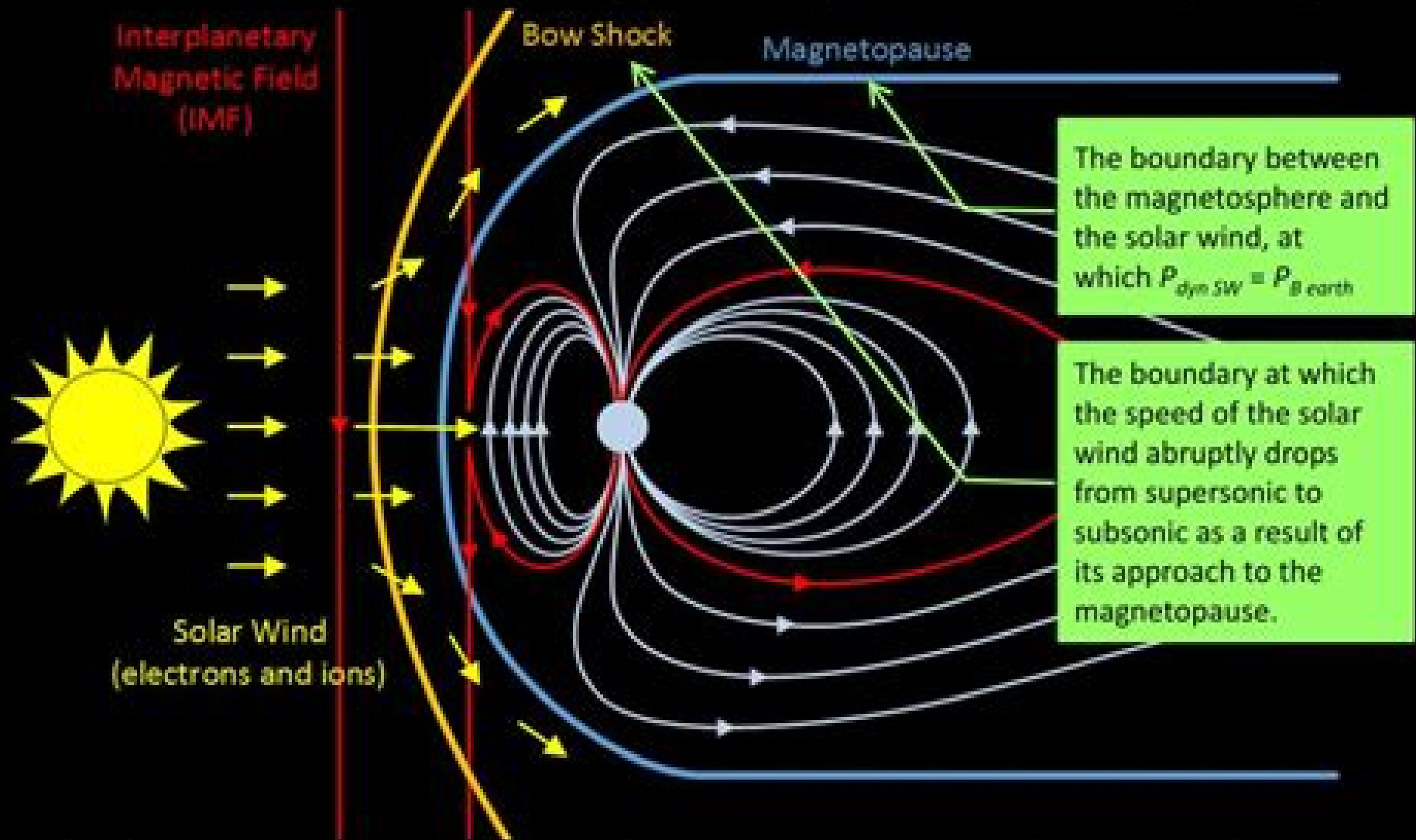


# Solar Wind–Magnetosphere Coupling



- IMF and the earth's magnetic fields are coupled by magnetic reconnection.

# Magnetosphere Ionosphere Coupling

**Y. Kamide, Wolfgang Baumjohann**



## **Magnetosphere Ionosphere Coupling:**

**Magnetosphere-Ionosphere Coupling** Y. Kamide, Wolfgang Baumjohann, 2012-12-06 In the past two decades a succession of direct observations by satellites and of extensive computer simulations has led to the realization that the polar ionosphere plays a principal role in large scale magnetospheric processes a manifestation of the physics linkage involved in solar terrestrial interactions Spatial temporal variations in high latitude electromagnetic phenomena such as dynamic aurorae electric fields and currents have proved to be extremely complex Now the challenge is to comprehend the vast amount of complicated measurements made in this magnetosphere ionosphere system of the Earth This book addresses the electrical coupling between the hot but dilute magnetospheric plasma and the cold but dense plasma in the ionosphere In five major chapters this book presents basic properties of magnetosphere ionosphere coupling morphology of electric fields and currents at high latitudes global modeling of magnetosphere ionosphere coupling modeling of ionospheric electrodynamics current issues such as auroral particle acceleration substorms penetration of high latitude fields into low latitudes

