CIPS

Center for Integrated Plasma Studies

University of Colorado at Boulder

Annual Report 1998

John R. Cary, Director
Carolyn M. James, Administrative Officer

September 1999

INTRODUCTION

Modern plasma physics is the study of collective, often nonlinear, electromagnetic processes in ionized gases called plasmas. Plasma physics related research at the University of Colorado is currently carried out primarily in the Physics Department, but also in the Astrophysical and Planetary Sciences Department, the Department of Applied Mathematics, and in the Departments of Mechanical Engineering, Aerospace, and Electrical and Computer Engineering. In the community at large, plasma research is conducted at NIST, at the High Altitude Observatory of NCAR, at the Space Environment Labs of NOAA, and at local companies such as Lodestar Corp. and Science Applications, Inc.

The purpose of CIPS is to provide a focal point and forum for the exchange of both educational and research ideas among scientists with these diverse affiliations. Research in plasma physics is extraordinarily broad, encompassing basic physics of plasmas, fusion sciences, space and astrophysics, beam and accelerator physics, laser-matter interactions, and industrial processing. CIPS possesses scientific expertise in all of these areas, and fosters unique new opportunities for sponsored research in interdisciplinary aspects of plasma physics. CIPS sets the guidelines for both undergraduate and graduate education in plasma physics at the University of Colorado, providing research opportunities and guidance for plasma physics Ph.D. candidates.

MISSION STATEMENT

The mission of the Center for Integrated Plasma Studies (CIPS) is to foster plasma and beam related science and research. In particular, CIPS provides a home for interdisciplinary plasma related activities. This includes coordination of high-performance scientific and networking capability. The Center for Integrated Plasma Studies additionally has the mission of scientific outreach, including making plasma physics, general physics and astrophysics highly accessible to the general public.

MESSAGE FROM THE DIRECTOR

The Center for Integrated Plasma Studies (CIPS) is completing yet another year of growth. CIPS members come from the departments of Physics, Astrophysical and Planetary Sciences, Applied Mathematics, and Electrical Engineering. Reimbursed project expenditures for all projects centered in CIPS were roughly $1.36 M for fiscal 1999 (April, 98 – March, 99), with new grants arriving in 1998 totaling $1.2M. This resulted in an increase in indirect cost recovery of 37% over FY98. At the same time, CIPS personnel increased with the addition of Dr. Alan Kiplinger as Senior Research Associate. CIPS now has three active Senior Research Associates, members of the plasma community who have decided to pursue careers in plasma research at CIPS. Overall, CIPS has 29 members, 30 graduate and undergraduate students, and 18 off campus affiliates.

CIPS has increased its visibility and service within the University in multiple ways. CIPS faculty are active in developing the plasma curriculum which include courses and students from several departments. Professor Cary is the Natural Sciences Coordinator in the Area Teaching Scholars program of the Faculty Teaching Excellence Program. Professor Goldman leads the development of the Physics 2000 web site that showcases the use of technology in teaching. CIPS also organizes the plasma seminar that is attended by faculty from many units both academic and research, such as LASP.

Our external funding has made it possible to support 14 graduate students on our various projects as well as four postdoctoral fellows. Our former students and postdocs are employed at prestigious universities and institutes throughout the country. Two recent postdocs, Carson Chow and Meers Oppenheim, are now in tenure track positions at the University of Pittsburgh and Boston University, while Bill Gabella runs the free-electron laser facility at Vanderbilt University. Other former students and postdocs are employed by at national laboratories or by private research corporation. In general, the plasma students trained by CIPS faculty and researchers find employment in the field of plasma physics.

CIPS research programs have made the University increasingly visible to the outside world. Our programs range over the breadth of plasma physics. Our experimental programs are concerned with both in situ measurements of ionospheric plasmas to laboratory plasma experiments investigating the fundamentals of transport in plasmas. Our theoretical programs study solar flares, space plasma turbulence, beam dynamics, and turbulence in strongly magnetized plasma. We have a strong computational component to our work. Professor Parker's simulations are carried out on massively parallel computers at Lawrence Berkeley and Los Alamos National Laboratories. Dr. Isidoros Doxas has built a supercomputer locally by linking together multiple Intel based machines with fast ethernet.

CIPS members have made the University more visible to the outside world also through their service contributions. CIPS members are active in the American Physical Society through membership in and chairmanship of the society and plasma division committees. Professor Parker was the team leader for "Cyclone": a DOE initiative to investigate the physics basis for transport predictions for ITER. The University of Colorado has just recently been asked to host the Particle Accelerator School. This last event will bring scientists and students from throughout the country to Colorado to give and take intensive, two-week courses.

The natural strength of CIPS is networked computational research, its capital investments in computers and networking, and the teaching experience of CIPS members has led to CIPS also being a center of teaching technology at the University. Professor Goldman's work in the Physics-2000 Outreach Website Project has led to external funding from NSF as well as from the Colorado Commission on Higher Education. Professor Goldman has also involved Colorado high schools in this work. The Solar System Collaboratory Project of Senior Research Associate Doxas is now funded by a large grant from the Department of Education after two years of funding from the Colorado Commission on Higher Education. The Collaboratory project involves Fort Lewis College, the University of Northern Colorado, the University of Southern Colorado, and the University of Colorado at Boulder.

CIPS is experiencing continued growth and success across the areas of research, teaching, service, and outreach, and it is finding the resources needed to carry out its mission.

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PERSONNEL

CIPS FELLOWS

Martin V. Goldman - Director and Professor of Physics
John R. Cary - Associate Director and Professor of Physics
James Meiss, Professor of Applied Mathematics
Scott Parker, Assistant Professor of Physics
Zoya Popovic, Associate Professor of ECEE
Scott Robertson, Associate Professor of Physics
Ted Speiser, Professor of APS
Raul Stern, Professor of Physics

CIPS MEMBERS

David Alexander, Research Associate
Fran Bagenal, Professor of APS
Dan Baker, Director of LASP
Yang Chen, Research Associate
Isidoros Doxas, Senior Research Associate
Tim Fuller-Rowell, Senior Research Associate with CIRES
Alan Gallagher, Lecturer with Physics
Scott Hendrickson, Research Associate
Mihaly Horanyi, Research Associate with LASP
James Howard, Research Associate
Alan Kiplinger, Senior Research Associate with APS
David Newman, Research Associate
Yasutaro Nishimura, Research Associate
Meers Oppenheim, Research Associate
Svetlana Shasharina, Senior Research Associate

RECENT PH.D.'S

R. Kathy Garvin-Doxas

CIPS SCIENTIST ASSOCIATES

HAO/NCAR
- Paul Charbonneau
- Tom Holzer
- Art Hundhausen
- BC Low
- Gang Lu
- Art Richmond
- Ray Roble

Lodestar Corp.
- Dick Aamodt
- Dan D'lppolito
- Jim Myra
- David Russell

Space Science Inst.
- Paul Dusenbery

SEC/NOAA
- Ernie Hildner
- Terry Onsager
- Vic Pizzo
- Howard Singer
- Ron Zwickel

NIST
- John Bollinger

VISITING SCHOLARS

James Drake, Department of Physics & Institute for Plasma Research University of Maryland

CIPS RESEARCH SUPPORT STAFF

John Adams, Professional Research Assistant
John Albers-Mead, Assistant
Krista Beck, Professional Research Assistant
Carolyn M. James, Professional Research Assistant
David Rea, Professional Research Assistant
David Underwood, Graphic Designer

