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A Final Report Submitted to the  
AIR FORCE OFFICE OF SCIENTIFIC RESEARCH

describing the research of the

**CENTER OF EXCELLENCE IN  
THEORETICAL GEOPLASMA RESEARCH**

performed under Grant AFOSR-90-0085 from the  
Air Force Office of Scientific Research in support of  
the University Research Initiative Program  
under the Air Force Research Initiative Topic

**Theory and Analysis of the Geo-Plasma Environment**

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Submitted by the  
Center for Space Research  
Massachusetts Institute of Technology

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Principal Investigator

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After six hard-working years, the MIT Center has fully matured and is now recognized world-wide as a star example of a successful enterprise between a prestigious educational institution and an established governmental research laboratory, the Phillips Laboratory. We are now receiving partial funding from AFOSR and NASA that will allow the Center to continue its now well-established research programs, and to develop other new frontier research projects. MIT has sponsored during the developing years an annual symposium series on the "Physics of Space Plasmas" and a workshop series on "Theoretical Geoplasma Physics". It has also participated, with the Graduate School of MIT, in a Minority Summer Research Program, to effect changes in the realm of graduate scientific training for minorities. All of these activities have received considerable praise and support from the world-wide scientific community.

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Submitted by the  
Center for Space Research  
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Principal Investigator

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## I. ABSTRACT

The Center for Theoretical Geoplasma Physics was established at MIT in 1986 through an AFOSR University Research Initiative grant. The goal of the Center since its inception has been to develop and maintain a program of excellence in interdisciplinary geoplasma research involving the mutual interaction of ionospheric scientists, aeronomists, plasma physicists and numerical analysts. During the past six years, members of the center have made seminal contributions to a number of definitive research findings in the fundamental understanding of ionospheric turbulence, particle acceleration, and the phenomenon of coupling between the ionosphere and magnetosphere. Some of the results of these research activities have already found practical applications toward the mission of the Air Force by scientists at the Geophysics Directorate of the Phillips Laboratory, particularly those affiliated with the research group headed by Dr. J. R. Jasperse of the Ionospheric Effects Branch.

After six hard-working years, the MIT Center has fully matured and is now recognized world-wide as a star example of a successful enterprise between a prestigious educational institution and an established governmental research laboratory, the Phillips Laboratory. We are now receiving partial funding from AFOSR and NASA that will allow the Center to continue its now well-established research programs, and to develop other new frontier research projects. MIT has sponsored during the developing years an annual symposium series on the "Physics of Space Plasmas" and a workshop series on "Theoretical Geoplasma Physics". It has also participated, with the Graduate School of MIT, in a Minority Summer Research Program, to effect changes in the realm of graduate scientific training for minorities. All of these activities have received considerable praise and support from the world-wide scientific community.

## II. INTRODUCTION

For the United States Air Force to enjoy its continuing success in meeting the demands of its mission heading into the 21st century, it must be prepared to operate in the "New Frontier" of space, particularly its every-changing turbulent geoplasma environment. Recognizing this importance, a Center of Excellence in Theoretical Geoplasma Research was established at the Massachusetts Institute of Technology in 1986 under the sponsorship of the Air Force Office of Scientific Research.

During the past six years, our Center has made substantive progress toward the goals set forth since its inception. In the research area, we have succeeded in developing the basic understanding of several microscale/mesoscale geoplasma phenomena of considerable importance. These include the study of the origin of high-latitude ionospheric turbulence, the formation of ion conics in the auroral and cusp regions, the formation of counterstreaming electrons along auroral field lines, the development of double layers in the boundary plasma sheet, the process leading to anomalous heat transfer in the polar wind ionosphere, the improvement of a relativistic theory of auroral kilometric radiation, and other related nonlinear terrestrial plasma processes. All together, we have published 83 *technical papers* and 6 books, and delivered 65 *invited and review lectures* at various national and international conferences.

A number of the afore-mentioned research findings have already found practical applications by our colleagues at the Geophysics Directorate of the Phillips Laboratory. Examples of such applications are: prediction of charged-particle precipitation patterns and deposition profiles in the diffuse-auroral zone of the ionosphere; prediction of solar EUV and X-ray fluxes based on ionospheric photoelectron measurements and transport calculations; and calculation of

ionospheric electron density profiles in the mid-latitude and high-latitude portions of the globe.

Our Center has interacted actively with a number of research organizations including the Geophysics Directorate/Phillips Laboratory, the Naval Research Laboratory, Cornell University, the Universities of California at Berkeley, Los Angeles and Irvine, the University of Maryland, the University of New Hampshire, Dartmouth College, Boston College, the Max-Planck Institutes for Extraterrestrial Physics and of Aeronomy, the Utah State University, the Lockheed Palo Alto Research Laboratory, the National Research Council of Canada, the Swedish Space Institute, and the Imperial College of London. Visits to these institutions and by scientists from these institutions have provided the necessary stimulus to keep our research program vibrant, up-to-date, and at the same time constantly in touch with practical motivations.

We have organized a series of Symposia on the "Physics of Space Plasmas." The principal purpose of these symposia is to provide an annual get-together for space scientists from the various research groups in the Boston-New England area. It has since attracted contributions from scientists world-wide. Each symposium included the presentation of an "Alfvén Lecture" established in honor of the Nobel Laureate, Professor Hannes Alfvén of the Swedish Royal Institute of Technology. Alfvén Lecturers have included such luminaries as Professor Oscar Buneman of Stanford University, Professor Jim Dungey of the Imperial College, London, Professor Eugene Parker of the University of Chicago, Dr. Roger Gendrin of the French National Laboratory of Ionospheric and Magnetospheric Physics, Professor James van Allen of the University of Iowa, Professor Charles Kennel of the University of California at Los Angeles, and Professor Alfvén himself.

The Center also inaugurated a series of Cambridge Workshops in Geoplasma Research. Each workshop is targeted at a specific topic of frontier geoplasma research and includes basic tutorial talks and invited specialty lectures. The format of the workshops has been designed to allow ample discussion time and interactions. These activities have received much praise from the world-wide geoplasma community for their innovative concepts and educational merits. Proceedings of the symposia and workshops entitled, "Physics of Space Plasmas" have become informal textbooks treasured by both established scientists and students in geoplasmas.

In addition, we have convened, in collaboration with the Universities of California at Los Angeles and Colorado, a Chapman Conference on Micro and Meso Scale Phenomena in Space Plasmas, which was enthusiastically participated by the throng of over 200 international experts in frontier space plasma research.

One of the prime missions of the MIT Center for Theoretical Geo/Cosmo Plasma Physics is to provide an environment for the development of talented young prospective students in geoplasma education. During the past three years, in cooperation with the MIT Minority Summer Research Program (MSRP), our Center has hosted one or more talented young minority undergraduate summer intern(s). By intermingling with the established scientists of the Center, the young interns obtain first hand knowledge of the true meaning of scientific research in space physics.

The Center is currently composed of 21 participating members. These include members of the faculty, staff, postdoctoral and graduate students at MIT as well as visiting scientists from other interacting institutions. Members of our Center have constantly been invited by various conferences, universities, and other organizations to deliver invited and review articles. In addition, the Center

pursues a vigorous visiting scientists program which has attracted many renowned scientists to the MIT campus.

The Center has a modern computing environment served locally by an inter-connecting group of workstations and externally by the National Center for Supercomputer Applications from the University of Illinois at Champaign-Urbana.

Currently, we are receiving partial financial support from AFOSR and NASA that will allow the continuation of this now, world-renowned program of research and education in geoplasmas.

The report is organized as follows. In Sec. III, we discuss the progress and accomplishments of our Center during the past six years. This is followed by the complete listings of research publications and invited lectures of the Center personnel in Sec. IV and Sec. V. Biographical sketches of the Center key personnel are provided in Sec. VI. A description of the workshop, symposium and other conference activities are given in Sec. VII. This is followed by a brief description of the minority outreach program in geoplasmas established at the Center since 1989 in Sec. VIII.

### III. ACCOMPLISHMENTS

In our 1986 AFOSR URI proposal, we proposed a unique program of theoretical research in geoplasma physics. The Center would be a single cohesive unit of scientists from several disciplines interacting effectively with one another and with groups from external ongoing experimental research programs. It would not be the purpose of the Center to carry out routine data analyses. Instead, our approach would be to interact with the experimental groups and to identify from the analyzed data those problems that had no ready-made explanations and to focus our efforts on the solution of such new problems. At all times, we would not lose sight of the practical applications of the developed theories to the prime mission of the Air Force.

During the past six years, we have endeavored to follow such guidelines while developing the various research efforts at the Center. We believe that we have succeeded in every aspect of the above goals. We feel that we have identified many new, interesting, and at the same time puzzling geoplasma problems that were not admissible to "routine" solutions. We have provided theoretical understanding to a number of such identified problems. In many of these instances, we were able to provide quantitative descriptions of the phenomena or make useful theoretical predictions for future observations and applications.

For example, our understanding of pitch-angle scattering and the dynamics of the central plasma sheet allowed us to construct a quantitative model of electron precipitation in the diffuse aurora. Because this precipitation helps control the electron density profile in the high-latitude ionosphere, it has a strong impact on the Air Force communication and surveillance systems that must operate in the region. Similarly, because of the effect of scintillation on these systems and the

close relationship between scintillations and the high-latitude ionospheric turbulence, our quantitative models of the latter phenomenon and its consequences can be expected to have great utility in the practical business of ionospheric weather prediction.

**Listed below are research topics that have been studied and analyzed by the members of the Center during the grant period.**

- Ion heating by low frequency waves in Earth's ionosphere and magnetosphere.
- Lower hybrid collapse, caviton turbulence, and charged particle energization in the topside ionosphere.
- Mode conversion processes involving the plasma turbulence of oxygen-hydrogen plasmas in the magnetosphere and ionosphere.
- Turbulent relaxation of magnetic fields in space plasmas.
- Path integral approach to nonlinear particle acceleration and diffusion in ionospheric plasmas.
- Ion and electron acceleration along auroral field lines.
- Nonlocal effects of finite beam-driven instabilities in space plasmas.
- Convection of ion cyclotron waves to ion heating regions.
- Decay of ion beam driven acoustic waves into ion holes and double layers along auroral field lines.
- Broad band spectrum of auroral plasma turbulence.
- Renormalization-group calculation of self-organized criticality and low-dimensional behavior of auroral substorm onsets.
- Theory of nonlinear electric fields in the auroral acceleration region.
- Stochastic MHD reconnection models for space plasmas.

- Multiple-cyclotron absorption of ion heating in the cusp/cleft region.
- Wave-particle ion cyclotron turbulence and evolution of the electron distribution in inhomogeneous space plasmas.
- ULF waves along auroral field lines in the central plasma sheet.
- Energy source and generation mechanism for auroral kilometric radiation.
- Trapped electrons as free energy source for the auroral kilometric radiation.
- Particle acceleration by intense auroral VLF waves.
- The electron beam instability and turbulence theories in space plasmas.
- Two stream interaction on auroral field lines.
- Energetic photoelectron and the polar rain.
- Monte-Carlo modeling of polar wind electron distributions with anomalous heat flux.
- Counterstreaming electrons generated by lower hybrid waves in the auroral region.
- Heating of thermal ions near the equatorward boundary of the mid-altitude polar cusp.
- Stabilization of the cyclotron autoresonance maser instability in space plasmas.
- Steady state magnetohydrodynamic clump theory and its application to turbulent magnetic reconnection in space plasmas.
- Nonlinear oblique whistler modes in collisionless shocks of space plasmas.
- Electromagnetic tornadoes in space.
- Radiations from large space structures in low Earth orbit with induced AC currents.
- Ion waves and upgoing ion beams observed by the VIKING satellite.

