

SPACE SCIENCES SERIES OF ISSI

# Outer Magnetospheric Boundaries: Cluster Results

G. Paschmann, S.J. Schwartz,  
C.P. Escoubet and S. Haaland (Eds.)



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# Outer Magnetospheric Boundaries Cluster Results Space Sciences Series Of Issi

**J Dewey**



## **Outer Magnetospheric Boundaries Cluster Results Space Sciences Series Of Issi:**

**Outer Magnetospheric Boundaries: Cluster Results** Goetz Paschmann, Steven Schwartz, C.P. Escoubet, S. Haaland, 2006-06-28 8 8 Boundary Layer Structure and Detached Plasma 305 8 8 1 Background 305 8 8 2 Structure inside the boundary layer 306 8 8 3 Observation of detached plasma 308 8 8 4 Summary 309 8 9 Summary and Conclusions 310 References 312 9 CLUSTER AT THE MAGNETOSPHERIC CUSPS 321 9 1 Introduction 321 9 1 1 Previous work 323 9 1 2 How Cluster investigates the cusp 325 9 2 The High Altitude Cusp 326 9 2 1 March 17 2001 328 9 2 2 February 4 2001 332 9 2 3 February 13 2001 337 9 2 4 Statistical survey 340 9 2 5 Waves and turbulence 343 9 3 The Mid Altitude Cusp 352 9 3 1 Structure Case study 352 9 3 2 Structure Statistical survey 354 9 3 3 Ionospheric ions 354 9 3 4 Mid altitude signatures of the LLBL 357 9 4 Discussion 359 References 360 10 MAGNETOPAUSE PROCESSES 367 10 1 Magnetopause Reconnection 368 10 1 1 Intermittent vs quasi steady reconnection 368 10 1 2 Component vs anti parallel reconnection 382 10 1 3 Tailward of the cusp reconnection 385 10 1 4 Quantitative tests of reconnection occurrence 388 10 1 5 Summary 391 10 2 Kelvin Helmholtz Instability at the Flank Magnetopause 391 10 3 Microphysics of Magnetopause Processes 396 10 3 1 Collisionless generalised Ohm's law 397 10 3 2 Ion di usion region observations 398 10 3 3 High frequency waves 402 10 3 4 Lower hybrid waves 405 10 3

**Outer Magnetospheric Boundaries: Cluster Results** Goetz Paschmann, C.P. Escoubet, S. J. Schwartz, S. Haaland, 2005-12-07 When the stream of plasma emitted from the Sun the solar wind encounters Earth's magnetic field it slows down and flows around it leaving behind a cavity the magnetosphere The magnetopause is the surface that separates the solar wind on the outside from the Earth's magnetic field on the inside Because the solar wind moves at supersonic speed a bow shock must form ahead of the magnetopause that acts to slow the solar wind to subsonic speeds Magnetopause bow shock and their environs are rich in exciting processes in collisionless plasmas such as shock formation magnetic reconnection particle acceleration and wave particle interactions They are interesting in their own right as part of Earth's environment but also because they are prototypes of similar structures and phenomena that are ubiquitous in the universe having the unique advantage that they are accessible to in situ measurements The boundaries of the magnetosphere have been the target of direct in situ measurements since the beginning of the space age But because they are constantly moving changing their orientation and undergoing evolution the interpretation of single spacecraft measurements has been plagued by the fundamental inability of a single observer to unambiguously distinguish spatial from temporal changes The boundaries are thus a prime target for the study by a closely spaced fleet of spacecraft Thus the Cluster mission with its four spacecraft in a three dimensional configuration at variable separation distances represents a giant step forward The present 20th volume of the ISSI Space Science Series represents the first synthesis of the exciting new results obtained in the first few years of the Cluster mission

*The Earth's Plasmasphere* Fabien Darrouzet, Johan de Keyser, Viviane Pierrard, 2009-08-21 James L Burch C Philippe Escoubet Originally published in the journal Space Science Reviews Volume 145 Nos 1 2 1 2 DOI