GRADUATE STUDENTS

Hikmet Andic, Visiting Research Scholar
Christopher Boozer, APS
Brendan Field, Physics
Kathy Garvin-Doxas, Communication
Richard Ghrist, Physics
Brent Goode, Physics
Samuel Jones, Physics
Charlson Kim, Physics
Jinhyung Lee, Physics
Feng Pan, Physics
Fernando Perez, Physics
Amanda Sickafoose, APS
Byron Smiley, Physics
Kiran Sonnad, Physics

UNDERGRADUATE STUDENTS

Michelle Backus
Lorraine Bell
Zachary Chandler
Polly Fordyce
Michael Fuchs
Greg Gengarelly
Taunya Henriksen
Benjamin Ihas
Craig Morrison
Ronald Sudomo
Matt Triplett
Wenming Ye
Richard Younger
Amanda Youngwirth

INTERNS

Amaria George, Reed College
Nathan Klingenstein, Boulder High School

CIPS RESEARCH GRANTS ACTIVE DURING CALENDAR YEAR 1998, BY PRINCIPAL INVESTIGATOR

Cary, John R.	
DOE, 1994-99	$467,000
DOE, 1995-200	$859,000
Doxas, Isidoros	
CCHE, 1997-98	$180,137
Dept. of ED, 1998-2001	$299,574
NASA, 1997-99	$121,068
NASA, 1997-00	$152,068
Univ. of Texas, 1998-99	$136,550
Goldman, Martin V.	
CCHE, 1997-98	$235,000
DOE, 1998-2000	$140,000
NASA, 1997-99	$113,000
NSF, 1998-2000	$236,465
NSF, 1994-98	$412,806
Kiplinger, Alan	
NASA, 1997-99	$124,353
NASA, 1998-99	$18,635
NSF, 1997-00	$150,000
Meiss, James D.	
NSF, 1996-99	$71,936
Newman, David	
NSF,1997-2000	$240,000
NSF, 1998-2000	$155,000
Oppenheim, Meers	
NASA, 1997-1998	$69,807
Parker, Scott	
DOE, 1997-2000	$259,000
DOE, 1997-2001	$270,000

Robertson, Scott

Graduate School	$2,000
DOE, 1997-98	$222,000
DOE, 1997-00	$273,000
NSF/DOE, 1997-00	$495,000
NSF, 1997-98	$5,000
NASA, 1998-00	$150,000
NASA, 1996-98	$30,000
NASA, 1997-98	$30,000
NASA, 1997-98	$56,000
NASA, 1997-2000	$169,500
NASA Glenn/Lewis, 1998-02	$73,065
NASA Goddard, 1997-99	$30,000

Stern, Raul

NSF, 1993-98	$330,000
NSF, joint with CALTECH, 1995-98	$130,511
NSF, joint with UCLA, 1994-99	$520,654
California Institute of Tech, 1995-98	$40,934

WORKSHOPS

SEVENTH WORKSHOP ON THE PHYSICS OF DUSTY PLASMAS,

Boulder, Colorado, April 6-9, 1998.
Organized by Mihaĺy Horańyi, Scott Robertson and Bob Walch.

This workshop brought together at the Boulderado Hotel over 50 participants from the United States, Europe and Asia to discuss the latest experimental and theoretical results in dusty plasma physics. Topics included industrial plasma processing, planetary moons and rings, laboratory plasmas, strongly-coupled plasmas, and nonneutral plasmas. The conference proceedings have appeared as a volume in the American Institute of Physics conference proceedings series.

SEMINAR SERIES

1 January - 31 May 1998
Seminar Series Coordinator: Meers Oppenheim

Date	Speaker	Title
March 9	Yang Chen, Princeton Plasmas Physics Lab, Princeton University	Simulation of wave-particle resonant interactions with new delta-f method
April 6	Hong Qin, Princeton University	Gyrokinetic Theory and Computational Methods for Low Frequency Electromagnetic Perturbations in Inhomogeneous Plasmas.
April 20	Chanchal Uberoi, Indian Institute of Science and Bell Laboratories	Surface Waves and Magnetic Reconnection in Space Plasmas.
May 18	Phil Snyder, Princeton University	Electromagnetic Turbulence and Transport in Magnetized Toroidal Plasmas
July 31	Niyaz N. Khusnatdinov, Thayer school of Engineering, Dartmouth College	Electrical and Optical Properties of Ice
August 28	Dr. Yasuturo Nishimura, CIPS	High-n ballooning modes in the nonlinear stage of sawtooth crash.

04 September 1998 - 04 December 1998
Seminar Series Coordinator: Yang Chen

Date	Speaker	Title
September 4	Robert L. McPherron, Space Environment Center, Environmental Research Laboratories	What is the Relation of Substorms to Magnetic Storms?
September 11	Alan Kiplinger, CIPS	The Solar Heliosphere Observatory (SOHO): some of its findings, finding it and its recovery
September 18	Samuel Jones, Physics department	Gyrofluid Simulations of Alfven Eigenmodes in the Magnetosphere
October 2	Charlson Kim, Physics dept. graduate student.	Plasma Simulation using Massively Parallel Computers
October 9	Dr. Glen R. Stewart, LASP, University of Colorado	Resonant wave-planet interactions in the early solar system.
October 16	Dr. Isidoros Doxas, CIPS	Substorm Dynamics form a Low-Dimensional Nonlinear Dynamics Model
October 30	Dr. Yang Chen, CIPS	Gyro-averaged Plasma Kinetic Equations for Low-Frequency phenomena
November 6	Professor Martin Goldman, Department of Physics, CIPS	Nonlinear 2-stream instabilities as an explanation for auroral bipolar wave structures
November 13	Dr. Scott Parker, Department of Physics, CIPS	Large-Scale Gyrokinetic Plasma Turbulence Simulations
December 4	Dr. Daniel D'Ippolito, Lodestar Research Corporation	Effect of Edge Convection on Tokamak Confinement

RESEARCH INTERESTS

JOHN CARY

My research interests are in the areas of plasma physics, beam (or accelerator) physics, nonlinear dynamics, and computational physics. My plasma physics interests range broadly, as does my funding. It includes studies of space plasma physics (NSF funded) as well as fusion plasma physics (DOE funded) of three-dimensional confinement systems (those with strong toroidal variation). My beam physics interests are in understanding collective instabilities as well as in the nonlinear dynamics of two-degree-of-freedom symplectic maps. In 1998, work in this area was published as a Physical Review Letter. As my nonlinear dynamics interests intertwine with plasma and beam physics, so do my computational physics interests. These computational interests are not in the traditional areas of massive computation, but rather in the developing area of scientific Object Oriented Programming. Here the challenge is to find the correct object representation of physical systems.

YANG CHEN

My research in CIPS is on the numerical simulation of turbulence transport in a tokamak. The simulation is based on a new hybrid fluid-electron-gyrokinetic-ion model. Instead of simply assuming an adiabatic response for the electrons, the gyrofluid equations are adopted in the new model for the electrons. The code is now the first complete 3-dimensional flux-tube code that has electromagnetic effects. In addition to my research, I also organize the weekly CIPS Plasma Seminar in the Fall Semester.

ISIDOROS DOXAS

The main subject of my research has been plasma turbulence in laboratory and space plasmas, especially as analyzed by the methods of nonlinear dynamics and large-scale particle simulations. I have worked on stochastic transport in fusion devices, and on the limits of quasilinear theory. For the past ten years I have participated in and directed research projects in magnetospheric physics, particularly on magnetic reconnection in the geomagnetic tail, and on global models of the dynamics of the coupled magnetophere-ionosphere system.

