Magnetospheric Imagery and Atmospheric Remote Sensing—Part 1

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Remote sensing techniques have long been used to probe the upper atmosphere and ionosphere. These techniques, along with *in situ* measurements, have provided a remarkable understanding of the physical and chemical processes governing solar-terrestrial relationships. Recent developments in detectors, optical coatings, electronics, and other related technologies and their availability for scientific experimentation have made remote sensing of atmospheric regions commonplace.

One of the recent and most promising entries in the application of remote sensing is that of global magnetospheric imagery. A large number of localized measurements have given us a very good picture of the magnetosphere and its response to solar and magnetic disturbances. However, a global picture of the magnetosphere was not obtained until UV imagers aboard various satellites vividly demonstrated the extent of the aurora and its dynamics on a global scale even under fully sunlit conditions. At the same time, experiments conducted since the mid-1970s have demonstrated that magnetospheric structure and processes can be routinely and continuously probed through optical remote sensing techniques.

A serendipitous observation of energetic neutral atoms produced by charge exchange of ring current ions with geocoronal hydrogen atoms has produced a flurry of activity in the development of various sensors suitable for magnetospheric imagery applications by measuring these neutrals. Several instruments designed to observe these neutrals will be included in upcoming NASA missions.

NASA has recently selected a number of experiments for the TIMED mission that will remotely probe the upper atmosphere and ionosphere. In addition, a science working group under the auspices of the Space Science Division of NASA has been studying the viability of magnetospheric imaging from a moderate-class explorer mission. This strawman Inner Magnetospheric Imager mission includes both optical as well as particle instruments. It is hoped that this exciting mission will provide magnetospheric physicists their first coordinated global view of the magnetosphere that can be used to test our present understanding, which is based on a large number of individual localized observations.

At the SPIE annual meetings in San Diego in 1992 and 1993, a total of 74 papers described various aspects of remote sensing of the magnetosphere and planetary atmospheres. From these and other contributed papers a total of 42 papers have been selected, after appropriate reviews, for publication in *Optical Engineering*. Due to the large number of papers, this special section will appear in two issues. This first issue consists of 25 papers. The remaining 17 will appear in the February 1994 issue. The paper topics range from instrument design and mission concepts to experimental results from various instruments and techniques. It is expected that these two volumes will serve as a reference for workers in these fields for many years to come.

By far the largest group of papers (eight) included in this issue discusses new instruments for upcoming missions. Four papers describe sounding rocket instruments and four other papers discuss theoretical aspects of imaging the magnetosphere and observational strategies. Most of the papers on neutral particle imaging will be in the February 1994 issue; however, three of them are included in this issue to provide a glimpse of "coming attractions." Three solar instruments, two novel ground-based instruments, and one x-ray imager complete the list of topics.

Sandel, Broadfoot, and Stalio describe a shuttle-based Hitchhiker payload that will spectroscopically study UV emissions from Jupiter and other astronomical objects. This international mission uses a spectrograph developed in the United States and a pointing platform developed in Italy. Harris et al. detail a sounding rocket experiment conducted at high spectral resolution to study the H Lyman-α line profile on Jupiter and the interplanetary medium. Baumgardner, Flynn, and Mendillo describe another planetary instrument that was used to discover the largest object in the solar system—Jupiter's magneto nebula. Nakamura et al. outline an EUV instrument to be used in the Japanese PLANET-B mission to Mars to measure helium distribution. The UV spectrograph for the Cassini mission to Saturn and its moon Titan is described by McClintock et al. It represents the first imaging UV spectrograph sent to a planet. Bush, Cotton, and Chakrabarti present a sounding rocket experiment consisting of a 304-Å multilayer mirror and a spectrophotometer to observe selected dayglow emissions simultaneously.

