Unsolved Problems of Magnetospheric Physics

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ABSTRACTS

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Variability of the Sun and Its Terrestrial Impact

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Name: Elizaveta Antonova

Title: Auroral oval mapping and the main problems of magnetospheric dynamics

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Abstract:
We study the topology of high latitude plasma domains and reanalyze the problem of the auroral oval mapping without using magnetic field models. The location of the trapping boundary of energetic particles inside the auroral oval is demonstrated. We compare the distribution of plasma pressure at low altitudes using data of DMSP observations and plasma pressure at the equatorial plane using data of THEMIS mission. It is shown that most part of the auroral oval is mapped to the surrounding the Earth plasma ring at geocentric distances smaller than 10-12Re in contrast to the ordinary suggestion of the auroral oval mapping to the plasma sheet proper. Transverse currents in the ring are the high latitude continuation of the traditional ring current. We show that obtained results can help in the creation of the non contradictory explanation of many magnetospheric phenomena including the formation of quite auroral arc in the conditions of the high level of plasma sheet turbulence. The main reasons leading to the real changes of the well established positions are discussed.

Name: Michael Balikhin

Title: How the fusion between physics and systems science can help us to understand solar wind-magnetosphere coupling.

Author(s): M. A. Balikhin, R. J. Boynton, S. A. Billings, and S. N. Walker

Affiliation:
Department of Automatic Control and Systems Engineering, University of Sheffield, Sheffield, U.K.

Abstract:
The methodologies developed in the field of System Science have proven valuable assets in the study of extremely complex, physical objects for which models based on first principles have not been developed. The traditional approach to modeling starts from first principles combined with knowledge about simple physical processes, advancing to an understanding of more complex processes and, in the final stages, conjugates them into an ultimate model of the complex physical object. In some sense, the system science advances our knowledge in opposite direction, building on the knowledge of the generic complex behaviour of a system. Applying advanced data analysis methods, systems science investigates the evolution of the overall system to provide information about the underlying physical processes involved in the system's dynamics. The Solar-Terrestrial system is one example of a physical system that still lacks a comprehensive physical model deduced from the first principles. It is shown how the fusion between the systems science and physics approach helps to understand coupling between the solar wind and the magnetosphere.

Name: Joachim Birn

Title: Onset and cessation of reconnection in the magnetotail, relation to substorms

Author(s): Joachim Birn, Yi-Hsin Liu, William S. Daughton, Michael Hesse, and Karl Schindler

Affiliation(s):Space Science Institute, Boulder, CO, USA

Abstract:r

It is commonly assumed that the onset of reconnection in the magnetotail involves a tearing instability. Using two-dimensional PIC simulations up to the real proton/electron mass ratio, we have explored the onset of tearing in 2D tail configurations. We found a clear threshold between stable and unstable configurations, depending on the magnitude of the normal magnetic field component, the current sheet thickness, and the assumed ion/electron mass ratio. An important open question, however, is how this onset and the reconnection rate are modified by 3D effects, particularly by the interaction with ballooning/interchange type modes. It is also well established that entropy-depleted earthward flows ("bubbles") caused by reconnection distort the magnetic field and can generate field-aligned current systems like the substorm current wedge. The "substorm effectiveness" appears to depend on the depth of flow penetration to Earth, which is controlled by the amount of depletion of the bubbles. It is, however, not known what determines this amount, whether it is related to a cessation of reconnection, what might govern that, and how these phenomena might be related to the recovery phase of a substorm and the replenishment of the plasma sheet.

Name: Lauren Blum

Title: Causes and Consequences of Radiation Belt Electron Precipitation

Author(s): L. W. Blum[1], J. W. Bonnell[1], X. Li[2]

Affiliation(s):
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[2.] Laboratory for Atmospheric and Space Physics (LASP), University of Colorado Boulder

Abstract:
There is still much to be understood about the processes contributing to relativistic electron enhancements and losses in the outer radiation belt: particle precipitation into the atmosphere is a critical part of radiation belt electron loss, and without detailed knowledge of this loss mechanism, we are unable to fully understand the contributions of acceleration mechanisms. An understanding of the causes of this loss, and the various wave modes responsible for electron precipitation, gives insight into when and where these loss processes are active. Electromagnetic ion cyclotron (EMIC) waves have been hypothesized to be a primary source of precipitation loss of radiation belt electrons, contributing to the net response and dynamics of the outer radiation belt. Here we investigate the relationship between EMIC waves and precipitation events, their spatial scales and global distributions. Through a combination of equatorial wave and plasma measurements and low altitude energetic electron precipitation measurements, we explore the nature and extent of electron loss to the atmosphere as well as what electromagnetic wave modes may be causing it. These studies aid in the understanding of outer radiation belt dynamics and the relationship between precipitating energetic electrons, electromagnetic waves, and global magnetospheric conditions.

