



PREFACE

The scientific symposium “Coordinated Measurements of Magnetospheric Processes” was held at the 32nd Plenary Meeting of COSPAR in Nagoya, Japan from July 12-13, 1998. One of the main objectives of this symposium was to gather the rich harvest of unprecedented insight into the workings of the Earth’s magnetosphere that has been garnered with the armada of ISTP and associated spacecraft. The success of this program has derived from the simultaneous availability of observations from multiple spacecraft. These missions include GEOTAIL, the Interball Tail Probe and Magion 4 subsatellite, the Interball Auroral Probe and Magion 5 subsatellite, the POLAR, WIND, ACE, IMP-8 missions and finally the most recent and unfortunately short-lived mission, Equator-S. Complementing the space-based segment of the ISTP program is a strong groundbased array of instrumentation including radars, photometers, magnetometers and other remote sensing devices together with an extensive modeling and theory segment. The symposium concentrated on the various aspects of the solar wind magnetosphere interaction leaving most aspects of magnetosphere-ionosphere coupling to a sister symposium.

The symposium consisted of both invited and contributed papers with about equal numbers of each. The scientific program was organized with the assistance of co-convenor, L. Zelenyi, and the advice of a program committee consisting of C. R. Clauer, B. J. Fraser, R. A. Hoffman, H. Kawano, N. Maynard, H. Opgenoorth, A. Rodger, G. Rostoker, I. Sandahl, S. Savin, T. Terasawa, M. Thomsen and the two co-convenors. The Nagoya assembly was very well organized in an excellent conference facility and the three-day symposium ran extremely smoothly despite the large number of papers that were submitted. There were 79 presentations of which 30 were posters and the rest oral. The sessions were well attended and very interactive. The sessions were well attended and very interactive. Of the 79 presentations 54 papers were submitted and 51 of these appear in this volume. These papers represent a good cross section of the research that is taking place in the magnetosphere today.

This volume is divided into seven chapters. The first chapter deals with missions and projects, the experimental programs that are the lifeblood of the ISTP effort. The first paper is by COSPAR president, G. Haerendel, on the Equator-S mission that provided essential measurements in the equatorial magnetosphere but lived far too short an existence. Almost miraculously, immediately after the demise of Equator-S, the Magion 5 subsatellite, the companion to the Interball Auroral Probe, came back to life after two years of silence having been lost just after launch. A summary of the Interball Auroral Probe results are given by Yu. Galperin. The next paper by C. P. Escoubet and R. Schmidt reviews the status of the Cluster program. The original four spacecraft were destroyed by the failure of the launch of the first Ariane 5. New spacecraft are now being built and will be launched most probably in 2001. The exploration of the magnetosphere is not the private reserve of the larger space faring nations but many smaller countries are now building and launching (with partners) spacecraft of their own. This chapter has papers on two of these missions. N. Trivedi covers the SACI-1, a Brazilian microsatellite to be launched in 1999 on a Chinese rocket into low Earth polar orbit, and Brian Fraser covers FedSat, an Australian microsatellite to be launched in 2000 on a Japanese launcher. Next, V. Korepanov discusses the project Variant for measuring field aligned currents.

While magnetospheric research benefits greatly from in situ observations, it requires contextual global groundbased observations as well. Magnetometer arrays are essential in this regard and this section covers two of these in China. Y. F. Gao discusses the Sino Magnetic Array at Low Latitudes (SMALL) and K. Schwingenschuh discusses the China Magnetometer (CHIMAG) project. Finally, T. J. Rosenberg reviews the correlative ionospheric-magnetospheric observations of the antarctic program.