*Magnetosphere-Ionosphere Coupling in the Solar System* Charles R. Chappell, Robert W. Schunk, Peter M. Banks, Richard M. Thorne, James L. Burch, 2016-10-31 Over a half century of exploration of the Earth's space environment it has become evident that the interaction between the ionosphere and the magnetosphere plays a dominant role in the evolution and dynamics of magnetospheric plasmas and fields Interestingly it was recently discovered that this same interaction is of fundamental importance at other planets and moons throughout the solar system Based on papers presented at an interdisciplinary AGU Chapman Conference at Yosemite National Park in February 2014 this volume provides an intellectual and visual journey through our exploration and discovery of the paradigm changing role that the ionosphere plays in determining the filling and dynamics of Earth and planetary environments The 2014 Chapman conference marks the 40th anniversary of the initial magnetosphere ionosphere coupling conference at Yosemite in 1974 and thus gives a four decade perspective of the progress of space science research in understanding these fundamental coupling processes Digital video links to an online archive containing both the 1974 and 2014 meetings are presented throughout this volume for use as an historical resource by the international heliophysics and planetary science communities Topics covered in this volume include Ionosphere as a source of magnetospheric plasma Effects of the low energy ionospheric plasma on the stability and creation of the more energetic plasmas The unified global modeling of the ionosphere and magnetosphere at the Earth and other planets New knowledge of these coupled interactions for heliophysicists and planetary scientists with a cross disciplinary approach involving advanced measurement and modeling techniques Magnetosphere Ionosphere Coupling in the Solar System is a valuable resource for researchers in the fields of space and planetary science atmospheric science space physics astronomy and geophysics Read an interview with the editors to find out more <https://eos.org/editors-vox-filling-earths-space-environment-from-the-sun-or-the-earth>

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Baumjohann,2012-06-12 In the past two decades a succession of direct observations by satellites and of extensive computer simulations has led to the realization that the polar ionosphere plays a principal role in large scale magnetospheric processes a manifestation of the physics linkage involved in solar terrestrial interactions Spatial temporal variations in high latitude electromagnetic phenomena such as dynamic aurorae electric fields and currents have proved to be extremely complex Now the challenge is to comprehend the vast amount of complicated measurements made in this magnetosphere ionosphere system of the Earth This book addresses the electrical coupling between the hot but dilute magnetospheric plasma and the cold but dense plasma in the ionosphere In five major chapters this book presents basic properties of magnetosphere ionosphere coupling morphology of electric fields and currents at high latitudes global modeling of magnetosphere ionosphere coupling modeling of ionospheric electrodynamics current issues such as auroral particle acceleration substorms penetration of high latitude fields into low latitudes

**Cross-Scale Coupling and Energy Transfer in the Magnetosphere-Ionosphere-Thermosphere System** Yukitoshi Nishimura, Olga Verkhoglyadova, Yue Deng, Shun-Rong Zhang,2021-12-07 Cross Scale Coupling and Energy Transfer in the Magnetosphere Ionosphere Thermosphere System provides a systematic understanding of Magnetosphere Ionosphere Thermosphere dynamics Cross scale coupling has become increasingly important in the Space Physics community Although large scale processes can specify the averaged state of the system reasonably well they cannot accurately describe localized and rapidly varying structures in space in actual events Such localized and variable structures can be as intense as the large scale features This book covers observations on quantifying coupling and energetics and simulation on evaluating impacts of cross scale processes It includes an in depth review and summary of the current status of multi scale coupling processes fundamental physics and concise illustrations and plots that are usable in tutorial presentations and classrooms Organized by physical quantities in the system Cross Scale Coupling and Energy Transfer in the Magnetosphere Ionosphere Thermosphere System reviews recent advances in cross scale coupling and energy transfer processes making it an important resource for space physicists and researchers working on the magnetosphere ionosphere and thermosphere Describes frontier science and major science around M I T coupling allowing for foundational understanding of this emerging field in space physics Reviews recent and key findings in the cutting edge of the science Discusses open questions and pathways for understanding how the field is evolving

Magnetosphere-ionosphere Coupling on Meso- and Macro-scales David Lee Murr,2003 Magnetosphere-ionosphere Coupling Rolf Boström,1972 *A Study of the Magnetosphere-ionosphere Coupling Processes* Lie Zhu,1990 **Global aspects of magnetosphere-ionosphere coupling** ,2007 Magnetosphere-ionosphere Coupling C.-G. Fälthammar,1985