Name: Jacob Bortnik

Title: Some outstanding problems in radiation belt and waves physics

Author(s): Jacob Bortnik[1], Richard M. Thorne[1], Wen Li[1], Xinliang Gao[2,3]

Affiliation(s):
[1]Department of Atmospheric and Oceanic Sciences, UCLA, Los Angeles, California, USA
[2]CAS Key Laboratory of Geospace Environment, Department of Geophysics and Planetary Science, University of Science and Technology of China, Hefei 230026, China
[3]Collaborative Innovation Center of Astronautical Science and Technology, China

Abstract:

While the field of radiation belt and waves physics has received considerable attention in recent years, due to the launch of the Van Allen Probes in Aug 2012, there are many puzzles which still remain to be solved. In this talk we briefly review our current understanding of the processes that drive radiation belt dynamics. We then turn our attention to problems that still remain to be solved: what causes the prompt acceleration of radiation belt electrons? Why do electron dropouts occur even during relatively quiet conditions, and why is it so hard to quantify the dynamics of the radiation belt electrons, even when solar wind conditions are known? These and other topics will be covered under the rubric of future magnetospheric research.

Name: Joe Borovsky

Title: Do We Really Understand Solar-Wind/Magnetosphere Coupling?

Author(s): Joe Borovsky

Affiliation(s): Space Science Institute and University of Michigan

Abstract:

Several aspects of how the solar wind couples to the Earth's magnetosphere and ionosphere. The following deficiencies in our understanding will be pointed out. (1) There is broad agreement that dayside magnetic reconnection is a controlling mechanism for the coupling, but there is an ongoing debate as to whether or not the solar-wind electric field $\underline{v}\times\underline{B}$ controls the dayside reconnection rate. (2) The solar-wind control of geomagnetic activity is usually studied and tested via correlations between solar-wind functions and geomagnetic indices, but there are mathematical versus physics aspects to correlations that raise the issues of whether correlations can be used as a test of the physical accuracy of solar-wind driver functions. (3) The nature of the viscous interaction between the solar wind and the magnetosphere is a mystery and there is a question of whether residual (non-dayside-reconnection) geomagnetic activity is caused by a viscous interaction or by reconnection tailward of the cusp. (4) There is a new understanding about the ability of the magnetosphere to control (reduce) the rate of dayside reconnection, but a lack of knowledge of the mass density of the dayside magnetosphere and a lack of knowledge about the relative roles of keV oxygen in the ion plasma sheet and eV oxygen in the plasma cloak. (5) A statistical increase in geomagnetic activity with increased levels of upstream solar-wind turbulence has been established, but the physical reason why turbulence or fluctuations increase solar-wind/magnetosphere coupling is a mystery. (6) The mechanisms of mass coupling from the solar wind into the magnetosphere (particularly via the LLBL) are not understood and the total mass flow has not been quantified.

Name: C. Robert Clauer

Title: Issues Concerning Polar Cap Electric Potential (Field) Saturation

Author(s): C. R. Clauer(1), Zhonghua Xu(1), J. Michael Ruohoniemi(1), Joseph Baker(1), Wayne Scales(1), Michael Nicolls(2), Marc Hairston(3), Rick Wilder(4), M.Maimaiti(1)

Affiliation(s): (1) Virginia Tech, (2) SRI International, (3) UT Dallas, (4) U of Colorado LASP

Abstract:

While several statistical investigations indicate that the polar convection electric field 'saturates' for large values of the driving solar wind electric field for both northward and southward IMF, recent Resolute incoherent scatter radar measurements show no such saturation. The electric field in the reverse convection cell during strongly northward IMF (between 10 - 30 nT) have values between 156 mV/m and 67 mV/m showing a linear variation with the driving field, measured on Sept 12-13, 2015. Does the electric field saturate or the potential? Are measurements by SuperDARN and DMSP drift-meter accurate for large drift values? If, indeed the polar ionospheric electric field does become non-linear with a strong driving electric field, could the ionosphere play an active role in that non-linearity? It seems that there is still uncertainty in the relation between the ionospheric electric field and solar wind driving. What would be the best way to measure this? Are these Resolute measurements unusual in some way?

Name: Mark Clilverd

Title: What are the magnetospheric drivers of the observed coupling of geomagnetic activity to the atmosphere?