MARTIN V. GOLDMAN

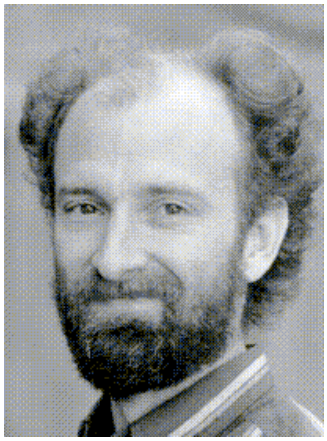
Current research interests include: plasma physics, nonlinear waves, electron-beam-plasma interactions, radiation-plasma interactions, nonlinear optics, computer simulations of plasma turbulence and coherent processes, theory of modification of Earth's ionosphere by high-power radar, theory and simulation of laser-plasma interactions, and theory and simulation of auroral ionosphere wave-particle interactions.

ALAN L. KIPLINGER

Research activities include studies of solar flares and other phenomena such as coronal mass ejections that are associated with acceleration of high energy particles. Since several aspects of research involve studying solar activity associated with interplanetary protons observed near Earth (i.e. the Sun - Earth connection) and new ways to predict or nowcast such storms in space, the efforts may be considered "applied astrophysics" as well as basic research. Activities also include archiving and study of optical data from a worldwide network of observatories as well as making direct optical observations at CU in order to assess properties of electron beam acceleration in flares.

JAMES MEISS

My research is in the area of dynamical systems, in particular the study of the onset and characterization of chaos. My recent teaching includes courses in dynamics, differential equations and chaos.



DAVID NEWMAN

My research has centered on theoretical and numerical studies of plasma wave turbulence in a variety of space and laboratory environments—in collaboration with Prof. Martin Goldman and Research Assoc. Meers Oppenheim. The recent focus of our research has been the analysis of nonlinear wave evolution in the auroral ionosphere at altitudes probed by the FAST satellite, in the artificially modified ionosphere during heating experiments at Arecibo, and in beam-plasma laboratory experiments at UCLA.

YASUTARO NISHIMURA

Research activities include theoretical research in fusion plasma physics; in particular, investigation of magnetic surface formations in three dimensional omnigenous stellarator equilibria and corresponding neoclassical particle transport. The omnigenous configuration being studied is predicted to have good plasma confinement properties and allows compact, economically feasible fusion reactor designs. The research is conducted both analytically (application of Hamiltonian dynamics to magnetic field line behaviors) and numerically (large scale MHD equilibrium and stability code).

MEERS OPPENHEIM

My research area is computational and theoretical space plasma physics.

SCOTT PARKER

My primary research is in the area of direct numerical simulation and basic theoretical understanding of plasma turbulence and transport. Research includes large-scale simulations of tokamak plasma turbulence. These simulations solve reduced equations in a five-dimensional phase space (called gyrokinetic formalism) using newly developed particle simulation methods which evolve the perturbed part of the distribution function along characteristics. These calculations involve many millions of simulation particles and must fully utilize the newest and most powerful massively parallel computers. For the first time, these fully nonlinear simulations have shown spectral features and transport levels similar to that observed in large present-day experiments. Other active research areas include theoretical and computational research on kinetic-fluid hybrid models, and renormalization procedures for collisionless kinetic systems to model nonlinear wave-particle interactions.

ZOYA POPOVIC

Projects in microwave and millimeter-wave quasi-optical systems, microwave high-efficiency amplifiers, antennas for wireless communications and fr photonics. Project with the Netherlands Foundation for Radioastronomy on a broad longterm (20-year) international project developing a new very large radiotelescope.

SCOTT ROBERTSON

My research interest is experimental plasma physics with emphasis on 1) space and laboratory plasmas containing dust, aerosols or large molecular clusters; 2) non-neutral plasmas with emphasis on transport processes; and 3) particle beams as plasmas.

SVETLANA SHASHARINA

Nuclear Fusion Theory: confinement, transport; Computer Science: C++ modeling.

TED SPEISER

Magnetospheric substorms, the geomagnetic tail, current sheets and their stability, remote sensing of the topology of the geomagnetic tail current sheet using satellite observations of energetic ions along with our model, and theories of the onset of geomagnetic substorms.

RAUL STERN

Research focuses on experimental basic plasma physics, a variety of programs, one at CU and three additional projects in collaboration with major national and international research and educational institutions (Caltech, UCLA, University of Provence, France)

PUBLISHED PAPERS IN REFEREED JOURNALS, IN 1998

JOHN CARY

"General Linear Theory of Damped, Beam-driven Oscillations of a Single Mode," P. H. Stoltz and J. R. Cary, Physics of Plasmas 5 (11) 4084, (1998).

"Increasing the Dynamic Aperture of Accelerator Lattices," Weishi Wan and John R. Cary, Phys. Rev. Lett. (81) 3655, (1998).

"Reusable Java Components for Physics Education," John R. Cary and David A. Alexander, Computers in Physics 12 (4) 314-318, (1998).

ISIDOROS DOXAS

"Interchange Trigger for Substorms in a Nonlinear Dynamics Model," W. Horton, V. Wong, R. Weigel, and I. Doxas, Physics of Space Plasmas (18), (1998).

"A Low-dimensional Dynamical Model for the Solar Wind Driven Geotail-Ionosphere System," W. Horton and I. Doxas, Geophys. Res. (103) 4561, (1998).

"Magnetic Energy Storage and the Nightside Magnetosphere-Ionosphere Coupling," W. Horton, W. Pekker, and I. Doxas, Geophys. Res. Lett. (25) 4083, (1998).

MARTIN V. GOLDMAN

"Langmuir Turbulence Associated with Ionospheric Modification: Challenges Associated with Recent Observations During a Sporadic-E Event," D. L. Newman, M. V. Goldman, F. T. Djuth, P. A. Bernhardt, Physics of Space Plasmas (15) 259-264, (1998).

"PIC Simulations of Bipolar Wave Structures Driven by Dense Beams in the Auroral Ionosphere," M. V. Goldman, M. M. Oppenheim, and D. L. Newman, Physics of Space Plasmas (15) 115-120, (1998).

"New Insights Into How Beam-Excited Instabilities Saturate," M. V. Goldman, D. L. Newman and M. M. Oppenheim, Physica Scripta (T75) 52, (1998).

ALAN L. KIPLINGER

"Hard X-Ray Spectroscopy for Proton Flare Prediction," H. A. Garcia, F. Farnik, A. L. and Kiplinger, in the Proceedings of the S.P.I.E. Missions to the Sun II, C. Korendy, ed., Vol. 3442 210, (1998).

"The Solar Minimum Active Region 7978, Its X2.6/1B Flare, CME, and Interplanetary Shock Propagation of 9 July 1996," M. Dryer, et al., Solar Physics (181) 159, (1998).

JAMES MEISS

"Computing Connectedness: An Exercise In Computational Topology," V. Robins, J. D. Meiss and E. Bradley, Nonlinearity (11) 913-922, (1998).

"Computing Periodic Orbits Using the Anti-integratable Limit," D. Sterling and J. D. Meiss, Physics Letters A (241) 46-52, (1998).

"Homoclinic Bifurcations for the Hénon Map," D. Sterling, H. R. Dullin and J.D. Meiss, Physica D accepted, (1998).

"Quadratic Volume Preserving Maps," H. E. Lomeli and J. D. Meiss, Nonlinearity (11) 557-574, (1998).