*A Theoretical Study of Magnetosphere-ionosphere Coupling Processes* Fei Cao,1991 *Observations of the Solar Wind-magnetosphere-ionosphere Coupling* Liisa Juusola,2009 Solar Wind-Magnetosphere-Ionosphere Coupling ,2000 Effort under this contract deals with coupling between the solar wind magnetosphere and ionosphere We have completed a

series of studies ranging from active experiments in the auroral ionosphere to substorm triggering in the magnetosphere

**Auroral Magnetosphere-Ionosphere Coupling** National Aeronautics and Space Administration (NASA), 2018-08-20  
Auroral arcs result from the acceleration and precipitation of magnetospheric plasma in narrow regions characterized by strong electric fields both perpendicular and parallel to the earth's magnetic field. The various mechanisms that were proposed for the origin of such strong electric fields are often complementary. Such mechanisms include 1 electrostatic double layers 2 double reverse shock 3 anomalous resistivity 4 magnetic mirroring of hot plasma and 5 mapping of the magnetospheric convection electric field through an auroral discontinuity Chiu Y T and Schulz M and Cornwall J M

Unspecified Center NASA CR 158662 ATR 79 9553 7 NASW 3120 *Alfvén Waves and Static Fields in Magnetosphere/ionosphere Coupling* David J. Knudsen, 1990 Perturbation electric and magnetic fields carry in excess of  $10^{10}$  to  $10^{12}$  W of electrical power between the magnetosphere and high latitude ionosphere. Most of this power is generated by the solar wind. The ionosphere at large spatial and temporal scales acts as a dissipative slab which can be characterized by its height integrated Pedersen conductivity  $\Sigma_p$  so that the power flux into the ionosphere due to a quasi static electric field  $E$  is given by  $\Sigma_p E^2$ . The energy transferred to the ionosphere by time varying electromagnetic fields in the form of Alfvén waves is more difficult to calculate because density and conductivity gradients can reflect energy. Thus field resonances and standing wave patterns affect the magnitude and altitude distribution of electrical energy dissipation. We use a numerical model to calculate the frequency dependent electric field reflection coefficient of the ionosphere and show that the ionosphere does not behave as a simple resistive slab for electric field time scales less than a few seconds. Time variation of spacecraft measured high latitude electric and perturbation magnetic fields is difficult to distinguish from spatial structuring that has been Doppler shifted to a non zero frequency in the spacecraft frame. However by calculating the frequency dependent amplitude and phase relations between fluctuating electric and magnetic fields we are able to show that low frequency fields

**Magnetosphere-ionosphere Coupling Currents in Jupiter's Middle Magnetosphere** Jonathan D. Nichols, 2004 *Magnetosphere-ionosphere Coupling During Active Aurora* Guy Grubbs II, 2016 In this work processes which couple the Earth's magnetosphere and ionosphere are examined using observations of aurora from ground based imaging in situ electron measurements and electron transport modeling. The coupling of these regions relies heavily on the energy transport between the two and the ionospheric conductances which regulate the location and magnitude of the transport. The combination of the datasets described are used to derive the conductances and electron energy populations at the upper boundary of the ionosphere. These values are constrained using error analysis of the observation and measurement techniques and made available to the global magnetosphere modeling community for inclusion as boundary conditions at the magnetosphere and ionosphere coupling region. A comparative study of the active aurora and incident electron distributions was conducted using ground based measurements and in situ sounding rocket data. Three

narrow field 47 degree field of view electron multiplying charge coupled device EMCCD imagers were located at Venetie AK which took high spatio temporal resolution measurements of the aurora using different wavelength filters 427.8 nm 557.7 nm and 844.6 nm The measured emission line ratios were combined with atmospheric modeling in order to predict the total electron energy flux and characteristic electron energy incident on the atmosphere These predictions were compared with in situ measurements made by the Ground to Rocket Electrodynamics Electrons Correlative Experiment GREECE sounding rocket launched in early 2014 The GREECE particle instruments were modeled using a ray tracing program SIMION in order to predict the instrument responses for different incident particles Each instrument model was compared with data taken in the lab in order to compare and update the models appropriately A rocket emulation system was constructed for lab testing prior to and during instrument integration into the rocket and used throughout the project to test instrument response and output EMCCD imagers were calibrated using known light sources in order to find the imager response at each pixel prior to and during deployment Electron transport models were modified to use the most recent versions of empirical atmospheric models and chemical reaction rates The electron transport models showed less than 20% and 50% error for intensity measurements 10 degrees and 20 degrees from magnetic zenith respectively An inversion technique was developed in order to derive the characteristics of the in situ electron populations using only the spectral ground based imaging The electron populations and atmospheric conductances were characterized using the inversion technique and the modified Robinson relation during the St Patrick's Day storm on 18 March 2015 Discrete arcs contained the most energetic electrons and highest conductances followed by pulsating aurora and then diffuse aurora These techniques can be used to constrain the electrons and ionospheric conductances responsible for different types of aurora using imaging data taken over long time periods when in situ measurements are unavailable