10 1007 s11214 009 9532 7 Springer Science Business Media B V 2009 The IMAGE and CLUSTER spacecraft have revolutionized our understanding of the inner magnetosphere and in particular the plasmasphere Before launch the plasmasphere was not a prime objective of the CLUSTER mission In fact CLUSTER might not have ever observed this region because a few years before the CLUSTER launch at the beginning of the 1990s it was proposed to raise the perigee of the orbit to 8 Earth radii to make multipoint measurements in the current disruption region in the tail Because of ground segment constraints this proposal did not materialize In view of the great depth and breadth of plasmaspheric research and numerous papers published on the plasmasphere since the CLUSTER launch this choice certainly was a judicious one The fact that the plasmasphere was one of the prime targets in the inner magnetosphere for IMAGE provided a unique opportunity to make great strides using the new and complementary measurements of the two missions IMAGE with sensitive EUV cameras could for the first time make global images of the plasmasphere and show its great variability during storm time CLUSTER with four spacecraft could analyze in situ spatial and temporal structures at the plasma pause that are particularly important in such a dynamic system

*Planetary Atmospheric Electricity* François Leblanc, Karen Aplin, Yoav Yair, Giles Harrison, Jean Pierre Lebreton, M. Blanc, 2008-12-04 This book is a comprehensive discussion of all issues related to atmospheric electricity in our solar system It details atmospheric electricity on Earth and other planets and discusses the development of instruments used for observation

*Dayside Magnetosphere Interactions* Qiugang Zong, Philippe Escoubet, David Sibeck, Guan Le, Hui Zhang, 2020-04-07 Exploring the processes and phenomena of Earth's dayside magnetosphere Energy and momentum transfer initially taking place at the dayside magnetopause is responsible for a variety of phenomenon that we can measure on the ground Data obtained from observations of Earth's dayside magnetosphere increases our knowledge of the processes by which solar wind mass momentum and energy enter the magnetosphere Dayside Magnetosphere Interactions outlines the physics and processes of dayside magnetospheric phenomena the role of solar wind in generating ultra low frequency waves and solar wind magnetosphere ionosphere coupling Volume highlights include Phenomena across different temporal and spatial scales Discussions on dayside aurora plume dynamics and related dayside reconnection Results from spacecraft observations ground based observations and simulations Discoveries from the Magnetospheric Multiscale Mission and Van Allen Probes era Exploration of foreshock bow shock magnetosheath magnetopause and cusps Examination of similar processes occurring around other planets The American Geophysical Union promotes discovery in Earth and space science for the benefit of humanity Its publications disseminate scientific knowledge and provide resources for researchers students and professionals Find out more about this book from this Q A with the editors

[Dawn-Dusk Asymmetries in Planetary Plasma Environments](#) Stein Haaland, Andrei Runov, Colin Forsyth, 2017-10-30 Dawn Dusk Asymmetries in Planetary Plasma Environments Dawn dusk asymmetries are ubiquitous features of the plasma environment of many of the planets in our solar system They occur when a particular process or feature is more pronounced at one side of a planet than the other For

example recent observations indicate that Earth's magnetopause is thicker at dawn than at dusk. Likewise auroral breakups at Earth are more likely to occur in the pre-midnight than post-midnight sectors. Increasing availability of remotely sensed and in situ measurements of planetary ionospheres, magnetospheres and their interfaces to the solar wind have revealed significant and persistent dawn-dusk asymmetries. As yet there is no consensus regarding the source of many of these asymmetries nor the physical mechanisms by which they are produced and maintained. Volume highlights include:

- A comprehensive and updated overview of current knowledge about dawn-dusk asymmetries in the plasma environments of planets in our solar system and the mechanisms behind them.
- Valuable contributions from internationally recognized experts covering both observations, simulations and theories discussing all important aspects of dawn-dusk asymmetries.
- Space weather effects are caused by processes in space, mainly the magnetotail, and can be highly localized on ground. Knowing where the source is, i.e. where dawn-dusk location is, will allow for a better prediction of where the effects on ground will be most pronounced.
- Covering both observational and theoretical aspects of dawn-dusk asymmetries.