The second chapter covers the global aspects of the interaction of the solar wind with the magnetosphere. In many respects this is the prime objective of the ISTP program, the one for which the ISTP constellation of spacecraft are ideally suited. The first paper, by C. T. Russell and colleagues, reveals the extreme distortion of the magnetosphere that occurred on May 4, 1998 due to a combination of high dynamic pressure and strong southward interplanetary magnetic field (IMF). This paper also serves as an introduction to the events of the day that will be the focus of future more detailed studies. One of the strengths of the ISTP program is the availability of imaging of the entire northern polar cap from the POLAR spacecraft. This enables the investigation of large-scale processes, such as the response of the aurora to solar wind pressure increases, as discussed in the second paper of this chapter by M. Brittnacher and colleagues. Next S. G. Kanekal et al. discuss how the magnetospheric radiation belts are affected by a series of interplanetary events, followed by a paper by N. C. Maynard and W. J. Burke on the penetration of the solar wind driven electric field into the inner magnetosphere. This chapter closes with three papers on the response of the magnetosphere to solar wind events. T. Takeuchi et al. discuss the response to the solar wind on May 13, 1995; M. Wuest et al. discuss the response to the interplanetary shock wave of January 10, 1997; and H. Kawano et al. discuss events observed by Interball 1 and Geotail.

A particular focus of the Interball 1, Polar and soon-to-be-launched Cluster spacecraft is the polar cusp. This region is very important because particles from the magnetosheath gain access to magnetospheric field lines here and they gain access to the ionosphere along these field lines. Since the magnetosheath and magnetospheric plasmas are magnetized, collisionless and topologically distinct, there are few mechanisms that allow these particles to leave one region and enter the other. The weakness of the magnetic field in the neighborhood of the cusp-magnetosheath interface facilitates these mechanisms but a weak field strength alone is not sufficient for the amount of entry observed. Candidate mechanisms are reconnection and turbulence. In Chapter 3 C. T. Russell reviews the polar cusp including recent observations and MHD modeling efforts. J. Merka and colleagues present Interball 1 measurements in the vicinity of the cusp while A. Fedorov and colleagues examine the particle and field structure in the region just external to the cusp. Finally, T. A. Fritz et al., discuss exciting but controversial results on the acceleration and trapping of energetic particles in the near cusp region.

In many senses the magnetopause is the extension of the polar cusp across the entire interface between the solar wind and the magnetosphere. Three general classes of studies are important for this region of the magnetosphere: studies of the magnetosheath that reveal how the properties of the plasma and fields evolve as they approach the magnetopause; studies of the structure of the boundary itself that reveal how the magnetospheric and magnetosheath plasmas interact; and studies of the size and shape of the magnetosphere that show the relative magnetic flux content of the dayside and nightside magnetospheres, the size of the energetic particle trapping region and the location of various plasma and field environments relative to our

communications and monitoring spacecraft. In Chapter 4 A. Rodger discusses how to monitor some of these boundaries from the ground. J.-H. Shue and colleagues compare models of the dependence of the size of the magnetosphere on solar wind dynamic pressure and the interplanetary magnetic field. H. Hasegawa et al. study this control for the distant tail. V. Kalgaev and Yu. Lyutov also examine the control of the magnetopause by the solar wind. Next S. Kokubun et al. look at surface waves on the dawn magnetopause and relate them to Pc5 pulsations seen in ground records, and J. Safrankova et al. discuss the flank magnetopause as seen by Interball 1. Z. Nemecek and colleagues follow with a discussion of the magnetosheath as seen by the same spacecraft. Finally, K. Kudela et al. examine Interball observations of energetic particle fluxes seen outside the magnetopause and N. V. Erkaev et al. present an MHD model of the magnetosheath parameters near the subsolar line.

Waves in the magnetospheric plasma are important for three reasons: they scatter charged particles along and across magnetic field lines; they transport energy along and across field lines; and they are diagnostic of processes occurring within and conditions within the plasma. One of the poorly understood areas of wave propagation in the magnetosphere is how sudden compressions of the magnetosphere propagate through the system. In the first paper in Chapter 5 D.-H. Lee reviews his work on this topic for linear waves. C. L. Waters then reviews the standing wave resonances on magnetospheric field lines and D. A. Neudegg treats propagation of ULF waves in the high latitude ionospheric wave guide. Lastly, E. E. Antonova examines turbulence in magnetospheric currents and D. McCaffrey et al. discuss a method for identifying three-wave coupling in a plasma.