"Quadratic Volume Preserving Maps: an Extension of a Result of Moser," K. E. Lenz, H. E. Lomeli and J. D. Meiss, Regular and Chaotic Motion, accepted, (1998).

"Stability of Minimal Periodic Orbits," H. Dullin and J. D. Meiss, Phys. Lett. A (247) 227-324, (1998).

DAVID NEWMAN

"Langmuir Turbulence Associated with Ionospheric Modification: Challenges Associated with Recent Observations During a Sporadic-E Event," D. L. Newman, M. V. Goldman, F. T. Djuth, and P. A. Bernhardt, Physics of Space Plasmas (15) 259-264, (1998).

"PIC Simulations of Bipolar Wave Structures Driven by Dense Beams in the Auroral Ionosphere," M. V. Goldman, M. M. Oppenheim, and D. L. Newman, Physics of Space Plasmas (15) 115-120, (1998).

"New Insights Into How Beam-Excited Instabilities Saturate," M. V. Goldman, D. L. Newman and M. M. Oppenheim, Physica Scripta (T75) 52, (1998).

YASUTARO NISHIMURA

"Tearing Mode Analysis in Tokamaks, Revisited," Y. Nishimura, et. al., Physics of Plasmas (5) 4292, (1998).

SCOTT PARKER

"Large-scale Gyrokinetic Turbulence Simulations: Effects of Profile Variation," S. E. Parker, C. Kim and Y. Chen, Physics of Plasmas, (1998).

"Simulation of Ion-temperature-gradient Turbulence in Tokamaks," A. Dimits, B. Cohen, N. Mattor, W. Nevins, D. Shumaker, S. Parker and C. Kim, Proceedings of the 17th IAEA Fusion Energy Conference, Yokohama, Japan, 1998.

SCOTT ROBERTSON

"Electrostatic Charging Properties of Apollo 17 Lunar Dust," Mihaĺy Horańyi, Bob Walch, Scott Robertson and David Alexander, Journal of Geophysical Research (103) 8575-8580, (1998).

"Confinement Times of Dust Particles in Electrostatic Traps," Chance Mahr, Bob Walch and Scott Robertson, Physics of Dusty Plasmas, edited by M. Horańyi, S. Robertson, and Bob Walch, American Institute of Physics, New York, (446) 41-47, (1998).

"Coulomb Crystals of Oil Drops in a Paul Trap," Richard Younger and Scott Robertson, Physics of Dusty Plasmas, edited by M. Horańyi, S. Robertson, and Bob Walch, American Institute of Physics, New York, (446) 265-270, (1998).

"Laboratory Experiments Relating to Noctilucent Clouds," Scott Robertson and Mihaĺy Horańyi, Physics of Dusty Plasmas, edited by M. Horańyi, S. Robertson, and Bob Walch, American Institute of Physics, New York, (446) 286-290, (1998).

RAUL STERN

"Laser-Induced Fluorescence Observation of Self Organized Ion Structures Induced by Electrostatic Perturbations," G. Bachet, F. Skiff, M. Dindelegan, F. Doveil and R. A. Stern, Physical Review Letters (80) 3260, (1998).

"Observations of Fast Anisotropic Ion Heating, Ion Cooling and Ion Recycling in Large-Amplitude Drift Waves", S. J. Sanders, P. M. Bellan and R. A. Stern, Physics of Plasmas (5) 716, (1998).

"Real-time Phase-Selective Data Acquisition System for Measurement of Wave Phenomena in Pulsed Plasma Discharges", S. J. Sanders, R. A. Stern and P. M. Bellan, Review of Scientific Instruments (69) 2027, (1998).

INVITED PAPERS IN 1998

JOHN CARY

"CORBA Data Objects for the National Transport Code Collaboration," K. G. Luetkemeyer, J. Cary et. al., Bull. Am. Phys. Soc. 43 (8) 1673, (1998).

"Efficient C++ Library for Differential Algebra," J. Cary and S. Shasharina, Beam Dynamics and Optimization, St. Petersburg, June, 1998.

"Efficient Differential Algebra Library in C++," International Sherwood Fusion Theory Conference, Atlanta, Mar. 24, 1998.

"MAPA: an Object-oriented Accelerator Modeling Code with a Graphical User Interface," D. L. Bruhwiler, J. Cary and S. Shasharina, Beam Dynamics and Optimization, St. Petersburg, June, 1998.

"Modeling and Simulation in Plasma Physics," DOE Workshop on Modeling and Simulation at PPPL, Jan. 23, 1998.

"Omnigenity and Quasisymmetry," US-Japan Conference on Stellarators, Princeton Plasma Physics Lab, January, 1998.

"Status of MAPA (Modular Accelerator Physics Analysis) and the Tech-X Object-oriented Accelerator Library," J. R. Cary, S. Shasharina and D. L. Bruhwiler, Proc. European Particle Accelerator Conf., Stockholm, 1998.

"Structure of the Demonstration Code for the National Transport Code Collaboration," J. Wiley et. al., Bull. Am. Phys. Soc. 43 (8) 1673, (1998).

"Summary of the DOE Workshop on Modeling and Simulation," Berkeley, Feb. 9, 1998.

"Symplectic Propogation of the Map, Tangent Map and Tangent Map Derivative through Quadrupole and Combined-Function Dipole Magnets Without Truncation," J. R. Cary, S. Shasharina and D. L. Bruhwiler, Proc. European Particle Accelerator Conf., Stockholm, 1998.

ISIDOROS DOXAS

"Force Balance in the Geotail Quasineutral Sheet and the MHD Closure," I. Doxas and W. Horton, American Geophysical Union, San Francisco, CA, 1998.

"The Fractal Dimension of the Driven Lorentz System and its Implications for Magnetopheric Indices," B. Goode, J. R. Cary, and I. Doxas, American Geophysical Union, San Francisco, CA, 1998.

"Magnetospheric Dynamics from a Low Dimensional Nonlinear Dynamics Model," I. Doxas, American Physical Society, New Orleans, LA, 1998.

"The Solar System Collaboratory," I. Doxas and F. Bagenal, American Geophysical Union, San Francisco, CA, 1998.

"The Solar Wind Driven Magnetosphere-Ionosphere as a Complex Dynamical System," W. Horton and I. Doxas, American Geophysical Union, San Francisco, CA, 1998.

"Substorm Prediction Properties of the Nonlinear Dynamics Model of the Solar-wind-magnetophere-ionosphere Coupling," I. Doxas and W. Horton, Space Weather Conference, Boulder, CO, 1998.

"WINDMI: A Physics Based Global Model of the Coupled Solar-Wind-Magnetosphere-Ionosphere," I. Doxas and W. Horton, Geospace Environment Modeling Conference, Snowmass, CO, 1998.

MARTIN V. GOLDMAN

"Competition Between Langmuir Wave-wave and Wave-particle Effects in the Auroral Ionosphere," K. Y. Sanbonmatsu, D. L. Newman, M. V. Goldman and G. T. Delory (presented by Sanbonmatsu), International Union of Radio Science (URSI) Meeting, Boulder, CO, Jan. 5, 1998.

"Influence of a Background Density Gradient on Langmuir Turbulence Generation During HF Heating of the Unpreconditioned Ionosphere," D. L. Newman and M. V. Goldman (presented by Newman), International Union of Radio Science (URSI) Meeting, Boulder, CO, Jan. 5, 1998.