*Dawn-Dusk Asymmetries in Planetary Plasma Environments* will be a valuable resource for academic researchers in space physics, planetary science, astrophysics, physics, geophysics and earth science.

**Annales Geophysicae**, 2008 *Solar Variability and Planetary Climates* Y. Calisei, R.-M. Bonnet, L. Gray, J. Langen, M. Lockwood, 2007-10-11

2. With a global average irradiance of  $342 \text{ W m}^{-2}$  the Sun is by far the largest source of energy for planet Earth. In comparison the internal energy produced by Earth itself is only about  $0.087 \text{ W m}^{-2}$  (Pollack et al 1993) which in turn is 3.5 times larger than the  $0.025 \text{ W m}^{-2}$  of heat produced by the burning of fossil fuels. About 31% (31 units) of the solar energy which arrives at the top of the atmosphere is reflected back to space by scattering from clouds, aerosols and the Earth's surface. Almost 20 units of solar radiation are absorbed in the atmosphere. The remaining 49 units are absorbed at the surface. Evaporation of water at the Earth's surface consumes 23 units and 7 units are transferred to the atmosphere by heat conduction. On balance 19 units are lost from the Earth's surface as infrared radiation, however consisting of 14 going upward and 95 returning from the atmosphere to the Earth's surface (see also Rosenfeld 2006). There is thus a sixfold recycling of energy. This is the greenhouse effect established by the presence of water vapor and other greenhouse gases ( $\text{CO}_2$ ,  $\text{CH}_4$ ,  $\text{N}_2\text{O}$  and CFCs) in the atmosphere. Due to human activities the latter have been increasing in the atmosphere, causing climate warming through an energy imbalance of  $2.53 \text{ W m}^{-2}$  more than 100 times larger than the heat released into the atmosphere by the burning of fossil fuels.

Multiscale Magnetospheric Processes Gurbax S. Lakhina, 2008

**ATMOSPHERE : AN INTRODUCTION** Dr. Santosh Kumar, Dr. Richa Chaturvedi, 2023-02-12

Recent Atmosphere is the result of long-term geological process, chemical and photochemical process of atmospheric elements and biogeochemical process of the biosphere. In geography, these all atmospheric processes are studied in the Climatology, which is a branch of geography and climatology and its all process depends upon atmospheric elements, its physical, chemical, biological, photometric, thermal, electric, magnetic and electromagnetic properties and their

process These all properties of the atmospheric gases and particles not only determine the climatic process but also the composition and structure of the atmosphere The Atmosphere An Introduction not only deals composition structure and atmospheric process but also try to elaborate all kith and keens of its gases type and their stratification in details It tries to analyse the role of different layers of the gases and their importance to protect biosphere and its ecosystem The book attempts to provide all information on recent basis data and research works That is why this book is more efficient and useful for all university students research scholars and teachers In this book both author have try to explain atmospheric facts with scientific view When students try to find scientific data and facts in reference to explain atmospheric process and fact in this global warming age they don t find appropriate reference This book provides solution with scientific view The book Atmosphere An Introduction emphasis atmospheric composition structure and process in three unites 1 Unit first deals about composition of atmosphere in ree rence to their different gasses and their climatological effect on earth biosphere 2 Unit second explain about the structure of defferent gaseous layaers and their function with their characteristics 3 Unit third explore gaseous circulation and its climatic effect on earth s weather

