting this June.

Berrah, Nora  
Western Michigan University  
For high-resolution work on few and many electron systems using lasers and synchrotron radiation leading to a better understanding of the interaction of light with matter.

Bray, Igor  
Flinders University of South Australia  
For the codevelopment of the Convergent Close-Coupling theory which has unified the theoretical treatment of electron-atom collisions at all energies, for both excitation and ionization processes.

Heinzen, Daniel J.  
The University of Texas, Austin  
For outstanding and groundbreaking work on cold-atom photoassociation spectroscopy.

Hill, III, Wendell Talbot  
University of Maryland  
For significant experimental contributions to our understanding of multiphoton dissociation and ionization of small molecules.

Hughes, Richard J.  
Los Alamos National Laboratory  
For work in the application of fundamental quantum mechanical principles to practical problems, including quantum computation and quantum cryptography, and for the development of experimental techniques in this regard.

Msezane, Alfred Z.  
Clark Atlanta University  
For continuing outstanding contributions to theoretical atomic physics, particularly the elucidation of small angle electron scattering through innovative theoretical approaches.

Orozco, Luis A.  
SUNY Stony Brook

For vital contributions to measuring the antipositron mass, trapping and spectroscopy of Francium, and the quantum nature of the interactions of atoms and light.

Pillet, Pierre

Laboratoire Aime Cotton

For fundamental work in adiabatic population transfer, many body interactions in a frozen Rydberg gas, and the formation of cold molecules.

Shimizu, Fujio

University of Electro-Communications

For outstanding contribution to laser spectroscopy, laser cooling and atom optics.

Uzer, Turgay

Georgia Institute of Technology

For original and creative insights into the dynamics of electrons and the relationships between classical and quantum mechanics.

Walker, Thad Gilbert

University of Wisconsin

For pioneering research in spin exchange, optical pumping, ultracold collisions, spin polarized beams and targets, laser cooling, and electron scattering.

Wootters, William Kent

Williams College

For contributions on the foundations of quantum mechanics and groundbreaking work in quantum information and communications theory.

Young, Linda

Argonne National Laboratory

For precision measurements in atomic structure and the development of laser- driven polarized hydrogen and deuterium sources.

## **STUDENT TRAVEL SUPPORT FOR STORRS MEETING**

Limited travel support is available to assist students in traveling to Storrs, CT for the DAMOP meeting this June. Students should complete the included form and return it before 1 May 2000, to Timothy J. Gay, Behlen Laboratory of Physics, University of Nebraska, Lincoln, NE 68588-0111.

## **NEWSLETTER INPUT**

If you have any information, ideas, meeting announcements, etc., which are of interest to DAMOP members, please send them to me at any time. They can either be included in the October 2000 Newsletter, or distributed to the DAMOP email list within a week of receipt.



Tim Gay  
EMAIL: tgay1@unl.edu  
FAX: 402-472-2879

## Election of Divisional Officers: Candidates for Office Vice Chair

### **GREENE, CHRIS H.**

B.S. (Physics and Mathematics), University of Nebraska, 1976; Ph.D. (Physics), University of Chicago, 1980; Postdoctoral Research Associate (Chemistry), Stanford University, 1980-81; Assistant Professor, Associate Professor, and Professor of Physics, Louisiana State University, 1981-88; Professor of Physics and Fellow of JILA, University of Colorado, 1988-present; Visiting Researcher, Laboratoire Aime Cotton, Orsay, 1993; I. I. Rabi Prize of the American Physical Society, 1991; APS Fellow, 1990; NSF Presidential Young Investigator, 1985-1990; Alfred P. Sloan Foundation Fellow, 1983-87; Louisiana State University Sigma Xi Award for Research in the Physical and Natural Sciences, 1984; Chair, 2001 I. I. Rabi Prize Committee; Director, Center for Theoretical Atomic, Molecular, and Optical Physics at JILA/CU, 1990-1999; Vice Chair (1992-93) and Chair (1994-95), Gordon Conference on Atomic Physics; ICPEAC Organizing Committee, 1983-86; DAMOP Executive Committee, 1991-94; Chair, AMO Physics Working Group, 1998 Workshop on Scientific Directions at the Advanced Light Source; Chair, Theory of Structure and Dynamics Panel, 1997 Department of Energy Workshop on Atomic, Molecular, and Optical Physics.

