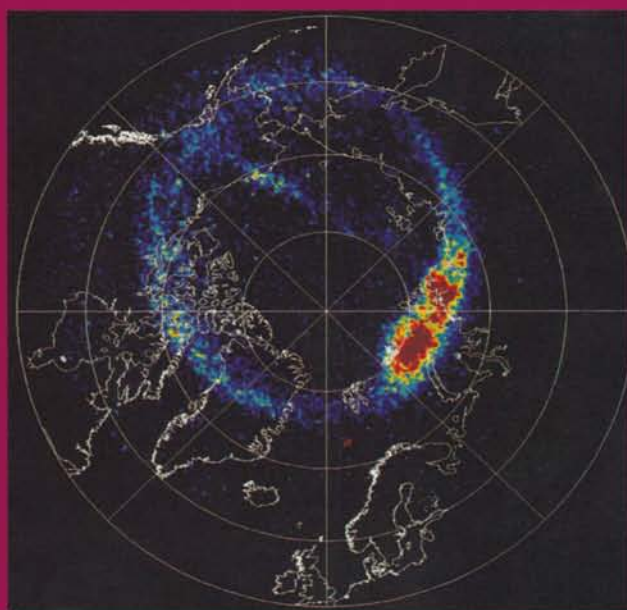


COSPAR COLLOQUIA SERIES Volume 9

**MAGNETOSPHERIC
RESEARCH WITH
ADVANCED TECHNIQUES**

Edited by R.L. Xu and A.T.Y. Lui



Pergamon

COSPAR COLLOQUIA SERIES

VOLUME 9

**MAGNETOSPHERIC RESEARCH
WITH ADVANCED TECHNIQUES**

PERGAMON

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MAGNETOSPHERIC RESEARCH WITH ADVANCED TECHNIQUES

*Proceedings of the 9th COSPAR Colloquium
held in Beijing, China,
15-19 April, 1996*

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Prof. R. L. Xu and A. T. Y. Lui, editors of the COSPAR Colloquia Series #9 on *Magnetospheric Research with Advanced Techniques*, in the COSPAR Colloquium on Magnetospheric Research with Advanced Techniques, 15-19 April, 1996, Beijing, China



Prof. G. Haerendel, President of COSPAR, giving opening address in the opening ceremony of the COSPAR Colloquium on Magnetospheric Research with Advanced Techniques

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PREFACE

The COSPAR Colloquium on Magnetosphere Research with Advanced Techniques was held in one of the biggest garden hotels in Asia, Beijing Friendship Hotel, on April 15-19, 1996. The Colloquium was sponsored by the Chinese National Committee for COSPAR, COSPAR, and the National Natural Science Foundation of China. The theme of the meeting focused on four areas of modern magnetospheric studies, namely: (1) multi-point observation, (2) innovative measurement techniques, (3) active experiments in space, and (4) numerical simulation and theoretical modeling. This meeting was held after the launch of several major magnetospheric satellites which set the stage for most intensive investigations ever of the Earth's plasma environment in the framework of the International Solar-Terrestrial Physics Program. These exciting new results and the ongoing discussions of innovative approaches to scientific instrumentation and spacecraft technology also provided the opportunity for the scientists, especially the Chinese Scientists to join the international space community and develop various international collaborative programs.

More than seventy scientists from all over the world participated, from countries of Austria, Belgium, Canada, China, Finland, Germany, Japan, Korea, Russia, Sweden and the United States. A total of 93 papers were presented to provide a broad spectrum of exciting new multi-platform observations from the International Solar-Terrestrial Physics Program, state-of-the-art instrumentation design, and simulation and modeling on supercomputers.

It was a busy time for meetings around April 1996 when this COSPAR Colloquium was held. Many colleagues who expressed an interest to attend this meeting felt unfortunate that they could not come due to conflicting commitments. Thanks to the hard work of the Scientific Organizers, Session Coordinators, and the Local Committee, the meeting preparation went smoothly without a hitch. We had received many letters and messages highly praising the organizational arrangement and scientific significance of this meeting. Fruition of this meeting includes plans of joint studies and protocols on some joint programs signed by both sides.

We organized the manuscripts submitted to this Monograph into: (1) Magnetospheric Observation and Measurement Techniques, (2) Active Experiments, and (3) Numerical Simulation and Theoretical Modeling. Papers presented in the meeting but not submitted to this Monograph are listed by title as unpublished papers at the end of this Monograph.

We would like to thank the Chairman and Co-Chairman of the Colloquium and the members of the Scientific Program Committee listed in the first page of this Monograph, the Chairman of the Local Organization Committee Houying Zhang and the committee members: Changchun Ai, Yidong Gu, Jicheng Kang, Kangwen Chen, Hai Lin, Quan Lin, Houren Pan, Faren Qi, Daheng Wang, and Yongren Zhao, the Executive Secretary: Fangyu Liao, Deputy Executive Secretary: Lei Li and Wei Li for an excellent job done in less than ideal circumstances. During the meeting the local Committee arranged a special program to visit the Great Wall and other historical sites around

Beijing, allowing the participants to gain an impression on the long historical tradition and recent progress of China. We are grateful to W.-H. Ip for his help during the beginning of this Colloquium, and to S. Grzedzielski for his encouragement during preparing this Colloquium Monograph.