**From the Outer Heliosphere to the Local Bubble** J.L. Linsky,V.V. Izmodenov,E. Mobius,Rudolf von Steiger,2009-04-29 Knowledge about the outer heliosphere and the interstellar medium which were long treated as two separate fields has improved dramatically over the past 25 years as a consequence of recent developments The discovery of interstellar pickup ions and neutral helium inside the heliosphere the determination of the interstellar hydrogen distribution in the heliosphere obtained using backscattered solar Lyman alpha radiation the prediction and subsequent detection of the hydrogen wall just outside of the heliopause the development of detailed global models for the interaction of solar wind plasma with the interstellar medium and most recently direct in situ plasma and field measurements inside of the heliosheath At the same time our understanding of the nearby galactic environment including the composition and dynamics of the warm gas clouds and hot gas in the local bubble has benefited greatly from absorption line spectroscopy using nearby stars as background sources and dynamic modeling The present volume provides a synopsis of these developments organised into seven sections Dominant physical processes in the termination shock and heliosheath three dimensional shape and structure of the dynamic heliosphere relation of the plasmas and dust inside and outside of the heliosphere origin and properties of the very local interstellar medium energy and pressure equilibria in the local bubble physical processes in the multiphase interstellar medium inside of the local bubble and the roles that magnetic fields play in the outer heliosphere and the local bubble The last theme is probably the most basic of all as magnetic fields play important roles in most of the phenomena discussed here The volume concludes with four papers providing the big picture by looking at the time evolution of both the heliosphere and the local bubble looking beyond the local bubble and finally addressing the challenges in modeling the interface between the two media

**The Origin and Dynamics of Solar Magnetism** M.J. Thompson,A. Balogh,J.L. Culhane,Å. Nordlund,S.K. Solanki,J.-P. Zahn,2009-05-01

Starting in 1995 numerical modeling of the Earth's dynamo has flourished with remarkable success. Direct numerical simulation of convection driven MHD flow in a rotating spherical shell shows magnetic fields that resemble the geomagnetic field in many respects: they are dominated by the axial dipole of approximately the right strength; they show spatial power spectra similar to that of Earth; and the magnetic field morphology and the temporal variation of the field resembles that of the geomagnetic field (Christensen and Wicht 2007). Some models show stochastic dipole reversals whose details agree with what has been inferred from paleomagnetic data (Glatzmaier and Roberts 1995; Kutzner and Christensen 2002; Wicht 2005). While these models represent direct numerical simulations of the fundamental MHD equations without parameterized induction effects, they do not match actual planetary conditions in a number of respects. Specifically, they rotate too slowly, are much less turbulent, and use a viscosity and thermal diffusivity that is far too large in comparison to magnetic diffusivity. Because of these discrepancies, the success of geodynamo models may seem surprising. In order to better understand the extent to which the models are applicable to planetary dynamos, scaling laws that relate basic properties of the dynamo to the fundamental control parameters play an important role. In recent years, first attempts have been made to derive such scaling laws from a set of numerical simulations that span the accessible parameter space (Christensen and Tilgner 2004; Christensen and Aubert 2006).

**Geology and Habitability of Terrestrial Planets** Kathryn E. Fishbaugh, Phillipe Lognonné, François Raulin, David J. Des Marais, Oleg Korabely, 2007-09-07 Given the fundamental importance of and universal interest in whether extraterrestrial life has developed or could eventually develop in our solar system and beyond, it is vital that an examination of planetary habitability go beyond simple assumptions such as "Where there is water, there is life." This book has resulted from a workshop at the International Space Science Institute (ISSI) in Bern, Switzerland, which brought together planetary geologists, geophysicists, atmospheric scientists, and biologists to discuss the multi-faceted problem of how the habitability of a planet co-evolves with the geology of the surface and interior, the atmosphere, and the magnetosphere. Each of the six chapters has been written by authors with a range of expertise so that each chapter is itself multi-disciplinary, comprehensive, and accessible to scientists in all disciplines. These chapters delve into what life needs to exist and ultimately to thrive: the early environments of the young terrestrial planets; the role of volatiles in habitability; currently habitable but possibly not inhabited geologic environments; the connection between a planet's inner workings and the habitability of its surface; and the effects on planetary atmospheres of solar evolution and the presence or absence of a magnetosphere. This book serves as an ideal reference for those planning missions that will hunt for biomarkers, especially on Mars, for biologists and geoscientists seeking the other side of the story, and for researchers and upper-level students interested in an in-depth review of the geologic evolution of terrestrial planets from their cores to their magnetospheres and how that evolution shapes the habitability of the planetary surface.