- Simulation of ion conic formation in the ionosphere and magnetosphere.
- Alfvén engine in space.
- Convection of ion cyclotron waves to ion heating regions in auroral zone.
- Wave observations and their relation to nonresonant and resonant particle heating processes.

In the next two sections, we include the detailed listings of scientific publications and invited lectures by members of our Center. These lists demonstrate the diversity and breadth of the accomplished research programs of the Center personnel and provide a good indicator of how well these research results are received by our peers.

#### **IV. CHRONOLOGICAL LISTING OF SCIENTIFIC PUBLICATIONS -- 83**

##### **Papers and 6 Books**

1. "Ion Heating by Low Frequency Waves", Tom Chang and M. André, to appear in Auroral Plasma Dynamics, ed. by R.L. Lysak, American Geophysical Union Geophysical Monograph, 1993.
2. "An Analytical Study of Mode Conversion in an Oxygen-Hydrogen Plasma", J.R. Johnson, Tom Chang, and G.B. Crew, Submitted to Physics of Fluids, 1993.
3. "A Numerical Study of Mode Conversion in an Oxygen-Hydrogen Plasma", J.R. Johnson, Tom Chang, and G.B. Crew, Submitted to Physics of Fluids, 1993.
4. "Path Integral Approach to Nonlinear Particle Acceleration and Diffusion in Space Plasmas," Tom Chang, Recent Trends in Physics, A.I.P. Publication, New York, to be published, 1993.
5. "Lower Hybrid Collapse, Caviton Turbulence, and Charged Particle Energization in the Topside Auroral Ionosphere and Magnetosphere", Tom Chang, Physics of Fluids, B5, 2646, 1993.
6. "Nonlocal Analysis of Finite-Beam-Driven Instabilities", Y. Serizawa and C.T. Dum, Physics of Fluids, B5, 1383, 1993.
7. "Ionospheric Lower Hybrid Collapse and Charged Particle Acceleration", J.M. Retterer, Tom Chang, and J.R. Jasperse, Proc. Intern. Beacon Satellite Symposium, p. 243, 1993.

8. "Low-Dimensional Behavior and Symmetry Breaking of Stochastic Systems Near Criticality: Can These Effects be Observed in Space and in the Laboratory?" Tom Chang, IEEE Trans. of Plasma Science, Special Issue on Space and Cosmic Plasmas, 20, 691, 1992.
9. "Turbulent Relaxation of Magnetic Fields - I: Coarse-Grained Dissipation and Reconnection", D. Tetreault, J. Geophys. Res., 97, 8531, 1992.
10. "Turbulent Relaxation of Magnetic Fields - II: Self-Organization and Intermittency," D. Tetreault, J. Geophys. Res., 97, 8541, 1992.
11. "Differential Renormalization-Group Generators for Static and Dynamic Critical Phenomena", Tom Chang, D.D. Vvedensky, and J.F. Nicoll, Physics Reports, 217, 279, 1992.
12. "Ion Acceleration along Auroral Field Lines - A Mesoscale Phenomenon", Tom Chang, Proc. First Brazilian Congress on Plasma Physics, p. 137, 1992.
13. "Path Integrals, Differential Renormalization-Group, and Stochastic Systems near Criticality", Tom Chang, Int. Jr. Engr. Science, 30, 1401, 1992.
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15. "Real Group Velocity in a Medium with Dissipation", L. Muschietti and C.T. Dum, Physics of Fluids, B4, 2389, 1992
16. "Convection of Ion Cyclotron Waves to Ion Heating Regions", K. Ronnmark and M. André, J. Geophys. Res., 96, 17373, 1991.

17. "Decay of Ion Beam Driven Acoustic Waves into Ion Holes", P.C. Gray, M.K. Hudson, W. Lotko and R. Bergmann, *Geophys. Res. Lett.*, 9, 1675, 1991.
18. "What Parts of Broadband Spectra are Responsible for Ion Conic Production?", L. Ball and M. André, *Geophys. Res. Lett.*, 18, 1683, 1991.
19. "Critical Points in the 16-Moment Approximation", F. Yasseen and J.M. Retterer, *J. Geophys. Res.*, 96, 1827, 1991.
20. "Theory of Electric Fields in the Auroral Acceleration Region," D. Tetreault, *J. Geophys. Res.*, 96, 3549, 1991.
21. "A Stochastic MHD Model of Reconnection in the Dayside Magnetopause", D. Tetreault, *Physics of Space Plasmas*, 10, 109, 1991.
22. "Heating of O<sup>+</sup> Ions in the Cusp/Cleft: Double-Cyclotron Absorption vs. Cyclotron Resonance", L. Ball and M. André, *J. Geophys. Res.*, 96, 1429, 1991.
23. "Wave Observations and Their Relation to "Nonresonant" Ion Heating in a "Weakly Turbulent" Plasma Model", L. Ball, M. André and J.R. Johnson, *Ann. Geophys.*, 9, 37, 1991.
24. "Nonlinear Wave Scattering and Electron Beam Relaxation", L. Muschietti and C.T. Dum, *Physics of Fluids B*, 3, 1968, 1991.
25. "Wave-Particle Ion Cyclotron Turbulence-Evolution of the Electron Distribution Function and Wave Spectrum", L. Muschietti and C.T. Dum, *J. Geophys. Res.*, 95, 173, 1990.

26. "Simulation Study of Ion Two Stream Instability in the Auroral Acceleration Region", P. Gray, M. Hudson, R. Bergmann and I. Roth, *Geophys. Res. Lett.*, 17, 1609, 1990.
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30. "Characteristic of ULF Waves Along Auroral Field Lines in the Central Plasma Sheet", J.R. Johnson, T. Chang and G.B. Crew, *Physics of Space Plasmas*, 9, 277, 1990.
31. "Energy Source and Generation Mechanism for Auroral Kilometric Radiation", E. Ungstrup, A. Bahnsen, H.K. Wong, M. André and L. Matson, *J. Geophys. Res.*, 95, 5973, 1990.
32. "Trapped Electrons as a Free Energy Source for the AKR", P. Louarn, A. Roux, H. de Feraudy, D. LeQueau, M. André and L. Matson, *J. Geophys. Res.*, 95, 5983, 1990.
33. "On Waves below the Local Proton Gyrofrequency in Auroral Acceleration", G. Gustafsson, M. André, L. Matson and H. Koskinen, *J. Geophys. Res.*, 95, 5889, 1990.

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37. "The Electron Beam Instability and Turbulent Theories", C.T. Dum, *Physics of Space Plasmas*, 9, 67, 1990.
38. "Turbulent Relaxation in Magnetohydrodynamic Plasma", D. Tetreault, *Phys. Fluids B*, 2, 53, 1990.
39. "Simulation Studies of Plasma Waves in the Electron Foreshock: The Transition from Reactive to Kinetic Instability", C.T. Dum, *J. Geophys. Res.*, 95, 8111, 1990.
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77. "Two-D Simulation and Theory of Ion and Electron Acceleration by VLF Turbulence in the Supraauroral Region", J.M. Retterer, T. Chang and J.R. Jasperse, *ISSS-3, Part 2*, 22, 1987.
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2. "Physics of Space Plasmas (1990)", Tom Chang, G.B. Crew and J.R. Jasperse (eds.), *SPI Conference Proceedings and Reprint Series, Vol. 10* (Scientific Publishers, Inc., Cambridge, MA, 1991).
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4. "Physics of Space Plasmas (1988)", Tom Chang, G.B. Crew and J.R. Jasperse (eds.), *SPI Conference Proceedings and Reprint Series, Vol. 8* (Scientific Publishers, Inc., Cambridge, MA, 1989).
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6. "Ion Acceleration in the Magnetosphere and Ionosphere", Tom Chang, M.K. Hudson, J.R. Jasperse, R.G. Johnson, P.M. Kintner, M.Schulz and G.B. Crew (eds.), Geophysical Monograph Series, Vol. 38 (American Geophysical Union, Washington, D.C., 1986).

## **V. INVITED LECTURES -- Total of 65**

1. "Lower Hybrid Collapse and the Theory of Low Altitude Ion Conics", J.M. Retterer, Tom Chang, and J.R. Jasperse, Cambridge Workshop on the Physics of Space Plasmas, Cambridge, MA, July 1993.
2. "Turbulent, Intermittent Relaxation in Space Plasma", D. Tetreault, Cambridge Workshop on the Physics of Space Plasmas, Cambridge, MA, July 1993.
3. "Lower Hybrid Collapse, Caviton Turbulence, and Charged Particle Energization in the Magnetosphere", Tom Chang, International Workshop on the Relationship between Plasma Experiments in the Laboratory and in Space, Banff, Canada, June 1993.
4. "Lower Hybrid Collapse, Caviton Turbulence, and Charged Particle Acceleration in Space", Tom Chang, International School on Space Plasma Physics, Russia, June 1993.
5. "Electromagnetic Tornadoes in Space", Tom Chang, International School on Space Plasma Physics", Russia, June 1993.
6. "Particle Energization in Space and Astrophysics", Tom Chang, IEEE International Workshop on Plasma Astrophysics and Cosmology, Princeton, N.J., May 1993.
7. "Hybrid Approach to Modeling Field-Aligned Transport in Polar Wind", F. Yasseen, Tom Chang, S.B. Supriya, and J.M. Retterer, American Geophysics Union, Spring Meeting, May 1993.

8. "Lower Hybrid Collapse, Caviton Turbulence, and Charged Particle Energization in the Topside Auroral Ionosphere and Magnetosphere", Tom Chang, Yosemite Meeting on Solar Plasma Physics, February 1993.
9. "Lower Hybrid Collapse and Charged Particle Acceleration", J.M. Retterer, Tom Chang, and J.R. Jasperse, American Geophysical Union, Fall Meeting, December 1992.
10. "Lower Hybrid Collapse, Caviton Turbulence, and Charged Particle Energization in the Topside Ionosphere and Magnetosphere", Tom Chang, American Physical Society, Division of Plasma Physics, Seattle, November 1992.
11. "Recent Advances in Auroral Ion Heating: Theory/Data Closure", Tom Chang, Western Pacific Geophysics Meeting, Hong Kong, August 1992.
12. "Low-Dimensional Behavior and Symmetry Breaking of Stochastic Systems Near Criticality: Can These Effects be Observed in Space and in the Laboratory?", Tom Chang, Western Pacific Geophysics Meeting, Hong Kong, August 1992.
13. "Ionospheric Lower Hybrid Collapse and Charged Particle Acceleration", J.M. Retterer, Tom Chang, and J.R. Jasperse, Beacon Satellite Symposium, Cambridge, MA, July 1992.
14. "Modeling Ion Conics in Space", Tom Chang, Nineteenth IEEE International Conference on Plasma Science, Tampa, FL, June 1992.