A number of papers report on future experiments to study the terrestrial environment. Christensen et al. describe an EUV spectrograph, a near-IR spectrometer, and three filter photometers to be flown aboard a NOAA-J spacecraft later this year as a part of the RAIDS mission. The primary purpose of the

RAIDS mission is to characterize the thermosphere and ionosphere through a suite of optical measurements. (A companion paper by McCoy et al. on other RAIDS instruments will be included in the February 1994 issue.) Torr et al. describe a UV imager for the ISTP mission. This uses a three-mirror system with multilayer coated interference filters (described in the next paper by Zukic et al.) for color selection. Harris et al. describe a sounding rocket instrument complement and mission to characterize the quiet nighttime emissions in the Earth's nightglow and their excitation mechanisms.

In the first of the papers on neutral particle "emissions" from the magnetosphere, Voss et al. report on observations made from the CRRES satellite. This might be the first instrument that specifically included a channel to observe neutrals in an ion mass spectrometer. Funsten, McComas, and Barraclough discuss various techniques for low-energy neutral imaging and the strengths and weaknesses of each. Mitchell et al. describe a neutral particle imager currently being developed for flight aboard the Cassini mission.

Four papers on novel instrument and experiment concepts that are applicable for atmospheric remote sensing appear in this issue. Hackwell and Warren describe a spectrograph for the 2- to 5-μm spectral region that employs a magnesium oxide aplanatic prism and an InSb array detector. Cotton and Chakrabarti describe an experiment concept employing an all-reflection interferometer to obtain line shapes of solar and airglow emissions at 1304 Å from a sounding rocket flight. Sandel and Broadfoot include the details of a grazing incidence spectrograph to measure the solar spectrum from 200 to 3200 Å simultaneously on a single intensified CCD at a 4-Å spectral resolution. Mende and Fuselier report on a novel spectrograph employing a Hadamard slit having a field of view of 50×1 deg for pushbroom spectral imaging.

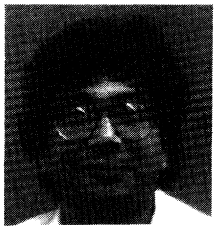
Measurement of the absolute solar UV flux poses a challenge that is addressed in two papers. Ogawa et al. used a transmission grating spectrometer in conjunction with silicon photodiodes in a spectrometer to be flown aboard a Hitchhiker and the SOHO mission. The paper by Vickers et al. concerns a sounding rocket experiment that analyzes photoelectron spectra produced by photoionization of noble gas by solar UV emissions. Both of these techniques hold promise for long-term observations of solar UV radiation without the usual degradation of instrument sensitivity that plagues conventional instruments. (Another paper related to this area by Daybell et al. will appear in the February 1994 issue.)

Several papers are devoted to the discussion of observational techniques and theoretical modeling. Bétrémieux et al. show the use of tomographic inversion techniques in 2-D spectral imaging that appear to have a significant throughput advantage over pushbroom techniques. Murphy and Chiu investigate in great detail the imaging of upflowing O^+ ions using resonance scattering of solar 834-Å emissions. Hesse et al. discuss charge-exchanged oxygen produced from upflowing O^+ ions that can be observed using low-energy neutral particle detectors. A computation of an isoplanatic patch and its application in adaptive optics is described by Yan, Zhou, and Yu.

Two instruments are described that can have potential application in magnetospheric imaging. A pinhole x-ray camera for imaging auroral emissions has been described by Parks, Werden, and McCarthy. The authors describe the performance of this instrument aboard four balloon flights. Cotton, Conant, and Chakrabarti describe a wide-field monochromatic 304-Å imager flown aboard a sounding rocket to image plasmaspheric He^+ ions from the inside out.

As can be seen, the topics discussed in this special section are diverse, from theoretical studies to novel instrument concepts. Contributors include undergraduate and graduate students as well as veterans of spaceflight instruments. A large number of techniques have been reported that may trigger new concepts for remote sensing of planetary atmospheres and magnetospheres.

I thank Dr. Brian Thompson and *Optical Engineering* for allowing me the privilege of these two special sections, which will make the papers included far more accessible than otherwise would be possible. I want to extend my personal thanks to the many contributors and reviewers and to the editorial staff headed by Lorretta Palagi who made this issue a reality.



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