"Langmuir Turbulence Associated with Ionospheric Modification: Challenges Associated with Recent Observations During a Sporadic-E Event," 30 minute invited paper presented by M. Goldman, 1998 MIT-Cambridge Symposium Workshop on the Physics of Space Plasmas, D. L. Newman, M. V. Goldman, Lisbon, Portugal, July 29, 1998.

"Nonlinear 2-stream Instabilities as an Explanation for Auroral Bipolar Wave Structures," 30 minute invited paper presented by M. Goldman, 40th Meeting of Division of Plasma Physics of American Physical Society, Martin V. Goldman, M. M. Oppenheim and D. L. Newman, New Orleans, LA, Nov. 16, 1998.

"The Physics-2000 Project, Interactive Physics on the World Wide Web," 30 minute invited paper presented by M. Goldman, 25th International Siggraph Conference on Computer Graphics and Interactive Techniques, Martin V. Goldman and David Rea, Orlando, FL, July 19, 1998 (published in refereed journal - Siggraph Computer Graphics Annual Conference Series, Pgs. 38-41, 1998).

"PIC Simulations of Bipolar Wave Structures Driven by Dense Beams in the Auroral Ionosphere," 30 minute invited paper presented by M. Goldman), 1998 MIT Cambridge Symposium Workshop on the Physics of Space Plasmas, M. V. Goldman, M. M. Oppenheim and D. L. Newman, Lisbon, Portugal, July 22, 1998.

"Theory and Kinetic Simulations of Observed Localized Nonlinear Waves," 1 hour invited paper presented by M. Goldman, International Conference on MHD Waves and Turbulence, M. V. Goldman, M. M. Oppenheim and D. L. Newman Nice, France, Dec. 1, 1998.

JAMES MEISS

"Continuation from an Anti-Integrable Limit," Southeast Dynamical Systems, College Park, Maryland, Mar., 1998.

"Destruction of Horseshoes for the Hénon Map," International Hamiltonian Systems Conference, Patzucuaro, Mexico, Dec., 1998.

"Normal Forms for Quadratic Maps," Dynamics in Astrophysics, Gainsville Florida, Feb., 1998.

DAVID L. NEWMAN

"Competition Between Langmuir Wave-wave and Wave-Particle Effects in the Auroral Ionosphere," K. Y. Sanbonmatsu, D. L. Newman, M. V. Goldman and G. T. Delory (presented by K. Sanbonmatsu), International Union of Radio Science (URSI) Meeting, Boulder, CO, Jan. 5, 1998.

"Influence of a Background Density Gradient on Langmuir Turbulence Generation During HF Heating of the Un-preconditioned Ionosphere," D. L. Newman and M. V. Goldman (presented by D. Newman), International Union of Radio Science (URSI) Meeting, Boulder, CO, Jan. 5, 1998.

"Langmuir Turbulence Associated with Ionospheric Modification: Challenges Associated with Recent Observations During a Sporadic-E Event," (presented by M. Goldman), D. L. Newman, M. V. Goldman, 1998 MIT-Cambridge Symposium Workshop on the Physics of Space Plasmas, Lisbon, Portugal, July 29, 1998.

"Nonlinear 2-stream Instabilities as an Explanation for Auroral Bipolar Wave Structures," (presented by M. Goldman), Martin V. Goldman, M. M. Oppenheim and D. L. Newman, 40th Meeting of Division of Plasma Physics of American Physical Society, New Orleans, LA, Nov. 16, 1998.

"PIC Simulations of Bipolar Wave Structures Driven by Dense Beams in the Auroral Ionosphere," (presented by M. Goldman), M. V. Goldman, M. M. Oppenheim and D. L. Newman, 1998 MIT Cambridge Symposium Workshop on the Physics of Space Plasmas, Lisbon, Portugal, July 22, 1998.

YASUTARO NISHIMURA

"Measurement of Magnetic Field Line Stochasticity in Nonlinearly Evolving, Non-equilibrium Plasmas", Y. Nishimura et al., 16th International Conference on the Numerical Simulation of Plasmas, Santa Barbara, California, 1998.

"Resolving Magnetic Field Stochasticity and Parallel Thermal Transport in MHD Simulation," Y. Nishimura, International Workshop on Nonlinear and Extended-MHD, Atlanta, Georgia, 1998.

SCOTT PARKER

"Gyrokinetic Simulation of Kinetic Alfven Waves in the Magnetosphere," S. E. Parker and S. Jones, National Science Foundation Geo-space Environment Modeling Workshop, Snowmass Village, CO, Jun. 15, 1998.

"Gyrokinetic Simulation of Tokamak Plasma Turbulence," S. E. Parker, Department of Energy Office of Basic Energy Sciences Workshop on Nonlinear Complex Phenomena, Gaithersburg, MD, Jan. 23, 1998.

"Large-scale Simulation of Plasma Turbulence," S. E. Parker, Department of Physics Colloquium, Auburn University, May 22, 1998.

"Similarities between Flux-tube and Global Gyrokinetic Turbulence Simulations," S. E. Parker and C. Kim, Atlanta, GA, Mar. 1998.

"Comparison of Flux-tube and Global Gyrokinetic Simulations," C. Kim and S. E. Parker, International Sherwood Fusion Theory Conference, Atlanta, GA, Mar. 1998.

"Higher Order Geometric Effects and Profile Variation in a 3D Gyrokinetic Flux-Tube Simulations," C. Kim and S. E. Parker, "American Physical Society, Division of Plasma Physics Annual Meeting, New Orleans, LA, Nov. 16-20, 1998.

"Large-scale Gyrokinetic Turbulence Simulations," S. E. Parker, Division of Plasma Physics Annual Meeting, New Orleans, LA, Nov. 16- 20, 1998.

"Numerical Convergence of Gyrokinetic Simulations of Ion-temperature-gradient Turbulence," A. M. Dimits, D. E. Shumaker, W. M. Nevins, B. I. Cohen and S. E. Parker, 16th International Conference on Numerical Simulation of Plasmas, Santa Barbara, CA, Feb. 10-12, 1998.

"Raised Nonlinear Thresholds and Numerical Convergence of Gyrokinetic Simulations of Ion-temperature-gradient Turbulence in Tokamaks," A. M. Dimits, D. E. Shumaker, W. M. Nevins, B. I. Cohen and S. E. Parker, International Sherwood Fusion Theory Conference, Atlanta, GA, Mar. 1998.

"A Split-weight Scheme for the Electron Dynamics in Tokamak Plasmas," I. Manuilskiy, W. W. Lee, H. E Mynick and S. E. Parker, International Sherwood Fusion Theory Conference, Atlanta, GA, Mar. 1998.

SCOTT ROBERTSON

"An Annular Malmberg-Penning Trap with Neoclassical Transport," Scott Robertson, IEEE International Conference on Plasma Science, June 1-4, 1998.

"Dusty Plasma Experiments Relating to Noctilucent Clouds," Scott Robertson and Mihaly Horanyi, IEEE International Conference on Plasma Science, June 1-4, 1998.

"Dusty Plasma Experiments Relating to Polar Mesospheric Clouds," Scott Robertson and Mihaly Horanyi, Bull. Am. Phys. Soc. (43) 1652, (1998).

"Electrostatic Charging of Lunar Dust," Mihaly Horanyi, Bob Walch, and Scott Robertson, Proc. of the Laboratory Space Science Workshop, Harvard Center for Astrophysics, April 1-3, p. 53, 1998.