15. "Ion Cyclotron Resonance Heated Conics", G. Crew and Tom Chang, Chapman Conference on Micro/Meso Scale Phenomena in Space Plasmas, Hawaii, February 1992.
16. "The Ion Conic Observed by Marie", J.M. Retterer, Tom Chang and J.R. Jasperse, Chapman Conference on Micro/Meso Scale Phenomena in Space Plasmas, Hawaii, February 1992.
17. "High-Frequency Electrostatic Plasma Instabilities and Turbulence in the Lower Ionosphere", J.R. Jasperse, B. Basu, J.M. Retterer, D.T. Decker and Tom Chang, Chapman Conference on Micro/Meso Scale Phenomena in Space Plasmas, Hawaii, February 1992.
18. "Ion Conics in the Magnetosphere - A Meso Scale Phenomena", Tom Chang, *First Brazilian Congress on Plasma Physics*, Santos, Brazil, December 1991.
19. "Path Integrals, Differential Renormalization-Group and Systems far from Equilibrium", Tom Chang, Eringen Symposium, 28th Annual Meeting of the Society of Engr. Science, Gainesville, Florida, November 1991.
20. "Ion Heating by Low Frequency Waves", Tom Chang, Chapman Conference on Auroral Plasma Dynamics", Minneapolis, Minnesota, October 1991.
21. "Evolution of an Ion Two-Stream Instability", R. Bergmann, Chapman Conference on Auroral Plasma Dynamics, Minneapolis, Minnesota, October 1991.
22. "Low-Dimensional Behavior and Symmetry Breaking of Nonlinear Stochastic Systems - Can these Effects be Observed in the Laboratory and in Space?"

- Tom Chang, International Workshop on Plasma Experiments in the Laboratory and in Space, Alpbach, Austria, June 1991.
23. "Ion Heating in the Cusp/Cleft - An Experiment in Space Using the VIKING and DE1 Satellites as Laboratory Equipments", M. André, General Assembly of IAGA, Vienna, Austria, August 1991.
  24. "Interaction of Upflowing Ions in the Auroral Acceleration Region", R. Bergmann, STAR Laboratory, Stanford University, May 1991.
  25. "Turbulent Relaxation in Space and Laboratory Plasmas", D. Tetreault, International Workshop on Plasma Experiments in the Laboratory and in Space, Alpbach, Austria, June 1991.
  26. "Beam Driven Instabilities in the Auroral Acceleration Region", R. Bergmann, International Workshop on Plasma Experiments in the Laboratory and in Space, Alpbach, Austria, June 1991.
  27. "Ion Heating: What Have We Learned from VIKING?", M. André, VIKING Workshop, Kiruna, April 1991.
  28. "Formation of Ion Conics by Lower Hybrid Turbulence", Tom Chang, Space Sciences Laboratory, University of Michigan, April 1991.
  29. "Path Integral Approach to Ion Heating", Tom Chang, Space Plasma Physics, Cornell University, April 1991.
  30. "Turbulent Relaxation in Space Plasma", D. Tetreault, Research Trends in Nonlinear Space Plasma Physics, La Jolla, CA, February 1991.

31. "Simulation and Theoretical Study of Wave Particle Interaction and Mode Coupling Processes in the Supraauroral Region", J.M. Retterer, Tom Chang and J.R. Jasperse, Research Trends in Nonlinear Space Plasma Physics, La Jolla, CA, February 1991.
32. "The Electron Foreshock", C.T. Dum, Workshop on Collisionless Shocks, Paris, April 1991.
33. "Classical and Anomalous Transport in the Chromosphere and Corona", C.T. Dum, European Geophysical Society, Weisbaden, Germany, April 1991.
34. "Electromagnetic Tornadoes in Space", Tom Chang, Space Plasma Physics, University of Maryland, April 1991.
35. "The Monte Carlo Technique for Mesoscale Space Plasma Phenomena", J.M. Retterer, Tom Chang and J.R. Jasperse, International School for Space Simulations, Nara, Japan, April 1991.
36. "Mechanisms for Ion Conic Generation", Tom Chang, Yosemite Conference on Transition Regions in Solar System Plasmas, Yosemite, CA, February 1990.
37. "Intermittency Structures in Plasma Turbulence", D. Tetreault, Space Plasma Sciences, University of New Hampshire, April 1990.
38. "Propagation Characteristics of ULF Waves Associated with Ion Conics", Jay Johnson, Cambridge Workshop in Theoretical Geoplasma Physics, Magnetic Fluctuations, Diffusion and Transport in Geoplasmas, Cambridge, MA June 1990.

39. "Theory and Simulation of the Electron Beam-Plasma Instability-Are the Textbook Approximations Valid?", C.T. Dum, University of Iowa, October 1990.
40. "Heating of Ion Conics in the Cusp/Cleft", M. André, Cambridge Workshop in Theoretical Geoplasma Physics, Wave-Particle Interaction Phenomena in Geoplasmas, Cambridge, MA July, 1989.
41. "Two Stream Interaction on Auroral Field Lines", R. Bergmann, Cambridge Workshop in Theoretical Geoplasma Physics, Wave-Particle Interaction Phenomena in Geoplasmas, Cambridge, MA, July 1989.
42. "3D Model of Double Layer Formation on Auroral Field Lines", D. Tetreault, Cambridge Workshop in Theoretical Geoplasma Physics, Wave-Particle Interaction Phenomena in Geoplasmas, Cambridge, MA, July 1989.
43. "The Electron-Beam Instability and Turbulence Theories", C.T. Dum, Cambridge Workshop in Theoretical Geoplasma Physics, Wave-Particle Interaction Phenomena in Geoplasmas, Cambridge, MA, July 1989.
44. "Interaction of Upflowing Ions in the Auroral Acceleration Region", Second Huntsville Workshop on Magnetosphere/Ionosphere Plasma Models, R. Bergmann, Huntsville, AL, October 1989.
45. "Classical Transport Properties of Plasmas", C.T. Dum, NATO Workshop on Physical Processes in Hot Cosmic Plasmas", Vulcano, Italy, July 1989.
46. "Particle Acceleration by Electromagnetic Ion Cyclotron Turbulence", G. Crew, Cambridge Workshop in Theoretical Geoplasma Physics, Wave-Particle Interaction Phenomena in Geoplasmas, Cambridge, MA, July 1989.

47. "Particle Acceleration by Intense Auroral VLF Turbulence", J.M. Retterer, Cambridge Workshop in Theoretical Geoplasma Physics, Wave-Particle Interaction Phenomena in Geoplasmas, Cambridge, MA July 1989.
48. "EIC Waves, Double Layers and Solitary Waves in the Auroral Acceleration Region", D. Tetreault, Second Huntsville Workshop on Magnetosphere-Ionosphere Plasma Models, Huntsville, AL, October 1989.
49. "Double Layers in the Auroral Acceleration Region", D. Tetreault, Physics Department, Dartmouth College, October 1989.
50. "Electromagnetic Tornadoes in Space", Tom Chang, International Union on Radio Science, National Meeting, Boulder, CO, January 1988.
51. "Electromagnetic Tornadoes in Earth's Magnetosphere and Ionosphere", Tom Chang, Eringen Symposium, Society of Engineering Science, Berkeley, CA, June 1988.
52. "Global Kinetic Theory of Astrophysical Plasmas", Tom Chang, American Physical Society Topical Conference on Plasma Astrophysics, Albuquerque, N.M., October 1988.
53. "Heating of Thermal Oxygen Ions near the Equatorward Boundary of the Mid-Altitude Polar Cusp", W.K. Peterson, M. André, G.B. Crew, A.M. Persoon, M. Engebretson and C. Pollock, NATO Advanced Research Workshop on Electromagnetic Coupling in the Polar Clefts and Caps, September 1988.
54. "Oblique Whistlers: Their Relevance to Nonthermal Coupling of Ions and Electrons in Accretion Flow and Supercritical Quasi-Perpendicular

- Collisionless Shocks", Tom Chang, Joint Varenna-Abastumani Workshop of Plasma Astrophysics, Varenna, Italy, Summer 1988.
55. "Global Kinetic Theory of Astrophysical Jets", Tom Chang, Joint Varenna-Abastumani Workshop of Plasma Astrophysics, Varenna, Italy, Summer 1988.
  56. "Plasma Simulation of Intense VLF Turbulence and Particle Heating in the Supraauroral Region", J.M. Retterer, T. Chang and J.R. Jasperse, Cambridge Workshop in Theoretical Geoplasma Physics, Polar Cap Dynamics and High Latitude Ionospheric Turbulence, Cambridge, MA, 1988.
  57. "Kinetic Global Collisional Model of Anisotropic Electrons Along Polar Cap Field Lines", Tom Chang, Cambridge Workshop in Theoretical Geoplasma Physics, Polar Cap Dynamics and High Latitude Ionospheric Turbulence, Cambridge, MA, 1988.
  58. "Low Latitude Flux Transfer Events", J.D. Winningham, MIT Symposium on the Physics of Space Plasmas, January 1988.
  59. "Simultaneous Observations of Ion Waves and Ion Conics in and near the Polar Cusp", M. André, H. Koskinen and L. Matson, Chapman Conference on Plasma Waves and Instabilities Magnetospheres and at Comets, Sendai, Japan, 1987.
  60. "MHD Clump Instability", D. Tetreault, American Physical Society, Division of Plasma Physics Meeting, Fall 1987.
  61. "Ion Acceleration in the Magnetosphere by Broad Band Lower Hybrid Waves and Electromagnetic Turbulence in the Ion Cyclotron Range of Frequencies",

Tom Chang, 22nd General Assembly of the International Union on Radio Science, September 1987.

62. "Simulation and Theory of Heavy Ion Acceleration", Tom Chang, Third International School on Space Simulations, Beaulieu, France, June 1987.
63. "Transverse Ion Heating in the Polar Cusp Region", M. André, H. Koskinen and L. Matson, Cambridge Workshop in Theoretical Geoplasma Physics, Cambridge, MA, 1987.
64. "Double Layers on Auroral Field Lines", D. Tetreault, Cambridge Workshop in Theoretical Geoplasma Physics, 1987.
65. "Ion Acceleration in the Magnetosphere by Broad Band Lower Hybrid Waves and Electromagnetic Turbulence in the Ion Cyclotron Range of Frequencies", Tom Chang, American Physical Society, Division of Plasma Physics Meeting, 1986.

## **VI. PROFESSIONAL PERSONNEL ASSOCIATED WITH THE PROGRAM**

Tom T.S. Chang, Director

John Belcher, Professor

Stanislaw Olbert, Professor (emeritus)

Daniel Hastings, Professor

Hannes Alfvén (Nobel Laureate), Sponsor of Alfvén Lectureship

C. Chan, Visiting Professor

G.B. Crew, Research Scientist

D. Tetreault, Research Scientist

J.R. Jasperse, Research Affiliate

Fareed Yaseen, Visiting Scientist

J.M. Retterer, Research Affiliate

C.T. Dum, Research Affiliate

Rachelle Bergaman, Consultant

S. Basu, Consultant

M. André, Visiting Scientist

J.D. Winningham, Visiting Scientist

Jay Johnson, Graduate Student and Research Assistant

W.T. Tam, Graduate Student and Research Scientist

Aly Seydi, UROP Student (Summer Minority Student Awardee)

Kenton Phillips, Computer Manager

Mary Terhune, Senior Secretary

Brief descriptions of the professional qualifications of the key personnel are given below.