Author(s): Mark A Clilverd[1], Craig J. Rodger[2], Hua Lu[1], Annika Seppala[1,3]

Affiliation(s): [1]British Antarctic Survey, [2]University of Otago, [3]Finnish Meteorological Institute

Abstract: What is the physical coupling that explains the observed link between geomagnetic activity variability and the atmosphere's North Atlantic oscillation (NAO)? – this is a vital component to understanding the past, present and future behaviour of weather patterns that have a significant influence on western-European wintertimes. The question builds on the previous identification that there are key periods in time where the variability in long-term geomagnetic activity explains a significant fraction of the behaviour of the NAO. The solution will probably involve the reanalysis of long-term geomagnetic activity datasets, and the development of a reclassification of the magnetic field perturbations in terms of climate-system effectiveness. This type of classification is critically lacking from the inputs of atmospheric coupled-climate models. We will show that the coupling between geomagnetic activity and the atmosphere is strongest for the declining phase of the solar cycle, but only for every other cycle – leading to the question about what is the actual physical mechanism in play?

Name: Mick Denton

Title: What is the origin of low-energy electrons in the inner magnetosphere?

Author(s): M. Denton (1, 2), G. Reeves (1, 3), R. Friedel (1, 3), B. Larsen (1, 3), M. Thomsen (4, 3), J. Borovsky (2, 5), R. Skoug (3), H. Funsten (3).

Affiliation(s):
(1) New Mexico Consortium
(2) Space Science Institute
(3) Los Alamos National Laboratory
(4) Planetary Science Institute
(5) University of Michigan

Abstract: Measurements of the low energy (10s-100s eV) electron population in the inner magnetosphere are challenging - it is primarily because of surface charging issues that electrons in the energy range from 10s to 100s eV have been relatively poorly sampled to date. This population, and its dynamics and evolution, have thus been neglected in comparison with other magnetospheric populations. This situation may be compared with the study of low-energy ions in the magnetosphere - a population that recently received renewed attention, and as a result, a better appreciation of its role in global magnetospheric dynamics (e.g. *Chappell et al.* [2008]). Knowledge of low energy electrons provides information on the dynamics of the magnetosphere system, on mass flow through this system, and on the origin of the charged particles that fill the inner magnetosphere. We discuss RBSP/HOPE and LANL/MPA observations - specifically the energy, spatial, and pitch-angle distributions of the low energy electrons - and speculate as to the under-appreciated role of this population in the magnetosphere.

Name: Colin Forsyth

Title: Combining long-term datasets to tackle unsolved problems in the magnetosphere

Author(s): C. Forsyth, I. J. Rae

Affiliation(s): UCL Mullard Space Science Laboratory, Dorking, Surrey, UK

Abstract: On a case-by-case basis, spacecraft coverage of the magnetosphere is sparse and whilst case studies of a small-spatial coverage of data points can provide insights into the micro or meso-scale physics, they can provide very little information on the system-level dynamics and properties of the magnetosphere. Taken together, missions such as Cluster, THEMIS, Geotail, Polar and others provide hundreds of spacecraft years worth of observations covering large swathes of the magnetosphere. Recent publications have shown that these long-term datasets can question the existing perceived knowledge of the properties of the magnetotail plasma such that even some "solved" problems may be called into question. In this presentation, we will discuss how by combining data from these missions with long-term ground-based datasets such as SuperMAG, we are in a prime position to examine long-term trends and short-term dynamics of the magnetosphere and answer questions such as "how does the plasma in the magnetotail influence substorm size and onsets", "how is energy transmitted through the magnetosphere during substorms", and "how does the solar cycle affect the magnetosphere".

Name: Reiner Friedel

Title: Quiet time relativistic electron pitch angle distributions in the inner magnetosphere

Author(s): R. H. W. Friedel (1,2), H. Zhao (3), Yue Chen (1) and M. Henderson (1)

Affiliation(s):

(1) Space Science and Applications, Los Alamos, New Mexico, USA

(2) The New Mexico Consortium, Los Alamos, New Mexico, USA

(3) Laboratory for Atmospheric and Sapce Physics, University of Colorado, Boulder, Colorado, USA

Abstract:

The shape of the relativistic electron pitch angle distribution (PADs) in the trapped inner region of the magnetosphere is a sensitive measure of many of the processes that govern the dynamics of these particles. We report here on recent statistical observations of relativistic electron PADs from the Relativistic Electron/Proton Telescope (REPT) on the Van Allen Probes mission, which show an unexpected dawn/dusk asymmetry that seems to be a persistent feature during quiet times of Dst < -20 nT. The observed PADs show a more peaked pancake distribution at dusk compared to dawn for energies above 1.8 MeV, with the difference becoming stronger at higher energies. These observations hint at persistent processes that can affect relativsitic electrons on timescales on the order of the drift period (~ 10 minutes).