"Experimental Studies of the Photo-electric Sheath in Vacuum," A. Sickafoose, J. Colwell, M. Horanyi, S. Robertson and B. Walch, Bull. Am. Phys. Soc. (43) 1731, (1998).

"Laboratory Experiments Relating to Noctilucent Clouds," Scott Robertson and Mihaly Horanyi, Proc. of the Laboratory Space Science Workshop, Harvard Center for Astrophysics, April 1-3, p. 65, 1998.

SVETLANA SHASHARINA

"Efficient C++ Library for Differential Algebra," J. Cary and S. Shasharina, Beam Dynamics and Optimization, St. Petersburg, June, 1998.

"Efficient Differential Algebra Library in C++," J.R. Cary and S. Shasharina, International Sherwood Fusion Theory Conference, Atlanta, Mar. 24, 1998.

"MAPA: An Object-oriented Accelerator Modeling Code with a Graphical User Interface," D. L. Bruhwiler, J. Cary and S. Shasharina, Beam Dynamics and Optimization, St. Petersburg, June, 1998.

"Numerically Efficient and Polymorphic C++ Classes for Differential Algebra," S. Shasharina and J. Cary, Bull. Am. Phys. Soc. 43 (8) 1675, (1998).

"Omnigenity and Quasi-symmetry," J. R. Cary and S. Shasharina, US- Japan Conference on Stellarators, Princeton Plasma Physics Lab, January, 1998.

"Status of MAPA (Modular Accelerator Physics Analysis) and the Tech-X Object-oriented Accelerator Library," J. R. Cary, S. Shasharina and D. L. Bruhwiler, Proc. European Particle Accelerator Conf., Stockholm, 1998.

"Symplectic Propagation of the Map, Tangent Map and Tangent Map Derivative through Quadrupole and Combined-Function Dipole Magnets without Truncation," J. R. Cary, S. Shasharina, and D. L. Bruhwiler, Proc. European Particle Accelerator Conf., Stockholm, 1998.

CURRENT RESEARCH PROGRAMS

COMPUTATIONAL SPACE PLASMA PHYSICS (NSF, DOE, NASA)

Computation space plasma physics research is carried out with the participation of members of the University of Texas.

There are a variety of well-funded space plasma theory projects carried out in CIPS which involve intensive use of computers and supercomputers to carry out numerical simulations.

Ionospheric Modification. This is a part of an international project in which high-power radio waves are used to heat and modify Earth's ionosphere. Experiments have been carried out at Arecibo, Puerto Rico, at several facilities in Alaska, and at various other sites around the world. Multidimensional kinetic simulations have been developed and run at CIPS for studying the generation of wave turbulence and the subsequent acceleration of electrons to high energies under a variety of ionospheric conditions. The simulation results will be compared with observations, such as airglow measurements, and will serve as the basis for new theoretical models.

Auroral Ionosphere. FAST and other spacecraft has recently measured intense biploar electric fields in the auroral ionosphere. Kinetic simulations of turbulence driven by intense beams have resulted in bipolar electrostatic fields with characteristics similar to the bipolar fields that have been observed by FAST. The simulations reveal that these fields are associated with coherent "tube-like" structures in phase space, which subsequently break up due to interactions with electrostatic whistlers.

Electrojet. Theoretical conjectures concerning the existence and magnitude of wave-driven currents in the E-region of the ionosphere have been supported by a series of nonlinear 2-D simulations, including simulations of the Farley-

Buneman instability, and by data collected by rocket instruments in the equatorial electrojet.

Magnetosphere. Entails the development of global models for the magnetotail and the magnetospheric-ionospheric coupling. Nonlinear dynamic techniques (embedding, dimensional analysis, Lyapunov exponents, etc.) are being used to compare physics-based models with existing data-based models. A graduate student, Brent Goode, is working under the supervision of John Cary and Isidoros Doxas on both the plasma physics and nonlinear dynamics aspects of the project. One of our projects is to determine whether the fractal nature of the statistics of earth-magnetic-field data is due to the system being chaotic, low-dimensional system in a strange attractor, or due to it being a stochastic system with colored noise. In the past year, a technique for distinguishing between these two systems was developed. Application to magnetic data shows that this system is not a stochastic system with colored noise.

BEAM PHYSICS (DOE)

Beam physics is the study of the creation and evolution of intense directed beams, of either charged particles or light. The study of this physics has permitted the design of beams of higher energy, higher quality, greater intensity, and reduced size. Such beams are used for cancer therapy, the study of elementary particles, and processing of semiconductors. Hence, the study of how intense beams propagate has an impact on large areas of basic science and technology.

Several areas of beam physics are being pursued at CIPS. Our nonlinear dynamics studies, applied to beams, has shown how to make it easier to capture a larger beam by reducing the volume of chaotic orbits. Current research is on how to optimize these complex systems in a flexible manner. Our work on beam instabilities, which showed that there is a nonlinear mechanism for extracting beam energy by the interaction of the beam with weak cavity modes, has now been published.

In the past year our group has become involved in the simulation of beams using the OOPIC (Object Oriented Particle in Cell) code for the study of two physics problems. The first is that of laser-plasma interactions for the purpose of accelerating particles by the large electric fields produced. These simulations are studying the injection of plasma particles by auxiliary lasers into the accelerating buckets. The second is a study of the effects of a nonlinear focusing system on beam halo. Beam halo can cause potentially large wall activation. It arises due to resonances of the beam particles with fields produced by beam oscillations. Our studies will show whether these effects can be mitigated by a nonlinear transport system.

Lastly, we have begun studies of non-neutral plasmas, which can be used to elucidate beam physics and are used for beam sources. In the limit of strong magnetic field and low temperature, transfer from parallel to perpendicular energy is minimized. Thus, in this limit there are two thermodynamic invariants to replace the total energy. We are developing a molecular dynamics simulation

to investigate phase transitions in this medium as a function of these separate thermodynamic parameters.

FUSION PLASMA THEORY AND COMPUTATION (DOE)

Recent developments in algorithms, massively-parallel computing, and object-oriented programming are having an enormous impact on plasma physics. Theoretical developments in nonlinear dynamics, kinetic-fluid closures as well as theory-based numerical methods such as delta-f and symplectic integration have also had an enormous impact. CIPS is unique in its international leadership in all of these areas of theoretical and computational basic plasma science.

Fusion plasma theory and computation is being investigated by several researchers at CIPS. Topics include large-scale massively parallel turbulence simulations; the use of modern computer science methods in modeling; optimization of three-dimensional magnetic confinement systems to eliminate chaotic orbits; macroscopic kinetic-MHD hybrid simulation; development of gyrokinetic-fluid hybrid models and the effects equilibrium and self-generated shear flow on turbulent transport.

Research in modern computer-science methods is directed towards developing models of highly complex systems, that due to the nature of research, change with time. One example is that of transport modeling in magnetic confinement systems. New transport coefficients and even equations for plasma turbulence are continually being proposed. To test these coefficients and equations, one must use them in a transport computation and compare the resulting predictions against experiment. This requires that one has a flexible modeling computer program capable of rapidly accepting new equations. Modern computer science methods, like Object-Oriented Programming, permit the design of such programs.

With developments in nonlinear dynamics, we are now better able to predict the loss of particles in complex three-dimensional magnetically confined plasmas. Such systems, known as stellarators, have long been known to offer advantages of being steady state. However, early configurations had large particle losses due to chaos. Our recent research has shown how to reduce these

large losses. We are now engaged in developing methods for incorporating legacy code for calculating these systems and their losses into modern, object-oriented optimization frameworks.