## **BIOGRAPHICAL SKETCHES OF KEY PERSONNEL**

**Dr. Tom Chang** is internationally known for his contributions in charged particle acceleration processes in the Earth's ionosphere and magnetosphere. He is currently directing a Center of Excellence effort in Theoretical Geoplasma Research at the Massachusetts Institute of Technology. In addition to his two Ph.D.'s in theoretical physics and engineering, he has done postdoctoral work at the University of Cambridge in England and was an Honorary Research Fellow at Harvard University's Lyman Laboratory of Physics. He is a Fellow of the American Physical Society and has served for many years as Editor of the international journal, *Plasma Physics*. He is currently a member of the NASA Space Physics Theory Working Group (SPTWG) and served as a member of the program committee of the Plasma Physics Division of the American Physical Society and the Committee for Visitors for the NSF Magnetospheric Physics Program. He is the Editor-in-Chief of the popularly referenced AGU monograph, "Ion Acceleration Processes in the Magnetosphere and Ionosphere", the series Editor of the SPI Conference Proceedings series, "Physics of Space Plasmas", an Associate Editor of the AGU journal, "Review of Geophysics", and served as a member of the Steering Committee of the International Conference on Plasma Science held in La Jolla in 1991 and on Plasma Astrophysics in 1993. He is the organizer of over a dozen National and International Conferences including the well-established Cambridge Workshop series in Theoretical Geoplasma Physics, which is held at MIT annually each summer. Tom Chang is an author/editor of over 130 scientific publications including 12 books and proceedings volumes. He was the recipient of the prestigious National Thompson Award.

**Dr. John Belcher** graduated summa cum laude in physics and mathematics from Rice University and obtained his Ph.D. in Physics from the California Institute of

Technology. He is internationally known for his innovative theory of Alfvén wave heating of the solar wind and is the principal investigator of the plasma experiment of the Voyager program. He is an authority in the physics of the ionospheres and magnetospheres of all planets and the heliosphere. As Professor of Physics at MIT, Dr. Belcher provides the broad perspective and insight that the Center relies upon in geoplasma research and studies.

**Dr. Stanislaw Olbert** has a Ph.D. from MIT and was a student of the world-renowned space physicist, Professor Bruno Rossi. He has been interested in the Physics of Space Plasmas since the very beginning. He is the author of the well-known text, "Introduction to the Physics of Space". He is known for his innovative research in cosmic rays, anomalous heat flux in the solar wind, and induced radiative losses of conducting objects in magnetized plasmas. Several of his students are now leading authorities in the field of physics of space plasmas.

**Dr. Daniel Hastings** obtained his A.B. with highest honors from the Oxford University in England. A Ph.D. graduate from MIT, Dr. Hastings has been active in space research for many years. He is an authority in the phenomena of plasma radiation due to the motion of conducting bodies in magnetized plasmas and critical ionization, and is currently Professor and Director of the Space Grant Program at MIT.

**Professor Hannes Alfvén** is the sponsor of the Alfvén Lecture series at MIT. Professor Alfvén is a Nobel Laureate in Space Physics and is known for the Alfvén waves that bear his name. He is generally considered as the father of theoretical space plasma physics. Every year, a world-renowned space physicist is invited to MIT to deliver a plenary lecture (the Alfvén Lecture) and to interact with members of the MIT Center on research topics of mutual interest. The

awardees of the lectureship include luminaries such as Professor James van Allen of the University of Iowa (discoverer of the van Allen belt), Professor Jim Dungey of the Imperial College of London (discoverer of the reconnection model of the open magnetosphere), Professor Oscar Buneman of the Stanford University (co-discoverer of the Farley-Buneman instability in ionospheric plasma physics), Professor Eugene N. Parker of the University of Chicago (discoverer of the solar wind theory), and others. Professor Alfvén visits MIT periodically and offers advice and precious encouragement to the theorists at MIT that only a Nobel Laureate can provide.

**Dr. Chun Chan** obtained his Ph.D. from the University of Wisconsin and received an Outstanding Graduate Student Award from IEEE's Nuclear and Plasma Science Society for his doctoral thesis. Professor Chan is world-renowned for his work in laboratory weak double layers simulating the auroral potential structures in the magnetosphere. He is currently Professor of Electromagnetics at Northeastern University. Professor Chan founded the Plasma Science and Microelectronics Laboratory that currently occupies over 7,000 sq.ft. of space and contains state of the art equipment in plasma physics, micro-fabrications, and materials science. Professor Chan collaborates with the MIT group on laboratory simulations of space plasma phenomena and is spending a year at MIT and the Geophysics Directorate to work with Dr. Tom Chang at MIT and Dr. J.R. Jasperse at GD/PL.

**Dr. G.B. Crew** received his A.B. summa cum laude in Physics and Mathematics from Dartmouth. He was a National Science Foundation Fellow at MIT where he received his Ph.D. in theoretical plasma physics. His research has been directed toward tractable, analytic formulations of space plasma phenomena including those related to the conical distribution of ionospheric ions in the magnetosphere and the stability of current sheets in the magnetotail in the presence of pre-existing

turbulence. Dr. Crew is currently serving as Chairman of the Computer Committee of the Center for Space Research. He has co-organized a number of scientific conferences and has been a co-editor of the corresponding proceedings. He is an author of over 30 scientific papers.

**Dr. D. Tetreault** is a renowned space plasma theorist with 18 years of research experience. A summa cum laude physics graduate from the University of New Hampshire, Dr. Tetreault received his Ph.D. in nonlinear plasma theory from the Massachusetts Institute of Technology under the direction of the renowned physicist, Professor Thomas Dupree. Dr. Tetreault is a member of Phi Beta Kappa and Sigma Xi, and held a National Science Foundation Fellowship during the years 1969-72. He has given numerous invited talks on nonlinear plasma theory involving auroral double layers, ion holes, turbulent reconnection and clump theory. He is an author of over 30 research articles in refereed journals.

**Dr. John R. Jasperse** is head of theoretical space plasma physics at the Geophysics Directorate of the Phillips Laboratory. A Harvard graduate, he obtained his Ph.D. from Northeastern University. He has received many awards and is internationally renowned for his work in ionospheric plasma instabilities and collisional processes. He has interacted with the MIT group for a number of years and has given the guidance of the research activities at the Center since its inception. His joint research activities at MIT included the understanding of particle acceleration in space plasmas, theory of turbulence and other topics. He has jointly sponsored with Dr. Tom Chang at MIT a number of international conferences and workshops.

**Dr. John M. Retterer** received his Ph.D. in astronomy with high honors from the University of California at Berkeley. He has enjoyed an appointment as Visiting

Scientist and Research Affiliate at MIT for a number of years. He is known for his innovative research in Monte Carlo and particle-in-cell simulations in space plasma physics, particularly in the field of VLF waves and electron beam excited plasma instabilities. He has been invited to deliver review and invited lectures on his specialty all over the world at many prestigious international conferences.

**Dr. C.T. Dum** is world-renowned for his work on plasma diffusion theory and large scale numerical simulations. Since obtaining his doctoral degree in Physics from MIT, Dr. Dum taught for a few years at the Cornell University before assuming his present position as head of the theory group of the Max-Planck Institute of Extraterrestrial Physics in Garching bei Munchen, Germany. Dr. Dum has been affiliated with our Center for many years. He is a member of the American Physical Society, the American Geophysical Union, and Sigma Xi. He has written over 40 definitive research articles in refereed journals and given over 50 invited and review lectures at many international conferences and workshops.

**Dr. Fareed Yasseen** obtained his Ph.D. from the Polytechnic Institute in Lausanne, Switzerland and was the student of the world-renowned plasma physicist, Professor E. Weibel. Dr. Yasseen has done outstanding research in theoretical space plasma physics. His ground-breaking work of the global analysis of collisional effects on photoelectron distributions in the polar wind has generated a new direction in polar wind research and investigators all over the world are following in his footsteps.

**Dr. Rachele Bergmann** obtained all her degrees from the University of California, Berkeley. She graduated in Physics and Applied Mathematics with distinction and wrote her doctoral thesis under the renowned space physicist, Professor Mary Hudson (now at Dartmouth College). Dr. Bergmann's work on ion

beam interactions in the auroral zone is recognized by her peers as the standard in the field. She is very popular as an invited lecturer at various national and international conferences. She is a member of Phi Beta Kappa and recently received a Faculty Excellence Award in Research at her University. She has contributed over 30 technical and scientific papers. Dr. Bergmann's current research interest is in ion-ion beam interactions and generation of double layers in the auroral region.

**Dr. Sunanda Basu** is one of the foremost women space scientists in the world. She is virtually on every scientific committee of IAGA, URSI, NSF, NASA, and other scientific societies. She is an expert in ionospheric plasma physics. Since 1990, Dr. Basu has been collaborating with the MIT Center as a consultant in studying the plasma wave spectra induced by velocity shear and gradient drift instabilities. She is also interested in ion acceleration processes in the ionosphere.

**Dr. Mats André** is at present the coordinator for the Swedish Satellite, Freja, which is scheduled to be launched this year. Trained as a theoretical space plasma physicist, Dr. Andre is also deeply involved with hardware and data analyses. He has obtained the degrees of Ph.D. and Docent and is now Associate Professor at the University of Umea as well as a senior scientist at the Swedish Space Institute. Dr. Andre has been collaborating with the MIT Center since its inception and has contributed in the areas of ion heating, low frequency turbulence, and double layers.

**Dr. J. D. Winningham** is an Institute Scientist at the Southwest Research Institute. He has made numerous seminal contributions to the anomalous particle distributions in the ionosphere and magnetosphere. He was a principal investigator on the Dynamics Explorer satellites and is involved with a number of

international space programs. His initial observations of the polar wind electrons and central plasma sheet ions stimulated much of the theoretical work in these areas at the MIT Center.

Mr. Jay Johnson is undoubtedly the top graduate student in theoretical space plasma physics at MIT. He came from the University of Colorado with a straight A+ average, where he worked with the famous plasma physicist, Professor Martin Goldman, as an undergraduate honor student. His grades at MIT are outstanding and ranked number one in the physics general examination in 1989. He interacts at the level of an accomplished postdoctoral student with a lot of insight and knowledge of space plasma research. As a graduate student, he has already published papers in the Geophysical Research Letters, the Journal of Geophysical Research and Annales Geophysicae. He has given a number of presentations including invited talks at various international and US conferences. His presentation on "Auroral Turbulence" at the 1990 Fall Meeting of AGU earned him an Outstanding Student Paper Award of the Solar-Planetary Relationship section of the American Geophysical Union.

Mr. W.T. Tam obtained his B.S. degree in physics from the University of California, Berkeley with highest honors. He has an outstanding record at MIT including a top grade in the physics general examination in 1991. During a short period of less than two years, Mr. Tam has already accomplished a great deal. One of his outstanding achievements is the discovery of a number of inaccuracies and errors in one of the most popular plasma dispersion codes that have been used world wide for important space plasma instability calculations. He has since developed a much more efficient and versatile plasma dispersion code capable of treating nearly all conceivable geometries and plasma environments.

Mr. Aly Seydi is a Summer Apprentice under the MIT Minority Opportunity Program. Mr. Seydi has accumulated an outstanding undergraduate record at the City University of New York and obtained A+'s for each and everyone of the mathematics courses that he has taken. He has advanced training in high speed computing and is conversed with the modern theories of physics. As an undergraduate student, he is already a teaching assistant in Calculus. As a junior, he has written a treatise on Special Relativity. Mr. Seydi will be working on a frontier research problem on particle acceleration in the ionosphere.

## **VII. MIT SYMPOSIA ON THE PHYSICS OF SPACE PLASMAS, CAMBRIDGE WORKSHOPS ON THEORETICAL GEOPLASMA RESEARCH, AND CHAPMAN CONFERENCE ON MICRO AND MESOSCALE PHENOMENA IN SPACE PLASMAS**

As it has been discussed in the introductory remarks, we have established both a workshop and a symposium series on space and geoplasmas. These activities have received much praise and support from the space physics community and are now enthusiastically participated by established scientists and graduate students world-wide. In addition, we have convened, in collaboration with the Universities of California at Los Angeles and Colorado, a Chapman Conference on Micro and Meso Scale Phenomena in Space Plasmas, which was enthusiastically participated by the throng of over 200 international experts in frontier space plasma research. The following are brief descriptions for these activities.