*Magnetosphere-ionosphere Coupling During Substorms* Kyle R. Murphy, University of Alberta. Department of Physics, 2014 This thesis concerns the development and evolution of the magnetospheric substorm In particular this thesis concentrates on the dynamics of Ultra Low Frequency ULF waves during the substorm growth and expansion phases the coupling of the ionosphere and magnetosphere through substorm onset and the substorm expansion phase and the location in the magnetosphere and physical processes leading to substorm onset Firstly we present a superposed epoch analysis of ULF waves through the substorm growth and expansion phase characterizing the two dimensional distribution of power spectral density and polarization of these waves with respect to auroral onset We demonstrate that ULF wave power during substorms is characteristic of a power law and that the distribution of wave power and polarization is consistent with the expected pattern in the presence of a substorm current wedge Secondly we examine the global field aligned current FAC morphology through the substorm growth and expansion phase We demonstrate for the first time that there is a clear reduction in FACs coupling the ionosphere and magnetosphere just prior to substorm onset We suggest that this change in coupling may play an important role in the destabilization of the

magnetosphere at substorm onset We also present the first two dimensional in situ observation of the FACs and ionospheric current sheets comprising the substorm current wedge in the substorm expansion phase We demonstrate that the structure of the substorm current wedge is significantly more complex than the classical view of the substorm current wedge Finally we present a comprehensive ground and in situ analysis of two substorms to determine where in the magnetosphere the substorms initiate We demonstrate that both substorms initiate on closed field lines in the inner magnetosphere More significantly we demonstrate that magnetic reconnection can follow substorm onset and that earthward magnetotail flows or auroral streamers their ionospheric counterparts are not a necessary condition for substorm onset

**Role of Ionospheric Conductance in Magnetosphere-ionosphere Coupling** Tapas Bhattacharya, 2014 Magnetosphere ionosphere MI coupling has been studied for a long time However not much work has been done on a systematic understanding of the relation between ionospheric Pedersen conductance its effect on the evolution and modification of field aligned currents FACs and the influence of conductance and FACs on the formation of parallel electric fields which cause particle precipitation Though the roles of ionospheric conductance gradients for FACs and parallel electric field evolution are directly related they are poorly understood This dissertation advances the understanding of these areas and all results of this study are based on numerical simulations that employ a three dimensional two fluid ions and neutrals simulation code The first part of this dissertation presents a systematic study of the magnetospheric and ionospheric influences on the evolution and modification of FACs with focus on the role of ionospheric Pedersen conductance and its gradients FACs are typically generated in the magnetosphere and are carried into the ionosphere by Alfvén waves During their reflection from the ionosphere these FACs are modified depending on the magnitude and distribution of ionospheric conductance For conductance gradients along the polarization of the wave strong Pedersen currents can be generated which in turn enhance the FAC as well The second part of this dissertation addresses the properties and evolution of parallel electric fields in an attempt to better understand the formation of discrete auroral arcs in response to the evolution of FACs for predetermined ionospheric conductance patterns Frequently auroral acceleration is believed to occur through U or V shaped potentials Therefore this part examines the properties of localized parallel electric fields in a uniform magnetic field It is demonstrated that localized parallel electric fields generate magnetic flux in the absence of source of free energy It is also shown that parallel electric fields generated in a FAC in the presence of an anomalous resistivity represent a load and can provide physical explanation for the auroral acceleration geometry The results demonstrate that such electric fields can be significantly enhanced by Alfvén wave reflection where both magnitude and gradients of the ionospheric conductance are important The strongly enhanced parallel electric field is associated with magnetic reconnection and modifies the FAC system such that thin current layers with curls and folds are observed to be embedded in the large scale current system

**Investigations of Magnetosphere-Ionosphere Coupling Relevant to Operational Systems** C. I. Meng, P. T. Newell, JOHNS HOPKINS

UNIV LAUREL MD APPLIED PHYSICS LAB.,1988 Important advances were made in understanding the dynamics of the magnetosphere and its coupling to the ionosphere Significant progress was made in the areas of polar cusp precipitation and dynamics dayside auroral morphology and auroral boundary dynamics polar rain the quiescent polar cap the physics of impulsive injection phenomena and problems of global magnetospheric plasma transport Keywords Auroral oval Magneto sheaths Polar cap absorption Defense meteorological satellite program Magnetosphere Ionosphere Aurora Cusp Storm Particle precipitation Magnetic storms JHD      **Auroral Magnetosphere-ionosphere Coupling** Y. T. Chiu,Michael Schulz,J. M. Cornwall,Aerospace Corporation,1979



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