We deeply appreciate the effort of D. N. Baker, P. A. Bernhardt, J. F. Carbary, C.-L. Chang, J. Chen, S. P. Christon, R. B. Decker, R. E. Erlandson, W. R. Hu, Y. Q. Hu, E. P. Keath, K. Liou, A. T. Y. Lui, Z. Y. Pu, G. Rostoker, J. Wanliss, D. G. Wei, R. H. Wei, P. H. Yoon, L. J. Zanetti, H. Zhao, G. C. Zhou and anonymous referees for their help in improving the quality of the manuscripts published in this Monograph. In particular, the Associate Editor of this Monograph Lei Li, deserves special mention for her major contribution in bringing together the materials for this Colloquium Monograph for publication by Elsevier Science in early 1998.

Ronglan XU

A. T. Y. LUI

OPENING ADDRESS OF THE COSPAR PRESIDENT TO THE COSPAR COLLOQUIUM ON MAGNETOSPHERIC RESEARCH WITH ADVANCED TECHNIQUES

Vice-President Yan, Chairman Xu, Ladies and Gentlemen,

This is the Ninth COSPAR Colloquium and the second one I am attending since I became president of COSPAR. I am most pleased to be here and to speak to you, in particular, since the subject of this conference is in my field of research and since I am here also in a second function, namely as Co-Chairman of this event together with Vice-President Professor Yan. In this second capacity, I would like to welcome you and wish you an interesting and stimulating scientific, social and also touristic event.

COSPAR was conceived at the beginning of the space era in order to promote space research and related applications with the emphasis on the exchange of results, information and opinions. By concentrating on data, methods and scientific insights COSPAR has always managed to keep clear of political interference, on the contrary, to build bridges across political barriers. Lately, after the fall of the iron curtain the bridging function of COSPAR in the area of space research may appear to have lost importance, but some barriers continue to exist and new challenges are emerging which need the platform offered by the Committee in order to bring together colleagues from East and West, from South and North, from poor and rich, from well-established and newly entering space-faring nations.

In this context, COSPAR is watching with particular attention the developments in Eastern and South-Eastern Asia. Japan and China have both been highly active and successful in space for several decades, have developed powerful launchers, associated infrastructure and space industry, and have established a still growing space research activity. But other nations are just entering, like Thailand, Indonesia and Korea. China took the initiative to call in 1992 in Beijing an Asia-Pacific Workshop on Multilateral Cooperation in Space Technology and Applications. A follow-up conference was held in Islamabad last year and a third one will be held in Seoul at the end of May. This conference is meant as a forum for concerned space agencies, other institutions and administration with the aim to establish closer cooperation and to learn from each other in science and applications. COSPAR applauds such efforts and tries to raise the awareness that science is one of the best technology drivers. Therefore, even when applications like telecommunications, weather services and Earth's observations are the immediate goals of a young space nation, it should allocate a sensible fraction of the resources to basic research, because besides the technology impact there is nothing better to motivate the young generation and future technology leaders of a nation than an early exposure to the great questions and goals of basic research. But of course, to be able to pursue one's career and expand one's knowledge in research, largely free of commercial and political interests, is a great privilege.

Let me now turn to this COSPAR Colloquium on Magnetospheric Research and Advanced Techniques with a few reflections. First on Magnetospheric Research. This field of research popped up with the very

first space vehicles. For almost four decades, it has produced an impressive list of discoveries of objects as well as of processes. It has profoundly affected our notion of the nature of the space between stars. At this point in time the field has entered its programmatic culmination with the Inter-Agency Solar-Terrestrial Physics Program, with the successful launches of Geotail, Wind, Interball Tail Probe, SOHO, Polar and with CLUSTER, Interball Auroral Probe, FAST and Equator-S to follow soon. It is natural that in this phase, when thinking about the future of our field, we feel some anxiety. What will be the challenges after reconnection, flux-transfer events, boundary layer formation, substorm onset, plasmoids, coronal mass ejections, auroral acceleration and kilometric radiation have been largely understood? Of course, this understanding will not be achieved immediately. But did we not promise, when proposing all these missions, that this was what we were after, and that these missions, once successfully executed, would bring us close to the desired goals? What will be our new questions, the new frontiers? When I say "our", I mean the younger ones among us, our students and successors. It is my belief that the more exciting tasks of the future will lead space plasma physics farther away from the Earth, to the planets, the outer heliosphere and above all to the Sun. We have already now an impressive program of ongoing missions in the solar system and very ambitious ones like Mars 96, Cassini and Rosetta in preparation. Solar Probe, Pluto Express, Mercury Orbiter, Intermarsnet, etc. are prospective candidates for the more distant future. All of them offer, at least in principle, opportunities for studying new aspects of plasmas and fields. But with the continuation of flight opportunities near Earth, also here new goals can be set and pursued, like the study of magnetic field-aligned processes as proposed in the IBIZA/IMPACT mission.