### **VII.1. MIT Symposia on the Physics of Space Plasmas**

Based on the premise that the Greater Boston-New England area had one of the world's greatest concentration of scientists and research groups active in the field of the Physics of Space Plasmas, and that a forum such as this would be of value for: cross fertilization, consolidation of their intellectual resources and periodic focusing of its potential on topical problems, an annual symposium was organized under the leadership of Tom Chang, John Belcher, and J.R. Jasperse. During the past few years, this symposium series has gained popularity that each year it is attended by over one hundred thirty scientists and graduate students world-wide. Although the participation of the symposia has become international, it still claims an active participation of the researchers regionally, including those from the Geophysics Directorate of the Phillips Laboratory, Naval Research

Laboratory, Goddard Space Flight Center, Harvard University, Dartmouth College, Boston University, Boston College, Cornell University, Columbia University, Princeton University, University of New Hampshire, and the University of Maryland.

Perhaps the most lasting and most valuable fruits of these meetings are the seminal discussions and follow-on collaborations they foster. A sampling of such results are listed below.

1. *A new boundary layer method* for solving pitch-angle scattering of electrons on auroral field lines was inspired by data presented by J. Whalen of the Geophysics Directorate and J. Sharber of the Southwest Research Institute.

2. *First reporting* of the unexpected high degree of order in the polar cap ionospheric convection for northward interplanetary magnetic field conditions was given by H. Carlson of the Geophysics Directorate. This work has stimulated our current theoretical study of sub-visual polar cap F-region arcs in collaboration with the experimentalists at Boston College, the Geophysics Directorate, and the Southwest Research Institute.

3. *First results* of closed-form solutions of the Balescu-Lenard-Poisson equations for collisional plasmas were reported by J.R. Jasperse of the Geophysics Directorate. Discussions at the meeting motivated an extension of the theory to phenomena at low frequencies.

4. *A new theory* of central plasma sheet oxygen conics within the diffuse auroral region resulted from data presented by J.D. Winningham of the Southwest research Institute.

5. *A new photoelectron model* in the polar wind was simulated by a presentation of S. Olbert on a non-classical electron heat flux theory of the solar wind.

6. *As a result of a review talk* of the equatorial spread-F theory by S. Ossakow of the Naval Research Laboratory, B. Basu of the Geophysics Directorate and B. Coppi of MIT realized the need for a treatment of the problem taking into account the curved magnetic field line. This was necessary theoretically in order to obtain a self-consistent calculation.

7. *A deep penetration* of the high energy tail of the solar wind electrons (strahl) into the magnetosphere was suggested by J. Scudder and D. Fairfield of the Goddard Space Flight Center. This could then be observed as part of the precipitating electron population in the polar cap. Because of the symposium interactions, D. Hardy and M.S. Gussenhoven of the Geophysics Directorate have searched and detected the presence of these particles using instruments aboard the DMSP satellites.

8. *Because of the visit of J. Dungey* of the Imperial College of London, discussions have led to the understanding of ULF turbulence in the auroral region. This research led to our current work on mode conversion of ULF waves, which forms a part of a doctoral thesis by J. Johnson, a graduate student at MIT.

9. *Lectures given* by R. Arnoldy of the University of New Hampshire and P.M. Kintner of Cornell University on lower hybrid spikelets have led to our current research activities at the Center on the collapse and formation of lower hybrid solitons and their effects on the ionospheric ion population.

Since 1987, we have inaugurated a prestigious Alfvén Lecture series in conjunction with the annual symposia in honor of the Nobel Laureate Hannes Alfvén of the Royal Institute of Technology of Sweden. The series is now more popular than ever. It is our intention to continue this tradition at MIT for future years to come. The following is a listing of the Alfvén Lecturers:

- Professor Hannes Alfvén, Royal Institute of Technology, Sweden
- Dr. Roger Gendrin, Director of the National Institute for Research, France.
- Professor James Dungey, Imperial College of London, England.
- Professor Oscar Buneman, Stanford University.
- Professor James van Allen, the University of Iowa.
- Professor Eugene N. Parker, the University of Chicago.
- Professor Charles F. Kennel, the University of California, Los Angeles

## **VII.2. Cambridge Workshops in Theoretical Geoplasma Physics**

During the past twenty years, some very useful progress has been made in the understanding of the nature and dynamics of the plasma domains of the terrestrial ionosphere and magnetosphere. However, only limited tutorial accounts of the subject are available in the published literature. Consequently, it becomes extremely difficult for beginning graduate students or researchers of related fields to become acquainted with the existing research topics that are being investigated by the active researchers in geoplasma physics. The Cambridge Workshops were conceived to address such a need.

Since its inception, they have become very well known and extremely popular. The workshop now typically attracts between 130 to 150 participants annually world-wide, including scientists from the Geophysics Directorate and the Naval Research Laboratory, as well as a large number of graduate students (30 to 40) from many outstanding institutions.

In addition to the workshops themselves, we have published detailed proceedings in book form. These Proceedings have become informal texts and principal reference books on the topics covered by the workshops and have received much praise from the graduate students and researchers.

**Below is a list of topics covered by the workshops:**

- Ionosphere/magnetosphere/solar wind coupling.
- Polar cap dynamics and high-latitude ionospheric turbulence.
- Wave-particle interaction phenomena in geoplasmas.

- **Magnetic fluctuations, diffusion and transport in geoplasmas.**
- **Nonlinear phenomena and active experiments in geoplasmas.**
- **Controversial issues and frontier research in geoplasmas.**
- **Chaos, Stochasticity, and Strong Turbulence in Space Plasmas.**

**Enclosed are the circulated announcements of our Symposium, Workshop and other conference activities for the past six years.**

FINAL ANNOUNCEMENT

**1993 MIT SYMPOSIUM  
&  
1993 CAMBRIDGE WORKSHOP  
- ON THE PHYSICS OF SPACE PLASMAS -**

**SYMPOSIUM: JULY 19, 1993**  
*Alfvén Lecturer, Prof. Charles F. Kennel, UCLA*  
*MIT Campus, Bldg 37-252, Marlar Lounge, Cambridge, MA*

**WORKSHOP: JULY 20-23, 1993**  
**CHAOS, STOCHASTICITY, AND STRONG TURBULENCE**  
*Special Lecturer, Prof. Ted W. Speiser, University of Colorado*  
*MIT Campus, Bldg 34-101, Edgerton Lecture Hall, Cambridge, MA*

**WORKSHOP FORMAT:**

- TUTORIAL LECTURES.
  - POSTER SESSIONS.
  - WORKSHOP AND DISCUSSION PERIODS.
  - INVITED LECTURES ON CURRENT TOPICS.
- List of invited speakers and chairpersons:

ASHOUR-ABDALLA, M.	CHEN, J.	KROLL, J.	SCHRIVER, D.
BELCHER, J.	DOXAS, I.	LEE, M. C.	SHERIDAN, T.
BHATTACHARJEE, A.	DUM, C.	LYNCH, K.	SONG, Y.
BINGHAM, R.	EASTMAN, T.	LYSAK, R.	SOTNIKOV, V.
BINSACK, J.	GEKELMAN, W.	LYU, L.	SPEISER, T.
BIRMINGHAM, T.	GOLDMAN, M.	MARTIN, R.	SUDAN, R.
BUECHNER, J.	GROVES, K.	MAUEL, M.	TAM, W.
BURINSKAYA, T.	GURNETT, D.	MONTGOMERY, D.	TEMERIN, M.
BURKHART, G.	HAMZA, A.	MUSCHIETTI, L.	TETREAU, D.
CAIRNS, I.	HOLLAND, D.	OTT, E.	THIDE, B.
CANIZARES, C.	HUBA, J.	RAM, A.	WALKER, D.
CARLSON, H.	JOYCE, G.	RETTNER, J.	WANG, Z.
CHAN, A.	KENNEL, C.	ROBINSON, P.	YASSEEN, F.
CHANG, T.	KESKINEN, M.	SAVENKOV, B.	ZANK, G.
CHAPMAN, S.	KLIMAS, A.	SHARMA, S.	

Topics of interest will include finite-dimensional chaos, fractals and multi-fractals, Poincaré sections, strange attractors, Lyapunov exponents, stochasticity, infinite-dimensional systems at forced and self-organized criticality, quasi-periodicity, solitons and cavitons, Langmuir and lower hybrid turbulence, nonlinear waves-particle interactions and particle acceleration, transition from weak to strong turbulence, DIA and clump theories, renormalized and renormalization-group theories, chaos in current sheets, magnetospheric convection, release mechanism of substorms, magnetopause and magnetotail reconnection, shear-induced auroral turbulence, helicity conservation, turbulent relaxation and diffusion, spatiotemporal chaos, broken symmetry, fluctuations and correlations, and strong turbulence in plasmas and fluids including MHD. Basic theories, experiments and applications in magnetospheric, ionospheric, stellar, heliospheric and astrophysical plasmas will be emphasized.

This symposium/workshop is sponsored by the MIT Center for Theoretical Geo/Cosmo Plasma Physics and partially supported by AFOSR, NASA, NSF and the Marlar Fund.

Proceedings of this activity will be published as Volume 13 in the *SPI Conference Proceedings and Reprint Series* and is included in the registration fee. Volumes 7-12 of the Proceedings of the 1987-92 workshops, may be ordered directly from Scientific Publishers, P.O. Box 6, MIT Branch Post Office, MA 02139-9992, (617) 861-6784.

FINAL ANNOUNCEMENT  
1992 CAMBRIDGE WORKSHOP IN  
THEORETICAL GEOPLASMA PHYSICS

THEME:

# CONTROVERSIAL ISSUES AND NEW FRONTIER RESEARCH IN GEOPLASMAS

LOCATION: MIT CAMPUS, BLDG 34-101, EDGERTON LECTURE HALL  
CAMBRIDGE, MA USA

DATES: AUGUST 10-14, 1992

## WORKSHOP FORMAT:

- TUTORIAL LECTURES.
  - POSTER SESSIONS.
  - WORKSHOP AND DISCUSSION PERIODS.
  - INVITED LECTURES ON CURRENT TOPICS.
- Tentative list of invited speakers and moderators:

ANDRE,M.  
ARNOLDY,R.  
ASHOUR-ABDALLA,M.  
ATKINSON,G.  
BASU,B.  
BELCHER,J.  
BENSON,R.  
BERCHEM,J.  
BOROVSKY,J.  
BRECHT,S.H.  
BUCHNER,J.  
CHAN,A.  
DING,DA-QING.  
DUM,C.  
EASTMAN,T.

FEDDER,J.  
GANGULI,G.  
GANGULI,S.  
HORWITZ,J.  
INAN,U.  
JASPERSE,J.  
KELLEY,M.  
KENNEL,C.  
KINTNER,P.  
KLIMAS,A.  
KOZYRA,J.  
LABELLE,J.  
LAZARUS,A.  
LEE,L.  
LUNDIN,R.

LYSAK,R.  
MAUEL,M.  
MENIETTI,D.  
MILLER,R.  
MONTGOMERY,D.  
NAGY,A.  
NEWELL,P.  
OSHEROVICH,V.  
PRICE,C.  
RETTNER,J.  
RODRIGUEZ,P.  
ROTHWELL,P.  
RUSMUSSEN,C.  
RYNN,N.  
SCHUNK,R.

