Guest Editorial
Space Weather

THIS ISSUE marks the fifth issue of the IEEE TRANSACTIONS ON PLASMA SCIENCE devoted to the study of Space and Cosmic Plasma. The theme of this issue is Space Weather. Each of the previous four issues has carried a theme for the purpose of updating the field in current topics of interest. The theme of the first issue (1986) was electrical engineering, plasma science, and the plasma universe. That of the second issue (1989) was the golden anniversary of magnetic storms and the aurora; the issue was dedicated to Hannes Alfvèn in recognition of his 80th birthday. The third issue (1990) was primarily on plasma cosmology. The theme of the fourth issue (1992) was plasma experiments in the laboratory and in space.

Space weather, the theme of the present issue, concerns the daily varying space plasmas of the Sun, the Earth and their vicinity. We are living in the vicinity of a star, viz., the Sun. Recently, there has been so much progress made in Solar hot plasma eruptions, Earth geomagnetic storms and substorms, and solar-geomagnetic connections that the time is now ripe to put all related and global aspects together into a field of space weather.

Indeed, this field is rapidly becoming very popular. The increasing understanding of the effects of solar activity on the Earth's environment has given rise to NASA's "Living With a Star" program. A national space weather program is now in operation and is being sponsored by AFRL, NOAA, and NSF. The scientific excitement surrounding space weather is shown by the occurrence of many conferences on this topic: 1) AGU organized a Chapman Conference in Florida to focus on space weather and will publish the conference volume as an AGU book; 2) the IEEE TRANSACTIONS ON PLASMA SCIENCE has a special issue on space weather in December 2000; and 3) Japan is organizing the first S-RAMP International Conference this autumn to study space weather.

The Sun controls the Earth's space weather. As a result of plasma instabilities, the Sun's plasma surface erupts from time to time as solar flares and, occasionally, as solar coronal mass ejections (CME). These hot solar plasma clouds travel outward and may hit the Earth's magnetosphere. Interactions with the Earth's plasma environment compress the bow shock, disturb the magnetospheric magnetic fields, and energize the plasma in the magnetosphere. The ionosphere is often disturbed. In severe cases, the induced ionospheric currents and their magnetic field fluctuations may cause power grid surges on the surface of the Earth.

Magnetic storms and aurorae are natural manifestions of the magnetic disturbance and energetic plasma events. In case of severe storms, the magnetic and plasma disturbances pose hazards to the onboard electronics of spacecraft, interfere measurements and telemetry, and may affect spacecraft survivability. For example, the sudden failures of geosynchronous communication satellite ANIK-1, Telstar-401, and Motorola Galaxy-4 occurred after days of severe CME passage, resulting in the loss of communication service to millions of customers. Even power systems on the Earth's surface have been affected during severe magnetic disturbances.

In view of the expected rapid increase in the number of spacecraft to be deployed in the new millennium, the space plasma community, including NASA, has begun to realize the importance of space weather and spacecraft plasma interactions. At the time of this writing, we are approaching a solar-cycle maximum, space weather as a theme of this IEEE special issue is especially timely.

In the initial stage of planning for this issue, the guest editors were fortunate to benefit from the generous advice of Prof. Daniel Baker, Prof. Robert Carovillano, Prof. George Siscoe, and Prof. Paul Song. We express our deepest thanks to them. We are pleased that some of the most important authorites and authors in each area have written papers for this issue.

The papers encompass practically all important areas in space weather, viz., plasma eruptions in the Sun, their propagation towards the Earth, disturbances in the Earth's space plasma and neutral atmosphere, spacecraft–plasma interactions and magnetic disturbance on power grids on the Earth's surface.

We divide space weather effects into several areas. Moving out from the Sun, we consider (in sections arranged in this order) these areas: solar plasma eruptions, solar–geomagnetic interactions, magnetospheric–ionospheric effects, effects on spacecraft, and power-system disturbances at the Earth surface. We have also planned a section on risk management in space weather and have included the traditional section on cosmic plasma that has appeared in every previous special issue of space plasmas.

The Sun controls the Earth's daily space weather. In particular, severe solar CME clouds carry "killer electrons" (of MeV energies) which are hazardous to spacecraft. In recent years, scientists have discovered that a sigmoid-shaped signature often appears near the CME eruption area days before a CME erupts. This may offer an exciting breakthrough in forecasting CME and allow time for space weather warning and for spacecraft to prepare for mitigation. We are grateful to have a co-discoverer to write on the sigmoid signature. Two invited comprehensive reviews of solar coronal mass ejections and their propagation follow that paper.

In view of the lack of textbooks in space weather, we start some main sections with tutorials and reviews on various salient features. We hope that such tutorials, written by authorities in

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each field, would benefit beginners, scientists, and engineers, as well as researchers.

With modern computers, it is now feasible to attempt global simulations of magnetospheric plasmas and to develop forecasting models of space weather. This is a rapidly advancing area. The tools and techniques developed will ultimately benefit the scientists, engineers, and users.

Interactions of spacecraft with energetic space plasmas is an increasingly important area. Since on-board electronic components are getting smaller and run on lower currents, they are subject to interference and damage by smaller external currents. More and more spacecraft will be deployed in the new millennium. Up-to-date knowledge of space plasmas and their interactions with spacecraft surfaces and spacecraft electronics will be of great value to electrical and electronic space engineers. The section on risk management of space weather concludes our special-issue topics.

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Dr. Lai is a Fellow of the Institute of Physics, U.K., a life member of AGU, a member of APS, and a senior member of AIAA. He was the chair of the Nuclear and Plasma Chapter of the IEEE, Boston section, 1993–1997. He has served as a member of the AIAA Technical Committee on Space Science and Astronomy from 1989 to 1992, and the AIAA Committee on Atmospheric and Space Environments Standards since 1992. Since January, 1997, he has become the chair of the AIAA Committee on Atmospheric and Space Environments Standards.

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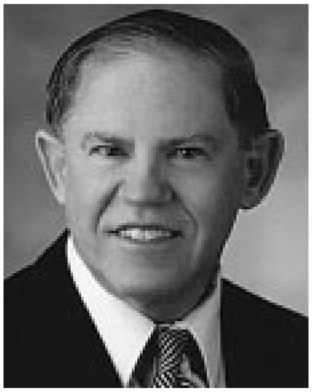
He is a Professor of Electrical and Computer Engineering at the University of Alabama, Huntsville. He has nearly 20 years of experience in numerical modeling and simulation of electromagnetic and plasma systems. He has richly contributed to the field of space plasma research through particle simulation of complex plasma processes such as antennas in plasmas, formation of electric double layers, waves and instabilities, large-scale plasma flow and charging of spacecrafts. His most recent works have been on development of a 3-D plasma codes for satellite–plasma interactions in NASA's tether project, and nonlinear evolution of waves in space plasmas; the codes employ the particle-in-cell method and massively parallel computing technique. He has developed a code for studying dynamical behavior of photorefractive materials used in nonlinear optics. He has also developed 1-D and 2-D particle-in-cell codes for liquid crystal devices. He is the author of about 140 refereed journal articles.



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