Name: Stephen A. Fuselier

Title: Communication between the nightside and the dayside magnetosphere

Author(s): Stephen A. Fuselier

Affiliation(s): Southwest Research Institute, San Antonio, Texas, USA

Abstract: In the standard picture of magnetospheric dynamics, reconnection at the dayside magnetopause transfers particle and magnetic flux to the nightside. This transfer cannot continue unabated. The nightside responds by expelling flux down the tail and injecting plasma in the direction of the Earth in a quasi-continuous or an explosive manner. The reconnection process on the dayside and the explosive reconnection process on the nightside are reasonably well understood from a local perspective. Less well understood are the global implications of these local transfer processes and the communication between the dayside and nightside. This talk reviews what is understood about the global implications for localized reconnection and discusses the process of transfer from the dayside to the nightside and (to a lesser extent) the transfer back to the dayside. This review includes new observations from neutral atom imaging of the magnetospheric cusps and magnetotail/plasma sheet.

Name: Christine Gabrielse

Title: The injection region's formation and evolution: large- or small-scale?

Author(s): Christine Gabrielse[1], E. Spanswick[2], V. Angelopoulos[1], E. Donovan[2], A. Runov[1], D. L. Turner[3], J. Liu[1]

Affiliation(s): (1) UCLA, (2) University of Calgary, (3) The Aerospace Corporation

Abstract:
Understanding particle energization and transport throughout the magnetotail is fundamental to modeling particle sources and losses in Earth's inner magnetosphere. Signatures of energization and transport, injections are observed as sudden increases in particle fluxes across several energy channels. A main source of the radiation belt's seed population, they also create anisotropies that drive ion cyclotron or whistler mode chorus waves responsible for losses or further acceleration. Where the injection region forms and how it evolves, however, is still unknown. The data thus far have supported two seemingly opposing models for the injection region: (1) a large-scale, near-Earth (~8-9 R_E) region that explosively forms perhaps as a result of current disruption and global dipolarization, which then propagates both earthward and tailward; (2) multiple, localized, transient acceleration episodes that propagate earthward with the dipolarizing flux bundle at fast speeds (~400 km/s) after reconnection, resulting in flux pile-up near Earth with effects then progressing downtail. I am interested in better understanding the acceleration and transport process: namely, does it result from a global phenomenon, such as disruption in the cross-tail current leading to global dipolarization, or does it begin with localized, earthward-travelling dipolarizing flux bundles and fast flows? Or possibly both?

Name: D.L. Gallagher

Title: What processes influence plasmaspheric refilling?

Author(s): D. L. Gallagher

Affiliation(s): NASA Marshall Space Flight Center

Abstract:
Just over half a century ago Don Carpenter, using whistler observations, found that plasma density near Earth was lost during geomagnetic storms. Since that time many have undertaken to understand the physical processes involved in the resulting ionospheric plasma outflow that repopulates this region. Ionospheric chemistry, thermospheric wind, convection $\vec{E}\ x\ \vec{B}$, and heating have often been incorporated into the analysis. Yet, theoretical studies have not yet successfully explained observed refilling, which most recently was observed to be twice as fast as modeling estimates. It has been speculated that plasma wave equatorial pitch angle scattering and heating may play a role and there is supporting circumstantial evidence, however these processes are not often included in physical models. Heavy ion composition is well recognized as critical to wave-particle instabilities and to the propagation of wave power through the inner magnetosphere; however our understanding of variation in composition is largely limited to finding enhanced oxygen ion outflow during increased activity. The context and state of what we do not know about plasmaspheric refilling will be further discussed during this presentation.

Name: Natalia Ganushkina

Title: Substorm-associated effects in the variations of low energy electron fluxes in the inner magnetosphere: Does the substorm's strength matter?

Author(s): Natalia Ganushkina (1, 2) Stepan Dugyagin (1), I. Sillanpää (1), D. Pitchford (3)

Affiliation(s): (1) Finnish Meteorological Institute, Helsinki, Finland, (2) University of Michigan, Ann Arbor MI, USA, (3) SES ENGINEERING, Luxembourg.

Abstract:

The fluxes of electrons with energies < 100 keV not usually analyzed in details when studying the electron radiation belts. These fluxes constitute the low energy part of the seed population, which is critically important for radiation belt dynamics. Moreover, energetic electrons with energies less than about 100 keV are responsible for hazardous space-weather phenomena such as surface charging. The electron flux at these energies varies significantly with geomagnetic activity and even during quiet-time periods. Significant variations in the low-energy electrons can be seen during isolated substorms, not related to any storm periods. Moreover, electron flux variations depend on the electron energy. Statistical analisys of AMC 12 CEASE II ESA instrument data (5-50 keV) and GOES MAGED data (40, 75, 150 keV) have revealed that electron fluxes increase by the same order of magnitude during isolated substorms with 200 nT of AE index and storm-time substorms with 1200 nT of AE index. If substorms are represented as electromagnetic pulses which transport and accelerate electrons additionally, how are their amplitudes determined, if not related directly to a substorm's strength? We present observational and modeling results on low energy electrons in the inner magnetosphere and on the role of substorms for them.