SEYLER,C.  
SHARMA,S.  
SILOVITCH,M.  
SONNERUP,B.  
STASIEWCZ,K.  
STEINBERG,J.  
TEMERIN,M.  
TETREAULT,D.  
VAGO,J.  
WINNINGHAM,J.P.  
WOLF,R.  
WU,C.C.  
YASSEEN,F.  
YOON,P.  
ZELENYI,L.

Topics will include (but not be limited to) lower hybrid spikelets, magnetosphere-ionosphere coupling, auroral kilometric radiation, auroral arcs, turbulent reconnection and flux transfer events, mesoscale phenomena involving kinetic effect and inhomogeneities, ionospheric transport processes, polar cap arcs, intermediate shocks, solar wind, heliosphere bow shock, electron conics, impulsive penetration and cusp phenomena, nonlinear dynamics, chaos, geomagnetic indices and low-dimensional behavior, and plasma physics involving negative ions.

This workshop is sponsored by the MIT Center for Theoretical Geoplasma Physics (established under the AFOSR-URI program).

Prospective participants are invited to register for the workshop on or before July 1, 1992.\* The registration fee is \$225 and will increase to \$250 after July 1st.

Proceedings of this workshop will be published as Volume 12 in the *SPI Conference Proceedings and Reprint Series* and is included in the registration fee. (Volumes 7, 8, 9, 10, 11 of the Proceedings of the 1987, 88, 89, 90, 91 workshops, may be ordered directly from Scientific Publishers, P.O. Box 6, MIT Branch Post Office, MA 02139-9992 at \$29, \$29, \$33, \$33, \$38 respectively.)

Prospective participants are also invited to submit abstracts for poster papers outlining their current research on or before June 15, 1992.\* Abstracts should be prepared in AGU format.

Travel support is available to a limited number of qualified graduate students. Deadline of application for travel support is June 15, 1992.\*

FINAL ANNOUNCEMENT  
1991 CAMBRIDGE WORKSHOP IN  
THEORETICAL GEOPLASMA PHYSICS

THEME:

# NONLINEAR PHENOMENA AND ACTIVE EXPERIMENTS

LOCATION: MIT CAMPUS, BLDG 34-101, EDGERTON LECTURE HALL  
CAMBRIDGE, MA USA

DATES: JUNE 24-28, 1991

## WORKSHOP FORMAT:

- TUTORIAL LECTURES.
- POSTER SESSIONS.
- WORKSHOP AND DISCUSSION PERIODS.
- INVITED LECTURES ON CURRENT TOPICS.

*Topics to be discussed at the workshop will include Interplanetary and Bow Shocks, Mesoscale Transport Phenomena, Nonlinear Wave-Particle Interactions, MHD, DIA and Clump Theory, Stochasticity, Path Integrals and Renormalization-Group, Strong and Weak Turbulence, Soliton Theory, Inverse Scattering, Double layers and Flux Transfer Events, Parametric Processes, RF heating, Beam-injection Experiments in Space, Plasma Releases, etc.*

- Partial list of invited speakers and moderators:

M.Ashour-Abdalla	F.Djuth	M.Keskinen	N.Otani
D.Baker	D.Dubois	P.Kintner	P.Palmadesso
Sa.Basu	C.Dum	M.Kuznetsova	F.Perkins
Su.Basu	G.Ganguli	A.Lazarus	P.Prichett
A.Bers	S.Ganguli	M.C.Lee	J.Retterer
J.Buechner	G.Ginet	W.Lotko	H.Rowland
T.Burinskaya	T.Gombosi	P.Malcolm	R.Sagalyn
W.Burke	D.Hastings	M.E.Mandt	R.Stenzel
G.Burkhart	R.Helliwell	E.Marsch	R.Sudan
H.Carlson	W.Horton	R.Martin	D.Tetreault
T.Chang	J.Huba	E.Murad	B.Tsuratani
J.Chen	J.Hughes	G.Murphy	R.Winglee
C.C.Chow	J.Jasperse	S.Ossakow	Y.Zakharov
G.Crew			

This workshop is sponsored by the MIT Center for Theoretical Geoplasma Physics (established under the AFOSR-URI program).

Prospective participants are invited to register for the workshop on or before May 15, 1991. The registration fee is \$200 and will increase to \$225 after May 15.

Proceedings of this workshop will be published as Volume 11 in the *SPI Conference Proceedings and Reprint Series* and is included in the registration fee. (Volumes 7, 8, 9 and 10, Proceedings of the 1987, 88, 89 and 90 workshops, may be ordered directly from Scientific Publishers, P.O. Box 6, MIT Branch Post Office, MA 02139-9992 at \$29, \$29, \$33, \$33 respectively.)

Prospective participants are also invited to submit abstracts for poster papers outlining their current research on or before May 6, 1991. Abstracts should be prepared in AGU format.

Travel support is available to a limited number of qualified graduate students. Deadline of application for travel support is May 6, 1991.

Additional information may be obtained from Tom Chang, Center for Theoretical Geoplasma Physics, MIT Center for Space Research, Room 37-271, Cambridge, MA 02139; Telephone number 617/253-7527; Telex number: 92-1473; E-mail: mt@space.mit.edu; FAX: (617) 253-0861.

FINAL ANNOUNCEMENT  
**1990 CAMBRIDGE WORKSHOP IN  
THEORETICAL GEOPLASMA PHYSICS**

THEME:

**MAGNETIC FLUCTUATIONS, DIFFUSION  
AND TRANSPORT IN GEOPLASMAS**

LOCATION: MIT CAMPUS, BLDG 34-101, EDGERTON LECTURE HALL  
CAMBRIDGE, MA USA

DATES: JULY 16-20, 1990

**WORKSHOP FORMAT:**

- TUTORIAL LECTURES.
- POSTER SESSIONS.
- INVITED LECTURES ON CURRENT TOPICS.
- WORKSHOP AND DISCUSSION PERIODS.
- Invited speakers and moderators will include:

A. Bhattacharjee	P. Gary	R. Lysak	D. Siebeck
W. Burke	N. Hershkovitz	C. Max	H. Singer
H. Carlson	M. Hudson	N. Maynard	B. Sonnerup
J. Chen	J. Hughes	S. Ossakow	R. Stenzel
L. Chen	J. Jasperse	T. Potemra	K. Takahashi
C. Z. Cheng	J. Johnson	P. Prichett	D. Tetreault
Y. Chiu	J. Kan	K. Quest	R. Thorne
T. Eastman	D. Klumpar	A. Ram	R. Treuman
M. Engebretson	L. Lee	A. Roux	B. Tsuratani
R. Erlandson	E. Basiuska-Lewin	R. Sagalyn	D. Winningham
J. Fedder	W. Lotko	M. Schulz	D. Winske
J. Foster	A. T. Y. Lui	C. Seyler	C. C. Wu

Two special sessions on "ULF Waves" and "Transport of Energy, Momentum and Particles at the Magnetopause" have been organized by Professor Robert Lysak of the University of Minnesota and Professor Lou Lee of the University of Alaska, respectively. Other major topics to be discussed are collisionless shocks, flux transfer events, reconnection processes, electromagnetic waves, currents in various geoplasma regimes, radiation belt physics, particle accelerations, geomagnetic field topology, low frequency turbulence, etc.

This workshop is sponsored by the MIT Center for Theoretical Geoplasma Physics (established under the AFOSR-URI program).

Prospective participants are invited to register for the workshop on or before June 16, 1990. The registration fee is \$175 and will increase to \$195 after June 16.

Proceedings of this workshop will be published as Volume 10 in the *SPI Conference Proceedings and Reprint Series* and is included in the registration fee. (Volumes 7, 8 and 9, Proceedings of the 1987, 8 and 9 workshops, may be ordered directly from Scientific Publishers, P.O. Box 6, MIT Branch Post Office, MA 02139-9992 at \$29, \$29, \$33 respectively.)

Prospective participants are also invited to submit abstracts for poster papers outlining their current research on or before May 1, 1990. Abstracts should be prepared in AGU format.

Travel support is available to a limited number of qualified graduate students. Deadline of application for travel support is May 1, 1990.

Additional information may be obtained from Tom Chang, Center for Theoretical Geoplasma Physics, MIT Center for Space Research, Room 37-271, Cambridge, MA 02139; Telephone number 617/253-7527; Telex number: 92-1473; E-mail: mt@space.mit.edu; FAX: (617) 253-0861.

THIRD ANNOUNCEMENT

1989 CAMBRIDGE WORKSHOP IN  
THEORETICAL GEOPLASMA PHYSICS

THEME:

**WAVE-PARTICLE INTERACTION  
PHENOMENA IN GEOPLASMAS**

LOCATION: MIT CAMPUS, CAMBRIDGE, MA USA

DATES: JUNE 12-16, 1989

**WORKSHOP FORMAT:**

- Tutorial lectures.
- Invited lectures on current topics.
- Invited speakers will include:
- Workshop and discussion periods.
- Poster sessions.

M.Andre	R.Helliwell	H.Okuda	D.Tetreault
M.Ashour-Abdalla	M.Hudson	W.Peterson	R.Treumann
R.Bergmann	U.S.Inan	R.Pottelotte	E.Villalon
G.Crew	P.Kintner	P.Pritchett	J.Winkler
C.Dum	D.Klumpar	J.Retterer	J.D.Winningham
R.Ergun	R.Lysak	I.Roth	D.Winske
G.Ganguli	H.Matsumoto	F.Skiff	C.S.Wu
S.Gary	R.McWilliams	M.Temerin	A.Yau

This workshop is sponsored by the MIT Center for Theoretical Geoplasma Physics (established under the AFOSR-URI program).

Prospective participants are invited to register for the workshop on or before May 16, 1989. The registration fee is \$175 and will increase to \$195 after May 16.

Proceedings of this workshop will be published as Volume 9 in the *SPI Conference Proceedings and Reprint Series* by Scientific Publishers, Inc. and is included in the registration fee.

Prospective participants are also invited to submit abstracts of poster papers outlining their current research on or before May 1, 1989 (new deadline). Abstracts should be prepared in AGU format.

Travel support is available to a limited number of qualified graduate students. Deadline of application for travel support is April 21, 1989 (new deadline).

A Boston Pop's Concert Night will be organized for the participants and their guests.

Registration forms may be obtained from Tom Chang, Center for Theoretical Geoplasma Physics, MIT Center for Space Research, Room 37-271, Cambridge, MA 02139; Telephone number 617/253-7527; Telex number : 92-1473; E-mail: mfj@space.mit.edu.

THIRD ANNOUNCEMENT

1988 CAMBRIDGE WORKSHOP IN  
THEORETICAL GEOPLASMA PHYSICS

THEME:

**POLAR CAP DYNAMICS  
AND HIGH LATITUDE  
IONOSPHERIC TURBULENCE**

LOCATION: MIT CAMPUS, CAMBRIDGE, MA USA

DATES: JUNE 13-17, 1988

**WORKSHOP FORMAT:**

- Tutorial lectures.
- Workshop and discussion periods.
- Invited lectures on current topics.
- Poster sessions.
- Invited speakers and panel moderators will include:

D.Anderson	B.Fejer	M.Kelley	T.Potemra
B.Basu	J.Foster	M.Keskinen	P.Reiff
San.Basu	G.Ganguli	P.Kintner	J.M.Retterer
Sun.Basu	T.Gombosi	J.Klobuchar	R.Schunk
W.Burke	R.Greenwald	L.Lee	J.Sharber
H.Carlson	D.Hardy	M.C.Lee	J.P.St.Maurice
Y.Chiu	R.Heelis	N.Maynard	J.Vickery
B.Coppi	J.Horwitz	T.Moore	E.Weber
G.B.Crew	J.Huba	S.Ossakow	J.D.Winningham
J.Fedder	J.Jasperse	P.Palmadesso	A.Yau

This workshop is sponsored by the MIT Center for Theoretical Geoplasma Physics (established under the AFOSR-URI program) and AFGL.