PHYSICS-2000 OUTREACH EDUCATION PROJECT (CCHE, NSF)

Physics-2000 Outreach Education Project is carried out with the participation of members of the Physics and Chemistry Departments, and funded in 1998 by the Math-Physics Directorate of NSF.

Physics-2000 is a uniquely multidisciplinary program which strives to create an environment of integration between education and technology. This is accomplished by bringing together students, educators, and the general public to experience a highly-accessible authoritative popular exposition of the underlying 20th century science, all of which is made widely and freely accessible on the Internet. In a project directed by Professor Goldman, individuals can perform their own virtual experiments by the simple manipulation of the computer mouse. These experiments include both "thought" experiments and simplified "real" experiments illustrating basic physical principles. Interaction is not limited to experienced users. With the help of this program, educators are teaching physics over the Web to K-12, college students, and the general public. Faculty and students have worked with a capable staff of programmers, artists, formatters, and other developers to create the virtual experiments and the accompanying narrative on the web site, www.colorado.edu/physics/2000. Some of these interactive applets include a dynamic periodic table of elements, nuclear reactions, principles of polarization, CRT operation, color mixing, liquid crystals, and LCD displays.

This program has been highly acclaimed throughout the nation and has received national press coverage. Content developed over the last year includes X-rays, CT scans, microwave ovens, the Bose-Einstein condensate, quantum interference, and the physics of electromagnetic waves, including production for radiation at the atomic level. Professors Scott Parker, Carl Wieman, and Carl Lineberger all contributed to the development of this educational project. This web site was used as a teaching supplement in a variety of undergraduate Physics department courses.

SOLAR SYSTEM COLLABORATORY (CCHE, DEPT. OF ED)

The Solar System Collaboratory is a collaboration of four Colorado schools: The University of Colorado at Boulder (UCB), The University of Northern Colorado at Greeley (UNC), The University of Southern Colorado in Pueblo (USC), and Fort Lewis College in Durango (FLC). The purpose of the collaboratory is to develop educational modules which can be incorporated into science courses at all levels of the undergraduate curriculum, and then to assist participating schools in teaching the modules collaboratively across the state. The educational objective is to help schools introduce student-centered learning into their science classes, and to give their students the open-ended problem solving skills that the increasingly high-tech economy demands.

In 1998 the collaboratory was awarded a three year grant by the Fund for the Improvement of Post-Secondary Education (FIPSE) of the US Department of Education to complete development of four modules suitable for an introductory Astronomy course for non-science majors. The FIPSE program is very competitive (approximately 4% of the 1600 proposals submitted in 1988 were funded) and we are very happy to be so honored.

DUSTY PLASMA PHYSICS (NASA, DOE, NSF/DOE)

There are three projects to study ionospheric space and laboratory plasma with small, suspended solid particles. Each project involves investigators in CIPS and in LASP and sponsorship is from NASA and DOE.

A) Laboratory study of the microphysics of noctilucent clouds

Noctilucent clouds occur in the polar region at approximately 86 km altitude where the temperature drops to 120 K. These clouds, far above those responsible for weather at the surface, may indicate increasing water vapor at high altitude as a result of climate change. The clouds are composed of submicroscopic ice crystals and their location is the lower region of the ionosphere. The crystals may become charged by electron and ion impact or by the photoelectric effect. The experiment uses a supersonic nozzle to form these crystals and inject them into a vacuum chamber where they may be charged by plasma or by ultraviolet illumination. Mass analyzers and charged particle detectors are used

effective volume of air sampled by the probe. Successful operation of the probe was demonstrated by the detection of a narrow layer at 86 km altitude containing about 4000 charged particles per cubic centimeter.

C) Dusty plasma dynamics near surfaces in space

The moon and several other smaller bodies in space are covered with layers of dust with a thickness of a meter or more. The electrostatic force is known to result in the levitation of charged dust above the lunar surface and may be important in the evolution of the surfaces of other solar system bodies. Our previous studies of the charging of lunar dust in plasma are being extended to a mineral with the composition of Martian dust. In addition, an ultraviolet lamp is being used for the study of photoelectric charging of isolated grains and the charging of grains above photo-emitting surfaces. The experiments have found 1) that isolated grains become positively charged by the loss of photoelectrons and 2) that grains above surfaces become charged negatively by accumulating electrons emitted by the surface.

Undergraduate research into strongly coupled dusty plasma

Particles with the same sign of charge repel one another and may form crystalline arrays when confined to a sufficiently small volume by an external force. A Paul trap with an alternating electrostatic field has been constructed to confine dozens of identically charged oil droplets and these have been observed to form regular arrays. The structure has been determined from analysis of videotapes of rotating arrays. A significant effort was required to develop a steady source of identically charged oil droplets. A description of the experiment is in press at the American Journal of Physics.

NONNEUTRAL PLASMA PHYSICS (NSF)

A new experiment became operational in 1998 to investigate fundamental transport processes in nonneutral plasmas of electrons. The experiment uses a Penning trap with a twist. A current-carrying conductor is placed along the axis that creates an azimuthal magnetic field in addition to the usual axial field. This added field, results in magnetic field curvature and magnetic shear and thus allows measurement of their effect upon transport driven by collisions. The experiment is unique in that the shear and curvature may be reduced to zero without the loss of confinement thus allowing smooth transitions from one type of system to another. Initial results indicate that the new apparatus performs as expected and a study of electric mobility has been completed. Undergraduates are involved in the construction and operation of this experiment.

BASIC AND APPLIED EXPERIMENTAL PLASMA PHYSICS (NSF, CNRS (FRANCE))

A) Stochastic Ion Heating

A long-term research program on a fundamental process: stochastic heating of plasma ions, initiated in 1982 in collaboration with P.M. Bellan at Caltech, involves the use of the Caltech ENCORE tokamak, in which intense drift-wave instabilities turn out to increase the background ion temperature by nearly two orders of magnitude. We have studied the physics of this process in detail, using multiple laser-induced fluorescence measurements techniques, which describe the ion Boltzmann velocity distribution function, with high time and velocity- and geometric-space resolution.

The 1998 activities in this area have focused on a central physics problem associated with a previously unexplained observation: that the stochastic heating of the ions initiates a sequence of processes in which 1. cold ions are heated until their orbits expand across the confining magnetic field and reach the ENCORE vessel wall, leading to 2. ion-electron recombination and plasma loss, followed by 3. re-ionization of gas atoms extracted from the wall by the incident hot ions, compensating for the plasma loss and re-constituting the initial cold plasma. We observed and documented these processes in detail using our diagnostic technique: specifically, re-ionization manifests itself as a burst of cold ions flowing in the direction from the wall towards the tokamak axis, occurring after the hot ions have reached the wall. The complete description of stochastic heating process in a real plasma device turns out therefore to be a cycle, whose elements we have isolated and quantified.

The main aspect in this area in which we report a significant advance for 1998 is the understanding of the re-ionization process. Our original data analysis appeared to raise a theoretical question, which we posed in a recent publication (see (1) below) describing our observations: could atoms desorbed from the vessel wall become ionized within the short distance from wall to axis ? Calculations we had initially performed appeared to indicate that theoretical

ionization rates were insufficiently high to allow reconstitution of the initial plasma, even though our observations firmly indicated that the ionization process did occur between wall and axis.