The magnetotail is more than just a wind sock responding to the variable gusts of the solar wind but rather is where the energy is stored that is extracted from the solar wind flow and it is the region in which that energy is released from storage and deposited in the auroral ionosphere and atmosphere. Because it is a region of acceleration of plasma, it is important to understand what plasmas are present in the tail to be accelerated. The first three papers of Chapter 6 concern themselves with this issue. K. Seki et al. discuss the origin and dynamics of the multiple ion flows in the tail; M. Hirahara et al. examine this outflow as seen by Akebono and Geotail; and B. Wilken et al. present an overview of energetic oxygen events in the tail. M. Fujimoto then discusses the cold dense plasma sheet and its relation to the low latitude boundary layer; H.E.J. Koskinen et al. discuss plasma entry into the magnetosphere; and O. Santolik et al. discuss electron fluxes in the tail.

When the energy builds up in the tail and is released in response to a time variation of the interplanetary magnetic field, the magnetosphere responds in a repeatable sequence of events called a substorm. Auroras move equatorward, then brighten, expand poleward and recover as the magnetic configuration of the tail evolves. At other times, the magnetosphere experiences a strong coupling to the solar wind for a long period and energy builds up, not just in the tail, but also in the ring current. Periods of such ring current development are called magnetic storms. Substorms can occur during storms but, unlike the ideas of the originators of the term substorm, storms are not simply large substorms but rather the result of a different set of solar wind conditions than substorms. However, this realization is not yet universal in the community. Another area of controversy concerns how the energy is released from the tail into the magnetosphere. It has been known for decades that substorms strongly affect the nightside magnetosphere as deeply as $7 R_E$. Moreover, it is the equatorward edge of the aurora that

brightens and not the poleward edge. Thus there must be important processes occurring deep in the magnetosphere associated with substorms. Since reconnection is thought to occur deeper in the tail than this, perhaps from 15-20 R_E downtail, it has been thought by some that reconnection of the tail lobes could not be the main agent for energy release in the tail. While there has been much movement in the area of minimizing the differences between these two schools of thought, much controversy remains. In the last chapter of the volume we examine these two very important topics. First R. Nakamura and S. Kokubun review the tail configuration during storms. Next, A.T.Y. Lui et al. propose a means to enhance the energy of a particular storm and M. Schulz and colleagues examine the x-ray emissions during a storm. T. Nagai reviews how substorms develop in the tail and W. Baumjohan et al. review substorm signatures in this same region. R. Lopez presents the case for the current sheet disruption model. T. Mukai et al. examine Geotail observations of reconnection in the tail and M. Hoshino reviews small-scale plasmoids in the tail. In the final three papers, H. Kawano et al. examine substorm effects on the mid tail region; Yu. Yermolaev and colleagues examine multipoint observations of substorms and S. Taguchi et al. examine traveling compression regions and their relationship to substorm onsets as registered of geosynchronous orbit.

In closing, I would like to thank the referees who worked so hard in reviewing these papers and whose efforts enabled the timely production of this volume. In a change from prior COSPAR policy we decided to not try to review papers during the symposium but to wait until referees were home with their reference materials and could do a more thorough job. We believe that as a result the papers in this volume have been significantly strengthened in the review process, but at the expense of some delay in the date of appearance. The referees who agreed to be identified were as follows:

B. Anderson, V. Angelopoulos, W. Baumjohan, G. Blanchard, C. W. Carlson, P. Chi, S. Cowley, N. Crooker, T. Dudok de Witt, M. Engebretson, C. J. Farrugia, B. Fejer, J. Fennell, F. Fenrich, B. Fraser, S. Fuselier, W. Goedecke, R.A. Greenwald, P. Greifinger, J.L. Horwitz, D. Huddleston, H. Karimabadi, L. Kepko, K. Khurana, G. Le, R. Lepping, M. Lester, X. Li, Y. Lin, R. Lopez, W. Lotko, R. McPherron, S. Mende, M. Moldwin, T. Mulligan, P. O'Brien, S. Ohtani, T. Onsager, S. Petriner, T. Phan, P. Pritchett, T. Pulkkinen, J. Raeder, G. Reeves, R. Richard, A. Rodger, T.J. Rosenberg, T. Sanderson, S. Savin, M. Scholer, R. Selesnick, K. Shiokawa, D. Sibeck, H. Singer, J.A. Slavin, B. Sonnerup, H. Spence, K. Takahashi, M. Thomsen, N. Trivedi, D. Weimer, R. Wolf, M. Yamauchi, D. Young and X. Zhou

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