Name: Gerhard Haerendel

Title: Overcoming Uncertainties in the Relation between Source and Aurora

Author(s): Gerhard Haerendel

Affiliation(s): Planck Institute for Extraterrestrial Physics, Garching, Germany

Abstract: A field of great uncertainty in magnetospheric physics is the relation between source regions in magnetosphere or tail, ionospheric phenomena, and energy conversion processes acting between the two. Because of their traceability, auroral arcs hold the greatest promise for drawing conclusions on identification and dynamics of their source regions. However, there are two obstacles: Arcs are tracing only narrow regions of magnetic stress release, and conjugate observations of source and aurora are rare. Furthermore, there is no unified understanding of the basic energy conversion processes. Two guiding principles are proposed. (1) The magnetic stresses may arise from three forces: plasma pressure force, inertial forces or flow braking, and magnetic pressure force. (2) There are two modes of conversion of the free magnetic energy into auroral particle energy: (a) Progressive release of already existing shear stresses, or (b) immediate conversion or dumping of inflowing energy, for instance by kinetic Alfvén waves. The first is behind the origin of inverted-V arcs, whereas the second leads to Alfvénic arcs. At the present state of the art, a diversity of concepts exists for the origin of auroral arcs, and there is much room for intuition. An ordering according to the above guiding principles will be attempted.

Name: Michael Hartinger

Title: What is the difference between a wave and a transient, and why does it matter for Solar Wind-Magnetosphere-Ionosphere coupling?

Author(s): Michael Hartinger and Robert Clauer

Affiliation(s): Bradley Department of Electric and Computer Engineering, Blacksburg, VA, USA

Abstract:
Magnetic perturbations with periods on the order of minutes to tens of minutes are often observed in the Earth's magnetosphere using satellites and ground-based instruments. We typically categorize these perturbations as transient events, such as traveling convection vortices (TCVs), or steady wave activity, such as standing Alfven waves. In many regions – particularly at large radial distances/high latitudes – it is difficult to distinguish between each type of behavior. This lack of a clear distinction makes it difficult to identify the excitation mechanism(s) for these perturbations and assess their role in solar wind-magnetosphere-ionosphere (SWMI) coupling. We discuss how the distinction between transients and waves affects our understanding of SWMI coupling and why making such a distinction is often challenging. We also discuss the observational, theoretical, and modeling work needed to assess the role of these perturbations in SWMI coupling.

Name: Rod Heelis

Title: Ionospheric Signatures of Magnetospheric Convection

Author(s): R.A. Heelis

Affiliation(s): University of Texas at Dallas

Abstract: Comparison of average and instantaneous signatures of magnetospheric convection in the ionosphere reveal striking differences that are not easily reconciled with the present notions of solar wind – magnetosphere interactions. Discovering the temporal and spatial scales of ionospheric convection signatures that characterize processes occurring at the dayside magnetopause, at the flanks of the magnetosphere, and in the tail remains an unsolved problem with important consequences for magnetospheric, ionospheric and thermospheric dynamics.

Name: Michael G. Henderson

Title: The Association of Auroral Streamers with Substorm Onsets

Author(s): M. G. Henderson

Affiliation(s): Los Alamos National Laboratory

Abstract:
Over the last several decades, a number of studies have shown that auroral breakup associated with substorm onset can be preceded by the arrival of equatorward-moving auroral forms from higher latitudes. In the 1970s, based on detailed analysis of all-sky imager data, Oguti [1973], defined the concept of a `contact breakup', which starts when an inclined (or `slanted') arc splits away from a poleward arc system and arrives in the equatorward part of the auroral distribution. Later, Henderson et al. [2006] used global auroral imager data to show that onsets could emerge from complex interactions between auroral streamers and omega-band forms at the equatorward edge of the bulge. And most recently, Nishimura et al. [2010] have claimed that all auroral breakups are preceded by the arrival of auroral forms from the poleward regions of the bulge. Here we review the observations and show that many auroral onsets may be only coincidentally related to the immediate arrival of auroral streamers and that the interaction is likely to be much more complex than is currently thought.

Name: Michael Hesse

Title: Does the Magnetosphere go to Sleep?

Author(s): Michael Hesse[1], Eigil Friis-Christensen[2], Masha Kuznetsova[1]

Affiliation(s): [1]NASA Goddard Space Flight Center, [2]Danish National Space Center

Abstract:
An interesting question in magnetospheric research is related to the transition between magnetospheric configurations under substantial solar wind driving, and a putative relaxed state after the driving ceases. While it is conceivable that the latter state may be unique and only dependent on residual solar wind driving, a more likely scenario has magnetospheric memory playing a key role. Memory processes may be manifold: constraints from conservation of flux tube entropy to neutral wind inertia in the upper atmosphere may all contribute. In this presentation, we use high-resolution, global, MHD simulations to begin to shed light on this transition, as well as on the concept of a quiet state of the magnetosphere. We will discuss key elements of magnetospheric memory, and demonstrate their influence, as well as the actual memory time scale, through simulations and analytical estimates. Finally, we will point out processes with the potential to effect magnetospheric memory loss.