It is gratifying to report that a fellow Plasma physicist at another institution, Prof. R. Boivin, studied our report and in response to the question we had posed, was sufficiently motivated and able to point us towards its resolution. Specifically, he suggested to us privately that the bulk electron temperature in the plasma might be high enough so that the electron rather than the cold-atom properties would be dominant in the re-ionization process. Following this suggestion, we re-analyzed our data and carried out calculations which indicate that the ionization rate was indeed sufficiently fast to account for the re-constitution of the plasma. A report pointing out this fact, as a Comment on our original publication, has been completed and is being submitted as a publication jointly co-authored with Dr. Boivin.

B) Scientific papers published in 1998:

(1) " Observations of Fast Anisotropic Ion Heating, Ion Cooling and Ion Recycling in Large-Amplitude Drift Waves", S. J. Sanders, P. M. Bellan and R. A. Stern, Physics of Plasmas 5, 716 (1998).

(2) "Laser-Induced Fluorescence Observation of Self Organised Ion Structures Induced by Electrostatic Perturbations", G. Bachet, F. Skiff, M. Dindelegan, F. Doveil and R.A. Stern, Physical Review Letters 80 , 3260 (1998).

(3) "Real-time Phase-Selective Data Acquisition System for Measurement of Wave Phenomena in Pulsed Plasma Discharges", S. J. Sanders, R. A. Stern and P. M. Bellan, Review of Scientific Instruments 69, 2027 (1998).

ACTIVITY HIGHLIGHTS FOR 1998

JOHN CARY

- Chair, Publications Committee, Division of Plasma Physics, American Physical Society
- Convenor of Working Group on Science, Conference on Opportunities and Directions in Fusion Energy Science for the Next Decade, Snowmass, July 1999
- Member, National Stellarator Program Planning Committee Program Committee, Particle Accelerator Conference
- Fellowship Committee, Division of Plasma Physics, American Physical Society
- Referee for multiple articles in Physical Review Letters, Physics of Plasmas, Nuclear Instrumentation and Methods
- Referee for multiple proposals from the Department of Energy and the National Science Foundation
- Associate Director of Center for Integrated Plasma Studies
- Member, Physics Department Evaluation Panel
- Supervisor of: I. Doxas, senior research associate in CIPS; K. Garvin-Doxas, researcher on physics education grant; Wenming Ye and Craig Morrison, system administrator for CIPS
- Member, Boulder Faculty Assembly
- Member, BFA Executive Committee

YANG CHEN

- Helped advise graduate research assistants in Dr. Scott Parker's Group

ISIDOROS DOXAS

- Advisor for Brent Goode, Ph. D. Candidate in Physics
- Mentor to 2 post-doctoral fellows

MARTIN GOLDMAN

- Chair of Publication Oversight Committee of American Physical Society.
- Maxwell Prize Committee of Division of Plasma Physics (DPP).
- Serials Committee of American Institute of Physics (AIP).
- Publication Committee of Division of Plasma Physics of American Physical Society.
- Steering Committee of RF Ionospheric Interactions Group.
- Plasma Astrophysics Working Group of the International Astronomical Unison (IAU).
- International Advisory Board of European Center for Nonlinear Sciences (ECNOS).
- Invited Lecture, Fine Arts Museum Front Porch Series.
- Chair of Computational Physics Committee.

- Director of Physics-2000.
- Presentation of Physics-2000 to Chancellor's Meeting of Presidents of Colorado Community Colleges.
- Member of ATLAS Steering Committee.
- Member of Technology & Arts Media Committee.
- Associate Editor of the journal, Physics of Plasmas.
- Designed Java Applet programs with D. Rea to simulate physics thought-experiments and actual experiments.
- Director of Center for Integrated Plasma Studies.

ALAN L. KIPLINGER

- Principal Thesis Advisor for Undergraduate Student, Pete Zink
- Independent Study/Research Study Groups Supervise; I employ students under the National Science Foundation's Research Experience for Undergraduates program (R.E.U.)
- UROP Advisor for Pete Zink in and independent study of Moreton waves.
- Hire undergraduate students by direct grant support and get them involved in solar research by teaching them various research and analysis techniques.
- Community Review Committee for the Colorado Student Assessment Program: grade 5 mathematics assessment (Reviewing the pool of mathematics items from which future assessments will be constructed).

JAMES MEISS

- Created and maintain the "Frequently asked questions" document for the sci.nonlinear usenet newsgroup. See http://amath/appm/faculty/jdm/faq.html
- Chair, ad hoc computer committee: Oversee computer staff, laboratory procedures and software & hardware maintenance for our research lab (15 Sun, 7 SGI), staff computers (11 Macintosh), and undergraduate lab (3 SGI).
- Graduate Committee. Graduate applications and vetting.
- Preliminary Examination Committee, Jan 98 and Aug 98. write and grade the PDE preliminary exam for MS and Ph.D. students
- Textbook Selection subcommittee for APPM 2360
- Applied Mathematics Alumni Newsletter. Created, and edited the first issue. Sent to over 600 alumni. See it at < http://amath/appm/alumni/newsletter_1.pdf>
- Aerospace Engineering Graduate Mathematics Committee, Fall 1998
- Faculty Teaching Excellence Program: Computer Technology Liaison
- Goldwater Scholarship: recruit and select applicants for this National Scholarship
- International Education Scholarship Committee. Presentations at bi-annual meetings
- Graduate School Subcommittee on Technology in the Humanities
- Center for Integrated Plasma Studies, Fellow
- Colorado Center for Chaos and Complexity
- New course development: APPM 2380, 5460

SCOTT PARKER

- Teaches Fall '98, PHYS 1240 Sound and Music, 3 credit hours, 71 students
- Teaches Fall '98, PHYS 4810/7820 Computational Physics, 3 credit hours, 17 students
- Teaches Fall '98, PHYS 7830 Graduate Plasma Seminar, 1 credit hr, 4 graduate students
- Research advisor for Charlson Kim, Samuel Jones, Chad Weisshaar
- Mentor for Postdoctoral Research Associate Dr. Yang Chen
- Advisor for 4 first-year graduate students
- Co-PI on the Physics-2000 Project supported by Colorado Commission on Higher Education
- Participated in the Faculty Teaching Excellence Program
- Serves as Vice Chair (Chair-Elect) on the Executive Committee of the International Sherwood Fusion Theory Conference
- Elected to serve three years on the Executive Committee of the American Physical Society Division of Plasma Physics
- Serves on the Executive Committee of the Numerical Tokamak Turbulence Project, a Department of Energy High Performance Computing and Communication Initiative, Computing Grand Challenge Application
- Chair of Physics Department Holiday Party
- Serves on the Graduate Committee
- Serves on the Physics Computing Committee
- Organized the Graduate Research Opportunities Seminar Series
- Serves on the Junior Faculty Steering Committee

SCOTT ROBERTSON

- American Physical Society:
- Co-chair of the 1998 Workshop on the Physics of Dusty Plasmas, held in Boulder, Colorado. Made hotel arrangements, invited speakers, organized program, edited proceedings. Work shared with Mihaly Horányi and Bob Walch.
- Member of the organizing committee of the Conference on Non-neutral Plasma Physics, to be held at Princeton University, August, 1999.
- Referee two papers for Physical Review Letters.
- Referee paper for Physics of Plasmas.
- Physics Department, member of Evaluations Committee, Fall 1998.
- Physics Department, member of the Engineering Physics Advising Committee.
- Physics Department, Chair of the Shop Committee, Spring 1998.

RAUL STERN

- External member, Institute of Plasma and Fusion Research, University of California.
- Member, Board of Visitors, U.S. Office of Naval Research.