Prospective participants are invited to register for the workshop on or before May 16, 1988. The registration fee is \$175 and will increase to \$195 after May 16.

Proceedings of this workshop will be published as Volume 8 in the *SPI Conference Proceedings and Reprint Series* by Scientific Publishers, Inc. and is included in the registration fee.

Prospective participants are also invited to submit abstracts of poster papers outlining their current research on or before April 30, 1988. Abstracts should be prepared in AGU format.

Travel support is available to a limited number of qualified graduate students.

Additional registration forms may be obtained from Tom Chang, Center for Theoretical Geoplasma Physics, MIT Center for Space Research, Room 37-271, Cambridge, MA 02139; Telephone number 617/253-7527; Telex number : 92-1473; E-mail: mfj@space.mit.edu.

THIRD ANNOUNCEMENT

**1987 CAMBRIDGE WORKSHOP IN  
THEORETICAL GEOPLASMA PHYSICS**

**THEME:**

***IONOSPHERE-MAGNETOSPHERE-SOLAR WIND  
COUPLING PROCESSES***

LOCATION: MIT CAMPUS, CAMBRIDGE, MA USA

DATES JULY 28 - AUGUST 1, 1987

***WORKSHOP FORMAT:***

- Morning tutorials: Two one-hour lectures each morning to be delivered by G. Siscoe (UCLA) and R. Lysak (U. Minnesota). These lectures will survey the current status of the various micro-, meso-, and macro-scale coupling processes among the ionosphere, magnetosphere, and the solar wind.
- Afternoon invited lectures on current topics and workshop. Invited speakers and panel moderators will include:

M. Ashour-Abdalla  
R. Bergmann  
W. Burke  
H. Carlson  
J. Craven  
G. Crew  
N. Crooker  
C. Dum  
C. Goertz  
A. Hasegawa

J. Jasperse  
R. Kaufmann  
H. Koskinen  
L. Lee  
W. Lotko  
J. Lyon  
N. Maynard  
R. McPherron  
P. Palmadesso  
J. Retterer

R. Schunk  
M. Silevitch  
R. Spiro  
B. Sonnerup  
E. Szuszcwicz  
M. Temerin  
D. Tetreault  
V. Vasyliunas  
R. Walker  
R. Wolf

- Evening poster sessions.

This workshop is sponsored by the MIT Center for Theoretical Geoplasma Research (established under the AFOSR-URI program) and AFGL.

Prospective participants are invited to register for the workshop on or before June 30, 1987. The registration fee will increase from \$150 to \$175 after June 30.

Proceedings of this workshop will be published as volume 7 in the *SPI Conference Proceedings and Reprint Series* by Scientific Publishers, Inc. and is included in the registration fee. Registration forms may be obtained from Tom Chang, Center for Theoretical Geoplasma Research, MIT Center for Space Research, Room 37-271, Cambridge, MA 02139; Telephone number: 617/253-7527; Telex Number: 92-1473

# PHYSICS OF SPACE PLASMAS

<u>DATE AND TIME:</u>	January 24, 1992, 8:30-17:30 (Friday)	
<u>LOCATION:</u>	Bldg. 37, Rm.252, Marlar Lounge, MIT Center for Space Research	
<u>ORGANIZED BY:</u>	T.Chang, J.Belcher, J.Jasperse, G.Crew	
<u>COFFEE, TEA AND MUFFINS:</u>	8:30 - 9:00	
<u>WELCOME:</u>	9:00-9:10	Master of Ceremony: J.Binsack(MIT) C.Canizares(MIT)
<u>SESSION I:</u>	9:10-10:30	Chairperson: J.Jasperse(GD/PL)
1. Opening Remarks:		E.Good(GD/PL)
2. Introduction & Presentation of Certificate:		S.Olbert(MIT)
3. <b>Alfvén Lecture:</b> "Spontaneous Discontinuity and the Stellar X-ray Emission"		E.N.Parker (U.of Chicago)
<u>COFFEE AND TEA:</u>	10:30-11:00	
<u>SESSION II:</u>	11:00-12:00	Chairperson: R.Carovillano(BC)
1. "Current Sheets"		A.Bhattacharjee (Columbia U.)
2. "Country Club Model of the Corona"		J.Scudder(GSFC/NASA)
<b>LUNCH ( \$5) 12:00 - 13:00</b> <b>Marlar Lounge - Rm. 37-252 - Coordinator: G. Crew</b>		
<u>SESSION III:</u>	13:00-13:30	Chairperson: T.Chang(MIT)
1. "NASA Space Plasma Physics"		G.Withbroe(NASA HQ)
<u>SESSION IV:</u>	13:30-14:30	Chairperson: J.Belcher(MIT)
1. "The Termination Shock of the Solar Wind"		M.Lee(UNH)
2. "Solar Wind Triggering of the VLF Heliospheric Radio Emissions"		R.McNutt(Visidyne)
<u>COFFEE AND TEA:</u>	14:30-15:00	
<u>SESSION V:</u>	15:00-16:30	Chairperson: R.Sagalyn(GD/PL)
1. "Mesoscale Plasma Structuring in the High Latitude Ionosphere"		Su.Basu Sa.Basu (BC & GD/PL)
2. "Dynamics, Structure & Energization in the Near Earth Space Plasma Environment"		M.Keskinen(NRL)
3. "New Low Energy Particle Measurements in the Inner Magnetosphere From the CRESS Satellite"		D.Hardy(GD/PL)
<u>REFRESHMENTS:</u>	16:30-17:30 (Rm. 37-232)	
<i>For Further Information Contact:</i>	Dr. Tom Chang, Mary Terhune (617) 253-7527 Dr. J.Jasperse (GL) (617) 377-5090	

\*\*See Reverse For Map, Room Locations and Parking Sites\*\*

# PHYSICS OF SPACE PLASMAS

- DATE AND TIME:** January 24, 1991, 8:30-17:00 (Thursday)  
(snow day: January 25)
- LOCATION:** Bldg. 37, Rm.252, Marlar Lounge, MIT Center for Space Research
- ORGANIZED BY:** T.Chang, J.Jasperse, G.Crew
- COFFEE, TEA AND MUFFINS:** 8:30 - 9:00
- MASTER OF CEREMONY:** J. Binsack (MIT)
- WELCOME:** 9:00-9:10 C. Canizares (MIT)
- SESSION I:** 9:10-10:10 Chairperson: R.Carovillano  
(Boston College)
1. Introduction & Presentation of Certificate
  2. **Alfvén Lecture:** "The Magnetospheres of Eight Planets and the Moon" J.van Allen (U. of Iowa)
- COFFEE AND TEA:** 10:10-10:40
- SESSION II:** 10:40-12:10 Chairperson: J. Jasperse (GL)
1. "Transverse Ion Acceleration at Rocket Altitudes" R.Arnoldy (UNH)
  2. "High Frequency Excitation in Outer Planetary Magnetospheres" I.Roth(UC/Berkeley)  
M.Hudson(Dartmouth)
  3. "Cusp Topology: A New Interpretation" J.D.Winningham(SWRI)
- LUNCH ( \$5 ) & MOVIE 12:10 - 13:10**  
**Marlar Lounge - Rm. 37-252 - Coordinator: G. Crew**
- SESSION III:** 13:10-13:40 Chairperson: M.Hudson(Dartmouth)
1. "NASA Space Physics Theory Program" T.Birmingham(NASA/GSFC)
- SESSION IV:** 13:40-14:40 Chairperson: R.Sagalyn (GL)
1. "Plasma Irregularity Studies with CRRES/Chemical Releases" H.Carlson (GL)
  2. "The van Allen Radiation Belts: New Measurements with CRRES" G.Mullen (GL)
- COFFEE AND TEA:** 14:40-15:20
- SESSION V:** 15:20-16:20 Chairperson: A.Lazarus (MIT)
1. "Problems of the Confinement of the Heliosphere" S.Grzedzielski (Polish Space Res.Ctr./ Polish Academy of Sci.)
  2. "Birkeland Currents in an Anisotropic Plasma" T.Birmingham(NASA/GSFC)
- WINE AND CHEESE PARTY:** 16:20-17:00 (Rm. 37-232)
- For Further Information Contact:** Dr. Tom Chang, Mary Terhune (617) 253-7527  
Dr. J.Jasperse (GL) (617) 377-5090

\*\*See Reverse For Map, Room Locations and Parking Sites\*\*

# PHYSICS OF SPACE PLASMAS

- DATE AND TIME:** January 25, 1990, 8:30-17:30 (Thursday)  
(snow day: January 26)
- LOCATION:** Rm. 37-252, Marlar Lounge
- ORGANIZED BY:** T.Chang, J.Belcher, J.Jasperse, G.Crew
- MASTER OF CEREMONY:** J. Binsack (MIT)
- COFFEE, TEA AND MUFFINS:** 8:30 - 9:00
- SESSION I:** 9:00-10:15      Chairperson: M.Hudson (Dartmouth  
Berkeley/Stanford)
1. Introduction & Presentation of Certificate
  2. **Alfvén Lecture:** "Space Plasma Experimentation  
by Computer Simulation"      O.Buneman (Stanford)
- COFFEE AND TEA:** 10:15-10:45
- SESSION II:** 10:45-12:30      Chairperson: J. Belcher (MIT)
1. "Voyager II at Neptune"      J.Belcher (MIT)
  2. "News from the Outer Heliosphere"      A.Lazarus (MIT)
  3. "The Continuing Mystery of the Interstellar  
Pickup Protons"      P.Isenberg (UNH)
- LUNCH ( \$4 ) & MOVIE 12:30 - 13:30**  
**Marlar Lounge - Rm. 37-252 - Coordinator: G. Crew**
- SESSION III:** 13:30-14:45      Chairperson: H.Carlson (AFGL)
1. "A Review of the Theory of Energetic  
Particle Transport in the Terrestrial Ionosphere"      J.Jasperse  
(AFGL/MIT)
  2. "Mapping the Cusp from the Magnetosphere  
to the Ionosphere"      N.Crooker  
(UCLA/AFGL)
- COFFEE AND TEA:** 14:45-15:15
- SESSION IV:** 15:15-16:30      Chairperson: R.Sagalyn (AFGL)
1. "Multisatellite Observations of Substorm Onsets"      J.Hughes (BU)
  2. "Prospects of Forecasting Weather in  
the Earth's Magnetosphere"      D.Swift  
(U.Alaska/AFGL/MIT)
- WINE AND CHEESE PARTY:** 16:30-17:30 (Rm. 37-232)
- For Further Information Contact:*** Dr. Tom Chang, Mary Terhune (617) 253-7527  
Dr. J.Jasperse (AFGL) (617) 377-5090