**RESEARCH INTERESTS:** Nonperturbative correlations among different quantum mechanical degrees of freedom in atomic and molecular systems; double photoionization of two- and three-electron atoms; ultracold collisions of two or three atoms; the theory of Bose-Einstein condensation; multichannel atomic and molecular Rydberg states and their properties in an external field; anisotropy produced in photofragmentation and the use of laser-induced fluorescence as a probe; linking quantal and semiclassical descriptions of highly correlated systems.

### **PHANEUF, RONALD H.**

B.S. 1969, M.S. 1970, Ph.D. 1973, University of Windsor. Postdoctoral Research Associate, JILA, 1973-75. Research Associate, 1975-81; Research Staff Member, 1981-85; Senior Research Staff Member, 1985-92; Program Manager, Atomic Physics and Plasma Diagnostics for Fusion, 1983-92; Director, Controlled Fusion Atomic Data Center, 1985-92, Oak Ridge National Laboratory. JILA Visiting Scientist, 1988-89. Chair and Professor of Physics, University of Nevada, Reno, 1992- present. APS Fellow, 1986. DAMOP Publications Committee, 1985-86; Executive Committee, 1988-89; Program Committee, 1989-91; Secretary-Treasurer, 1993-96; Nominating Committee, 1996

(chair), 1997; Fellowship Committee, 1999; Local Committee for 1993 DAMOP Meeting. NRC Committee on Atomic, Molecular and Optical Science (CAMOS), 1990-93; AMO Sciences Assessment Panel, Committee on Physical Sciences, Mathematics and Applications, 1992-93; Analysis of FAMOS Survey of AMO Scientists, 1992-93. Screening Panel for DOE E. O. Lawrence Award, 1994. Editorial Board, Journal of Physical and Chemical Reference Data, 1986-88. International Conference on the Physics of Highly Charged Ions, Program Committee, 1990-92. APS Topical Conference on Atomic Processes in Plasmas, Program Committee, 1987, 1993, 1995, 1999. ICPEAC General Committee, 1983-87, 1997 - present. Advisory Group on Atomic and Molecular Data for Fusion, International Atomic Energy Agency, 1983-1992. Director, Nevada DOE/EPSCoR Program, 1998-2000. Member, American Association of Physics Teachers, 1993-.

**RESEARCH INTERESTS:** Interactions of multiply charged ions with electrons, photons, atoms and molecules; photon-ion interactions using synchrotron radiation; charge-changing and excitation processes; atomic processes in plasmas; fusion energy.

## Candidates for Executive Committee

### LETT, PAUL D.

B.S. Marquette University, Milwaukee, WI, 1980, Ph.D. University of Rochester, Rochester, NY, 1986. Physicist, Atomic Physics Division, National Institute of Standards and Technology (1986-present). APS Fellow; Member APS DAMOP, DLS, TG/PMFC; Member, Optical Society of America; NIST Sigma Xi Young Scientist Award, 1993, U.S. Department of Commerce Silver Medal (1996); Director, Physics Laboratory Summer Undergraduate Research Fellowship program (SURF) (1997-); NIST EEO/Diversity Award (1999); Editorial board "Quantum and Semiclassical Optics: Journal of the European Optical Society, B" (1997-8); Program committee, IQEC, 1998; Member of NRC Committee on Atomic Molecular and Optical Science (CAMOS) (1999-).

**RESEARCH INTERESTS:** Laser cooling and trapping of neutral atoms; ultracold collisions and photoassociation spectroscopy. Quantum optics, frequency standards, quantum information processing, fundamentals of quantum mechanics.