Name: Bogdan Hnat

Title: Turbulence and reconnection in the terrestrial magnetotail

Author(s): B. Hnat[1], K. T. Osman[1] , K. H. Kiyani[1], W. H. Matthaeus[2], S.C. Chapman[1, 3, 4] and Yu. V. Khotyaintsev[5]

Affiliation(s):
[1]Centre for Fusion, Space and Astrophysics; University of Warwick, Coventry, CV4 7AL, UK; 2 Bartol Research Institute, Department of Physics and Astronomy, University of Delaware, Delaware 19716, USA; [3] Department of Mathematics and Statistics, University of Tromsø, N-9037 Tromsø, Norway□; [4] Max Planck Institute for the Physics of Complex Systems, 01187 Dresden, Germany□; [5] Swedish Institute of Space Physics, Uppsala, Sweden

Abstract:
Turbulence and reconnection represent two fundamental and not fully understood aspects of plasma dynamics and are important in transport within the plasma sheet. Observations show that the magnetic fluctuations within this region exhibit key features associated with turbulence: multi-scaling and intermittency. Recent numerical studies show that the reconnection leads to turbulent flows in the later stages of the process. The relationship between magnetic reconnection and plasma turbulence is investigated using multipoint in-situ measurements from the Cluster spacecraft within a high-speed reconnection jet in the terrestrial magnetotail. We show that work done by electromagnetic fields on the particles, J.E, has a non-Gaussian distribution and is concentrated in regions of high electric current density. Hence, magnetic energy is converted to kinetic energy in an intermittent manner. Furthermore, we find the higher-order statistics of magnetic field fluctuations are characterized by multifractal scaling on magnetofluid scales and non-Gaussian global scale invariance on kinetic scales. These observations suggest J.E within the reconnection jet has an analogue in fluid-like turbulence theory in that it proceeds via coherent structures generated by an intermittent cascade. This supports the hypothesis that turbulent dissipation is highly nonuniform.

Name: Vania K. Jordanova

Title: Outstanding Inner Magnetospheric Questions and Problem Areas

Author(s): Vania K. Jordanova

Affiliation(s): Los Alamos National Laboratory, Los Alamos, NM 87545, USA

Abstract:
The Earth's inner magnetosphere is a highly dynamic system, coupled through a complex set of physical processes to the outer magnetosphere and the ionosphere. The largest variations in the inner magnetospheric plasma and fields occur during geomagnetic storms and are related to the intensification of the ring current, the magnetically trapped charged particles (10's keV) circling Earth between ~2 to 5 Earth radii (R_E). The mechanisms for particle injection in the near-Earth space environment and their subsequent trapping or loss have been studied for many years; however their theoretical evaluation and implementation in numerical models remain challenging. We discuss critical problems in present-day numerical models which, although powerful tools to study large-scale storm dynamics, depend on various sets of assumptions as well as knowledge of initial and boundary conditions. Using our RAM-SCB model that couples the kinetic ring current-atmosphere interactions model with an Euler potential-based three-dimensional plasma equilibrium code we address several outstanding questions in inner magnetospheric dynamics: a) the role of convective versus inductive electric fields in ring current energization, b) the depth of particle penetration into the inner magnetosphere, and c) the effects of ion composition variation during storms.

Name: Nadine M.E. Kalmoni

Title: Are all substorm onset arcs created equal?

Author(s): N.M.E. Kalmoni[1], I.J. Rae[1], C.E.J. Watt[2], K. R. Murphy[3], C. Forsyth[1], C. J. Owen[1]

Affiliation(s): [1]Mullard Space Science Laboratory, University College London, Holmbury St. Mary, Dorking, RH5 6NT, UK
[2]Department of Meteorology, University of Reading, Reading, UK
[3]NASA Goddard Space Flight Center, Greenbelt, ML, USA

Abstract: An auroral substorm is marked by a sudden brightening and poleward expansion of the most equatorward auroral arc, and corresponds to the start of a rapid global reconfiguration of the magnetotail. Using the high temporal and spatial resolution of the THEMIS All Sky Imagers, small scale azimuthal structures (beads) have been observed along the onset arc in the minutes leading up to substorm onset. These beads have been observed simultaneously in both hemispheres and grow exponentially. This suggests that beady substorm onset arcs are the ionospheric signature of a magnetospheric instability which manifests itself at the inner edge of the plasma sheet. In our previous work we have statistically characterised the growth and spatial scales of the beads in a few clearly beady substorm onsets and conclude that they are most consistent with a Shear-Flow Ballooning Instability. In this talk, we discuss the possibility that all substorm onset arcs are the result of magnetospheric instabilities, and further discuss methods of analysis that could provide the answer to the unsolved magnetospheric problem of “what creates the substorm onset arc?”