A field of research is as good as its tools. In magnetospheric research the development of the key instrumentation has gone through several, if not many iterations. The progressive advancement of techniques, experimental, computational and theoretical, is the subject of this conference and rightly so. In addition, I regard it as highly significant that it is held in Eastern Asia, in the region of new space markets.

With the expansion and increasing resolution of the accessible parameter spaces comes, almost necessarily, new knowledge and advancement of understanding. But in view of the growing distances from Earth of our future activities, the frequency of flight opportunities is bound to decrease, even with "faster, better and cheaper" approaches. So, we are all challenged to work economically, proceed in the direction of miniaturizing, of data compression, of low-cost developments of systems and subsystems. Small satellites, use of flight opportunities mainly designed for other purposes, complementary ground-based work, these are some ways to go. I am confident that space plasma physics will not have to complain about a lack of tasks. For a while, however, the emphasis will be on harvesting and not on seeding. Let us enjoy this phase and exploit it fully!

Finally, a word about COSPAR. Unified by the applications in, on and from space, COSPAR covers a wide variety of disciplines. Organized in seven Commissions, various Sub-Commissions, Panels and Task Groups, the authority for the definition of the scientific program lies entirely with the scientific community. The topics that need to be highlighted at the bi-annual Scientific Assemblies or the thematically more confined Colloquia and Workshops, they are chosen by the about 4000 Associates, who elect their Commission chairs and organize themselves in the business meetings during the Assemblies and by correspondence in between. The Council, COSPAR's highest authority, assisted by the Bureau and Executive have the task to establish the right balance between disciplines. They, of course, also provide the necessary infrastructure and raise and distribute financial support for conference

attendees. The latter is one of the greatest concerns of the COSPAR Bureau, since the spirit of donation is fading rapidly in the present climate of economic crises. Nevertheless, we try hard to mitigate the hardships introduced by recent economic-political developments.

I do not want to miss this chance to remind you all to our forthcoming Scientific Assembly in Birmingham (14 - 21 July) as well as of the preceding 10th COSPAR Colloquium on Asteroids, Comets and Meteorites at Versailles. The following Scientific Assembly, 1998, will be held in Japan, in Nagoya.

This is my first visit to Mainland China. Although brief, I look forward with great expectations to this first glimpse of a great country with great people and, of course, to an exciting conference for all of us.

G. Haerendel
President of COSPAR

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Session I

***Magnetospheric Observation
and
Measurement Techniques***

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INVESTIGATION OF A SUBSTORM FOLLOWING AN EXTENDED INTERVAL OF NORTHWARD INTERPLANETARY MAGNETIC FIELD

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ABSTRACT

Strong northward interplanetary magnetic field was observed for an extended period by the Wind spacecraft at an upstream distance of $\sim 200 R_E$ from February 8-10, 1995. Within this period was a brief break of southward IMF on February 9 which led to a substorm of moderate intensity (~ 500 nT) with its expansion onset at ~ 0431 UT. In this paper, this substorm is examined with data from eleven spacecraft in space and two networks of ground stations covering both the northern and southern hemispheres. Detailed analysis of this event shows (1) an unusually long duration of the magnetospheric reconfiguration prior to expansion onset for this isolated substorm (2) new evidence for multiple particle acceleration sites during substorm expansion, and (3) indications for sunward plasma flow in the plasma sheet during the late expansion phase of a substorm not related to a single acceleration site (e.g., an X-line) moving from the near-Earth tail to the more distant tail.

INTRODUCTION

One of the main objectives of the ISTP (International Solar Terrestrial Physics) program is to investigate the flow of energy, momentum, and mass from the Sun through the magnetosphere to the ionosphere and the atmosphere. Achieving this objective in the ISTP era has the distinct advantage over previous attempts because of the unprecedented multi-point measurements available and planned for ISTP activities. In this paper, we address this ISTP task by studying an isolated substorm with eleven spacecraft (Wind, IMP-8, Geotail, six geosynchronous satellites, one DMSP satellite, and Freja) and two networks of ground stations (Canopus and SuperDARN) from the ISTP data base.

Studying an isolated substorm is particularly appropriate to address this ISTP task because a large amount of energy, momentum, and mass from the solar wind pass through the magnetosphere during a substorm episode. Furthermore, studying an isolated substorm instead of a substorm embedded within a sequence of substorm disturbances allows one to eliminate the possible interference from preceding substorm activity. Consequently, a clearer identification of features genuinely associated with the different phases of a substorm can be made without the ambiguity introduced by the remnants of previous activities. Before the onset of this substorm under study, a magnetic cloud passed over the Earth, engulfing the Earth's magnetosphere with a prolonged period of steady northward interplanetary magnetic field (IMF). This sets up an ideal situation for our study since the magnetosphere was then