### MEYSTRE, PIERRE

Physics Diploma 1971, PhD 1974, Physics, Swiss Federal Institute of Technology, Lausanne, Switzerland; Habilitation (Theoretical Physics), Ludwig-Maximilians University Munich, Germany, 1983; Research Associate, University of Arizona, 1974-1977; Staff Member, Max-Planck Institute for Quantum Optics, 1977-1986; Lecturer (Privat Dozent), University of Munich, 1984-1986; Professor, Optical Sciences Center, University of Arizona, 1986-present, Department of Physics, 1990-present, Chair of Quantum Optics, 1998-present. Fellow of the Optical Society of America; Fellow of the American Physical Society; Humboldt Research Prize, 1995. Member of the Board, Quantum Optics

Division, German Physical Society, 1982-1986; Editorial Board, European J. Phys. B: Quantum Optics, 1992- 1996; Editorial Board, Physical Review A, 1992-1996; Advisory Board, AIP Atomic, Molecular and Optical Physics Handbook, 1992-1996; DAMOP Publication Committee, 1992-1995; Advisory Board, Rochester Theory Center for Optical Science and Engineering, 1995-present; Editorial Board, Springer Series in AMO Physics, 1996-present; DAMOP Program Committee, 1996-1999, DAMOP Fellows Committee, 1998- 1999; Editorial Board, Gordon and Breach Series in Laser in Science and Technology, 1999-present; NRC FAMOS Update Panel, 1999-present.

**RESEARCH INTERESTS:** Theoretical quantum optics, statistical properties of radiation, laser theory, cavity QED, quantum degenerate atomic systems, BEC, linear and nonlinear atom optics

### **MURNANE, MARGARET M.**

B.Sc. University College Cork, Ireland 1981; Ph.D. UC Berkeley 1989. Assistant Professor of Physics, Washington State University 1990-1995; Associate Professor of EECS and Physics, University of Michigan 1996 - 1999; Professor of Physics, University of Colorado 1999 - present. AWARDS: Fellow of the Optical Society of America, 1998; Maria Goeppert-Mayer Award of the American Physical Society, 1997; Presidential Faculty Fellowship of the National Science Foundation, 1993; Sloan Foundation Fellowship, 1992; Presidential Young Investigator Award of the National Science Foundation, 1991; Simon Ramo Award of the American Physical Society, 1990; University of California President's Postdoctoral Fellowship, 1989. SERVICE: Topical Editor for Optics Letters in Ultrafast Phenomena (Optical Society of America); Editorial Board of Review of Scientific Instruments (American Institute of Physics); Chair, National Research Council Committee on Atomic, Molecular, and Optical Sciences (2000-2002); Conference co-Chair, Gordon Conference on Nonlinear Optics (1999); Executive Committee Member, American Physical Society Division of Laser Science; Conference Chair, APS Division of Laser Science Annual Meeting (1999) Conference Co-Chair, OSA International Conference on Ultrafast Phenomena (2000); Board of Directors of the Optical Society of America (2000 - 2003); Executive Committee Member, American Physical Society (2000-2002)

**RESEARCH INTERESTS:** High field physics; Ultrafast atomic, molecular and optical physics; laser science; coherent control of high field optical interactions; ultrafast coherent x-ray generation and applications; ultrafast plasma physics; x-ray lasers; attosecond science.

### **PINDZOLA, MICHAEL S.**

B.A., University of the South, Sewanee, TN, 1970; Ph.D., University of Virginia, Charlottesville, VA, 1975; NRC Resident Research Associate, NASA Goddard Space Flight Center, MD, 1975-1977; Faculty, Department of Physics, Auburn University, AL, 1977-present, currently Alumni Professor; Consultant, Physics

Division, Oak Ridge National Laboratory, TN, 1980-present; Fellow of the American Physical Society, 1993; Fellow of the Institute of Physics (London), 1995; Co-chair of NSF workshops on "The Application of Many-Body Theory to Atomic Physics", 1993, "New Developments in Electron-Atom Scattering", 1996, "Computational Atomic and Molecular Physics", 2000, at ITAMP, Harvard University, Cambridge, MA. Co-chair of APS Topical Conference on "Atomic Processes in Plasmas", 1998, at Auburn University, Auburn, AL.

**RESEARCH INTERESTS:** atomic and molecular processes in astrophysical and controlled fusion plasmas, few-body dynamics in photon, electron, and heavy particle interactions with atoms.

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