# PHYSICS OF SPACE PLASMAS

\*\*\* FINAL ANNOUNCEMENT \*\*\*

- DATE AND TIME:** January 19, 1989, 8:30-17:30 (Thursday)  
(snow day: January 20)
- LOCATION:** Rm. 37-252, Marlar Lounge
- ORGANIZED BY:** T.Chang, J.Belcher, J.Jasperse, G.Crew
- MASTER OF CEREMONY:** J. Binsack (MIT)
- COFFEE, TEA AND MUFFINS:** 8:30 - 9:00
- SESSION I:** 9:00-10:15      Chairperson: H. Carlson (AFGL)
1. "Welcoming Remarks" & Presentation of Certificate      J.Jasperse (AFGL)
  2. Alfvén Lecture: "Anomalous Resistivity in the Geotail Neutral Sheet"      J.Dungey (IMPERIAL COLLEGE,LONDON)
  3. "Words of Appreciation"      W.J.Hughes (BU)
- COFFEE AND TEA:** 10:15-10:45
- SESSION II:** 10:45-11:55      Chairperson: J. Jasperse (AFGL)
1. "Driven Steady State Reconnection"      T. Forbes (UNH)
  2. "Turbulent Reconnection in Plasmas"      D. Tetreault (MIT)
- LUNCH ( \$3 ) & VOYAGER MOVIE 12:00 - 13:00**  
**Marlar Lounge - Rm. 37-252 - Coordinator: G. Crew**
- SESSION III:** 13:00-13:45      Chairperson: T. Chang (MIT)
1. "World-Wide Solar-Terrestrial Space Science Programs"      S. Shawhan (NASA HQ)
- SESSION IV:** 13:45-15:00      Chairperson: J. Belcher (MIT)
1. "Voyager II at Neptune"      J. Belcher (MIT)
  2. "Interstellar Pickup Ions in the Solar Wind"      M. Lee (UNH)
- COFFEE AND TEA:** 15:00-15:30
- SESSION V:** 15:30-16:45      Chairperson: R. Sagalyn (AFGL)
1. "Particle Entry at High Latitudes in the Earth's Magnetosphere"      S. Gussenhoven (AFGL)
  2. "Energetic Photoelectrons and the Polar Rain"      D. Decker (BC/AFGL)
- WINE AND CHEESE PARTY:** 16:45-17:45 (Rm. 37-232)

*For Further Information Contact:* Dr. Tom Chang, M. Jeanig (617) 253-7527  
Dr. J.Jasperse (AFGL) (617) 377-5090

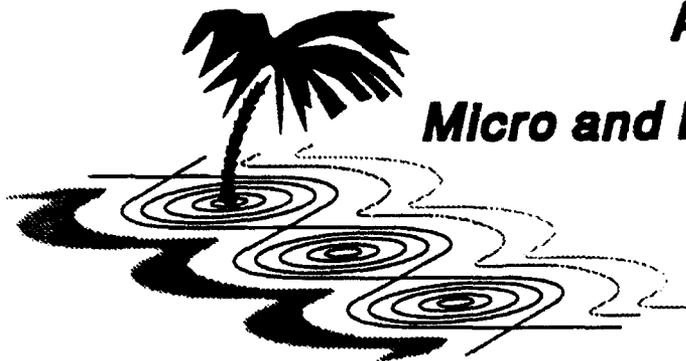
**\*\*See Reverse For Map, Room Locations and Parking Sites\*\***

# PHYSICS OF SPACE PLASMAS

- DATE AND TIME:** January 26, 1988, 8:30-17:30 (Tuesday)  
(snow day: January 27)
- LOCATION:** Rm. 34-101, Edgerton Lecture Hall
- ORGANIZED BY:** T.Chang, J.Belcher, J.Jasperse, G.Crew
- MASTER OF CEREMONY:** J. Binsack (MIT)
- COFFEE, TEA AND DANISH:** 8:30 - 9:00
- SESSION I:** 9:00-10:15      Chairperson: T. Chang (MIT)
1. "Welcoming Remarks"      J.Jasperse (AFGL)
  2. **Alfvén Lecture:** "How does the Magnetospheric Plasma Escape Thermalization?"      R.Gendrin(CNET/CRPE, FRANCE)
- COFFEE AND TEA:** 10:15-10:45
- SESSION II:** 10:45-11:55      Chairperson: J. Belcher (MIT)
1. "Solar Wind in the Outer Heliosphere"      A. Lazarus (MIT)
  2. "Limits on Spacecraft Charging in the Jovian Magnetosphere"      R. McNutt,Jr.(MIT)
- COMPLIMENTARY LUNCH & VOYAGER MOVIE 12:00 - 13:00**  
**Marlar Lounge - Rm. 37-252 - Coordinator: G. Crew**
- SESSION III:** 13:00-14:45      Chairperson: J.Jasperse (AFGL)
1. "Magnetoconvection on the Solar Surface"      G. Simon (AFGL)
  2. "Polar Cap Arcs"      H. Carlson (AFGL)
  3. "On the Spectral Character of Turbulent Flow in the Auroral Ionosphere"      M. Kelley (Cornell)
- COFFEE AND TEA:** 14:45-15:15
- SESSION IV:** 15:15-16:25\*      Chairperson: N. Maynard (AFGL)
1. "Global Solar Wind, Magnetosphere, Auroral Dynamics"      G. Parks,(NASA HQ., U.WASH)
  2. "Low Altitude Flux Transfer Events"      D.Winningham(SWRI/MIT)
- WINE AND CHEESE PARTY:** 16:30-17:30\* Marlar Lounge, Rm. 37-252
- For Further Information Contact:*** Dr. Tom Chang, M. Jeanig (617) 253-7527  
Dr. J.Jasperse (AFGL)(617) 377-5090

# PHYSICS OF SPACE PLASMAS

- DATE AND TIME:** January 9, 1987, 8:30 - 17:30 (Friday)
- LOCATION:** Room 37-252 (Marlar Lounge) Center for Space Research
- ORGANIZED BY:** J. Belcher, T. Chang, J.R. Jasperse
- MASTER OF CEREMONY:** J. Binsack (MIT)
- COFFEE, TEA AND DANISH:** 8:30 - 9:00
- SESSION I:** Chairperson: T. Chang 9:00 - 9:40
1. "Welcoming Remarks" H. Carlson (AFGL)
  2. "Plasma Universe" H. Alfven (RIT/Sweden & UCSD)
- COFFEE AND TEA:** 9:40 - 10:30
- SESSION II:** Chairperson: J.R. Jasperse (AFGL) 10:30 - 12:00
1. "The Solar Wind Coupling Problem with Solutions" G. Siscoe (UCLA)
  2. "Viking Observations of Intense Electrostatic Hiss Bands in the Source Region of Auroral Kilometric Radiation" R. Pottelette (CRPE/France)
  3. "The Effect of the Magnetospheric Electric & Magnetic Fields on the Average Characteristics of the Auroral Zone" D.A. Hardy/  
M.S. Gussenhoven-Shea (AFGL)
- COMPLIMENTARY LUNCH & VOYAGER MOVIE (URANIAN ENCOUNTER) 12:00 - 13:00**
- SESSION III:** Chairperson: J. Belcher (MIT) 13:00 - 14:30
1. "An Overview of the Uranian Magnetosphere" J. Belcher (MIT)
  2. "Pick-up Protons Seen Near Comet Halley" A. Lazarus (MIT)
  3. "Plasma Circulation in Arbitrary Oriented Magnetospheres" R. Selesnick (MIT)
- COFFEE AND TEA:** 14:30 - 15:00
- SESSION IV:** Chairperson: W. Burke (AFGL) 15:00 - 16:30
1. "Solutions of the linearized Balescu-Lenard-Poisson Equations for a Weakly-Collisional Plasma: Some New Results" J.R. Jasperse/B. Basu (AFGL)
  2. "Detailed In-Situ Observations of Low-Altitude Perpendicular Ion Acceleration" A. Yau (Herzberg Inst./NRC/Canada)
  3. "Gyroresonance Heating of Central Plasma Sheet O<sup>+</sup>-Conics by Lefthand Polarized Waves" T. Chang (MIT)
- CLOSING REMARKS:** B. Coppi (MIT) 16:30 - 16:40



**AGU Chapman Conference on  
Micro and Meso Scale Phenomena  
In Space Plasmas**

**Kapaa, Kauai, 1992**

- **Conveners:** Maha Ashour-Abdalla, UCLA;  
Tom Chang, MIT;  
Paul B. Dusenbery, U. Colorado.
- **Time & Place:** Feb. 17-21, 1992, on the island of Kauai, Hawaii.
- **Program Committee:** The conveners, together with Jean Berchem, and Robert J. Strangeway, UCLA; Jim Burch, SwRI; R. L. Carovillano, Boston College; and Geoffrey B. Crew, MIT.
- **Science:** This Chapman Conference will be convened to address the basic questions of agreement between space observations and the body of plasma theory which attempts to account for the interrelations of particle behavior and electromagnetic field fluctuations, and the general behavior of space plasmas at small and medium scales. In particular, the conference will be especially concerned with observations of space plasmas (variously characterized as fluctuating, nonequilibrium, collisionless, collisional, or turbulent) which illuminate various plasma processes (stochastic, quasilinear or nonlinear wave-particle interactions) which determine the plasma behavior within the framework of traditional or non-traditional plasma kinetic theory.
- **Abstracts:** Should be prepared in the standard AGU format and sent to AGU by Nov. 15, 1991.
- **Students:** Limited funds are available to support graduate student attendance at the conference. You should make your application to AGU by Nov. 15, 1991.
- **Proceedings:** A proceedings for the conference is planned as a publication in the AGU Geophysical Monograph Series.
- **Inquiries:** Questions on the scientific program should be addressed to the conveners; other inquiries should be directed to AGU.

## **VIII. MINORITY OUTREACH PROGRAM IN GEOPLASMAS**

One of the prime missions of the MIT Center for Theoretical Geo/Cosmo Plasma Physics is to provide an environment for the development of talented young prospective students in geoplasma education. During each of the past three years, in cooperation with the MIT Minority Summer Research Program (MSRP), our Center has hosted one or more young minority undergraduate summer intern(s) recruited through keen nation-wide competition. During the summer, each intern is introduced to the basic knowledge of plasma theory as applied to space physics as well as numerical simulation and computational techniques. By intermingling with the established scientists at the Center, many of whom world-renowned, the young interns acquire the true meaning of scientific research.

Each summer intern is encouraged to present research seminars summarizing the results of his/her research activities throughout the summer. The intern is also introduced to the real atmosphere of scientific gatherings by actively participating in the Cambridge Workshop in Theoretical Geoplasma Physics that is held at the MIT campus each summer. There they learn how scientists present their ideas and debate with their peers in frontier space physics research. This program has received much praise from the scientific community.

**The following is a typical summer intern's program:**

- Introduction to Plasma Physics using the elementary text authored by F. Chen.
- Introduction to numerical computation including simulation techniques.
- Application to real space plasma research problems.

- Learn how to tie in theory with actual experimental observations.
- Deliver bi-weekly research seminars and a thesis type presentation at the end of the summer.
- Participation in the Cambridge Workshop on Theoretical Geoplasma Physics.
- Receive suggestions from members of the Center with regard to additional courses and skills to be acquired during the coming academic year at the student's home institution.

**The topics of research of the past summer interns are:**

- Particle Diffusion in Space (Danielle Sharp).
- Chaos in Two Dimensions with Application to Space Plasmas (Danielle Sharp).
- Stochastic Heating of Charged Particles in Earth's Ionosphere (Aly Seydi).
- Particle Drift in the Dipole Field (Janel Cobb).
- Stochastic Behavior of a Charged Particle in an Electromagnetic Field (Kimani Stancil).