Name: S. G. Kanekal

Title: Open Questions in Radiation Belt Physics

Author(s): S. G. Kanekal[1], D.N. Baker[2], and D. G. Sibeck[1]

Affiliation(s): 1. NASA Goddard Space Flight Center, Greenbelt, MD, USA
2. Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO, USA

Abstract:
Despite the fact the Earth's radiation belts were discovered more than fifty years ago, many fundamental aspects of their dynamics remain only poorly understood. The outer radiation belt, in particular, is very dynamical and shows variability in energetic electron populations that wax and wane over several orders of magnitude. This variability is due to energization and loss processes that lead to enhanced and depleted numbers of electrons. The twin spacecraft mission, Van Allen Probes launched in the fall of 2012, carries a comprehensive suite of instruments that measure particles and plasma waves. The primary science goal is to understand the physics of the radiation belts. In more than 2 years of observations Van Allen Probes has succeeded in shedding light on several fundamental questions regarding the acceleration and loss of outer Van Allen belt electron population. However, the detailed observations have also revealed new phenomena such as the "electron Storage ring", and the "impenetrable barrier". We review these and other observations and discuss their implications regarding our understanding of the physics of these energetic particles in the Van Allen belts.

Name: Lois Keller Sarno-Smith

Title: "Unresolved and underappreciated issues in Plasmaspheric Physics regarding Ion Composition, Wave-Particle Interactions, and Plasmapause Boundary Studies"

Author(s): Roxanne M. Katus, Michael W. Liemohn, Dennis Gallagher

Affiliation(s): University of Michigan, Marshall Space Flight Center

Abstract:
Earth's plasmasphere is a torus of cold (approximately 1 eV), dense plasma that co-rorates with Earth. Although the plasmasphere comprises the bulk density of the magnetosphere and is a controlling factor in wave propagation and scattering rates, the space science community has focused their attention elsewhere. Recently, missions such as the Van Allen Probes and IMAGE EUV have brought a wealth of plasmaspheric data to analyze and generated new questions about the plasmasphere that we may have not considered previously. In this talk, we will discuss recent findings and the unresolved questions stemming from those results – including the unique behavior the high energy (1-10 eV) plasmasphere population, wave propagation in the plasmasphere, and recent insights and challenges in plasmapause detection.

Name: Larry Kepko

Title: What causes auroral arcs and why we should care?

Author(s): Larry Kepko

Affiliation(s): NASA Goddard Space Flight Center

Abstract:
Auroral phenomena come in many shapes and forms, from diffuse to discrete, and spiral complicated structures to long, thin arcs. Despite decades of research, there is no consensus on the magnetospheric driver of even the simplest auroral form: the auroral arc. Auroral arcs can often span many hours of local time and be long-lived (10s of minutes or more). Discrete auroral arcs are broadly understood to be created by, or associated with, regions of upward field-aligned current (downward acceleration of electrons). Yet while macroscale auroral structure is sometimes thought to represent magnetospheric structure, exactly how this ionospheric and near-ionospheric structure maps to the magnetosphere is a major unsolved mystery. In addition, there are major questions about the magnetospheric drivers of auroral arc – flow shear, gradient of some magnetospheric plasma parameter, etc. In this talk I will review current thinking on the magnetospheric processes that create auroral arcs, identify open questions, and suggest methods for solving this fundamental question.

Name: Mona Kessel

Title: Things we don’t yet understand about solar driving of the radiation belts.

Author(s): Mona Kessel

Affiliation(s): NASA GSFC

Abstract:
The primary science objective of the Van Allen Probes mission, formerly Radiation Belt Storm Probes, is to provide understanding, ideally to the point of predictability, of how populations of relativistic electrons and penetrating ions in space form or change in response to variable inputs of energy from the Sun. To the point of predictability: knowledge and understanding is not yet there. There are some forecasting technologies currently in place, but their inherent limitations are inhibiting substantive improvements in radiation belt forecasts. Many radiation belt phenomena are understood to some degree; there are two kinds of energization – radial diffusion and local acceleration, and there are two regions of loss – through the magnetopause and precipitation into the atmosphere. And radiation belt models are beginning to examine and match observed conditions. Growing statistics are also having success at characterizing the state of the radiation belts. But exactly when to expect certain behaviors based on solar conditions remains a work in progress. There is as yet no real connection between events on the sun and the response of the radiation belts. A framework for success in this endeavor can only be built on cross-disciplinary coordination from a team of solar, heliospheric and magnetospheric scientists.