*Origin and Early Evolution of Comet Nuclei* Hans Balsiger, Kathrin Altwegg, Walter Huebner, T. Owen, Rita Schulz, 2008-09-27 Comet nuclei are the most primitive bodies in the solar system.

They have been created far away from the early Sun and it is supposed that their material has been altered the least since their formation. The workshop was bringing together representatives of several scientific communities in the fields of interstellar clouds, star-forming regions, the solar nebula, and comets. The intent was to formulate the current understanding and interconnectivity of the various source regions of comet nuclei and their associated compositions and orbital characteristics. The goal was to better understand the survival of cometary materials: grains, molecules, free radicals, and atoms from extrasolar sources; circumstellar shells and molecular clouds; their modifications in the solar nebula and the effects of their properties on the formation and early physical and thermal evolution of the macroscopic bodies: the comet nuclei in the various subnebulae. Closely associated is their transport into the outer solar system: the Kuiper belt and Oort cloud. The distinction between direct measurements in situ or by remote sensing of cometary material properties and properties derived from indirect means deduced from laboratory studies and theoretical deductions was emphasized with the aim to guide future investigations. The book is intended to serve as a guide for researchers and graduate students working in the field of planetology and solar system exploration. It should also help to influence the planning of scientific strategies for the encounter of the Rosetta spacecraft with Comet Churyumov Gerasimenko.

**Particle Acceleration, Space Plasma Physics, Solar Radiation and the Earth's Atmosphere and Climate**, 2006

**Multispacecraft Measurements For Space Physics** Joseph E. Borovsky, David Gary Sibeck, David Knudsen, Xochitl Blanco-Cano, Katariina Nykyri, 2025-03-19. Multi spacecraft scientific missions for space physics have been flown since the 1960s with early missions such as IMP, VELA, Helios, and ISEE. Much of the success in understanding the Earth's magnetosphere and ionosphere and the physics and evolution of the solar wind has come from multi spacecraft measurements. Multi spacecraft measurements have been essential for studying the transport of plasma and energy, the motion of boundaries, the evolution of structure, the growth of instabilities, particle injections, and the rudiments of cross-scale coupling, and they have allowed accurate determinations of the orientation of plasma boundaries and current sheets, the geometry of magnetic field structures, the remote connections along magnetic field lines, and the direction of plasma wave vectors. Multispacecraft missions continue into the present, including planned constellation-type missions plus the use of the Heliophysics Great Observatory, a collection of data from diverse spacecraft throughout the heliosphere. Modern four spacecraft volumetric measurements are enabling the measurement of the gradients, divergences, and curls of the vector fields.

**Strategies of Life Detection** Oliver Botta, Jeffrey Bada, Javier Gómez Elvira, Emmanuelle Javaux, Franck Selsis, Robert Summons, 2008-07-18. This book collects papers presented at a workshop taking an interdisciplinary look at methods designed to detect life on other planets. It serves as a reference to scientists and instrument developers working in the field of in situ and remote life detection.

**Mercury** A. Balogh, Leonid Ksanfomality, Rudolf von Steiger, 2008-02-23. This fascinating book reviews the progress made in Mercury studies since the flybys by Mariner 10 in 1974-75. Thus far it is the only book on

Mercury which balances a wide range of Earth based observations made under difficult conditions with the only available space based data The text is based on continued research using the Mariner 10 archive on observations from Earth and on increasingly realistic models of this mysterious planet s interior evolution      *The British National Bibliography* Arthur James Wells,2006      **Subject Guide to Books in Print** ,1991

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