Name: Craig Kletzing

Title: Challenges in the Understanding of Auroral Physics

Author(s): C. A. Kletzing

Affiliation(s): Department of Physics & Astronomy, The University of Iowa, Iowa City, IA, USA

Abstract:
The study of the Earth's aurora has been underway since the beginning of the space-age, yet significant challenges to our understanding of the underlying physics remain to this day. This is undoubtedly because the physics involved is fundamentally kinetic in nature making the plasma physics quite non-trivial. While the idea of a potential drop along the magnetic field line is now widely accepted, the detailed understanding of how this potential drop arises and evolves remains a key question. Among topics for discussion are the questions of the distribution of field-aligned potential drop along the field, the detailed, self-consistent modelling of this region, and the role which waves, particularly Alfven waves, play in the Earth's auroral zone.

Name: Mike Liemohn

Title: The challenges associated with near-Earth nightside magnetospheric current systems

Author(s): Michael W. Liemohn[1], Natalia Yu. Ganushkina[1,2], Roxanne M. Katus[1,3], Raluca Ilie[1], Daniel T. Welling[1], Lois. K. Sarno-Smith[1], Darren L. De Zeeuw[1]

Affiliation(s):

1 = Department of Atmospheric, Oceanic, and Space Sciences, University of Michigan, Ann Arbor, MI USA
2 = Earth Observations Unit, Finnish Meteorological Institute, Helsinki, Finland
3 = Department of Physics, West Virginia University, Morgantown, WV, USA

Abstract:
A number of distinct current systems exist in the near-Earth nightside magnetosphere, especially during active times when fresh plasma is continuously or sporadically injected from the tail. These systems include the eastward and westward symmetric ring current, the partial ring current, the banana current, and the cross-tail current, including its transient diversion into the ionosphere as the substorm current wedge. Identifying and properly describing the morphology, intensity, and timing of these current systems is a difficult task with present-day observations, yet this is a critical issue because the closure path of these currents is related to the type and magnitude of nonlinear feedback on the dynamics of the geospace system. The recent history of near-Earth nightside current system definitions used by the community is presented, pointing out similarities and differences between various studies covering this topic. The possible scientific implications of misidentification of current closure path are explored, illustrating the unresolved nature of the issue and the need for further examination. It concludes with a discussion of some of the open questions regarding near-Earth nightside magnetospheric current systems.

Name: Graciela López Rosson

Title: EPT observations of flux enhancements and depletion of particle in the Radiation Belts after the March 17 event.

Author(s): G. López Rosson, V. Pierrard

Affiliation(s): Belgian Institute for Space Aeronomy, Université Catholique de Louvain

Abstract:
Geomagnetic storms can be unpredictable, as long as the response of the radiation belts.
Sometimes we observe flux enhancements mainly after Dst events (electrons), or SEP (protons and alpha particles), but there are also another times, which are less commons, when particles almost disappear from certain regions. These flux variations affect and change the configuration of the Van Allen Belts.
We present as an example of this situation the event occurred on March 17, 2015. The new instrument EPT (Energetic Particle Telescope), onboard ESA satellite PROBA-V, launched May 7, 2013, has observed this behavior: the particles flux enhancement, a depletion of particles after the increment, and finally a restructuration of the radiation belts.
We are trying to understand which mechanism are behind those variation, and why can be so different from an event to another one.

Name: Ramón E. López

Title: Unsolved magnetospheric problems and what we can learn from global MHD simulations

Author(s): Ramón E. López

Affiliation(s): Department of Physics, The University of Texas at Arlington, Arlington Texas, USA

Abstract:
There are a number of problems in magnetospheric physics for which there is still no general consensus, including the saturation of the transpolar potential, the factors that control the dayside merging rate, and how and why substorms occur. Many of these phenomena have their counterparts in the behavior of global MHD models, suggesting that there are processes working on the MHD scale that can provide the answers to these questions, even if essential physics is missing. For example (and most notably) ideal MHD codes do not have the physics of reconnection in them, but they mimic the role of reconnection in the real magnetosphere. This, in turn must tell us something fundamental about the ultimate drivers of the process that are being mimicked. In this presentation, I will discuss a variety of unsolved problems and present potential answers based on the results of global MHD studies. I will also present examples from global MHD that present challenges for our understanding of issues such as interhemispheric polar cap asymmetries and linear versus nonlinear behavior of the solar driver in producing magnetospheric output.

Name: Gang Lu

Title: Energetic and Dynamic Coupling of the Magnetosphere and Ionosphere During Geomagnetic Storms

Author(s): Gang Lu

Affiliation(s): High Altitude Observatory, National Center for Atmospheric Research

Abstract:
Earth's magnetosphere and ionosphere are intrinsically coupled via magnetic field lines. During geomagnetic storms, strong electric fields and currents are transmitted between the magnetosphere and high-latitude ionosphere, providing an important source of energy and momentum for the coupled system. Enhanced energetic particles from the magnetosphere penetrate into the ionosphere and upper atmosphere where they produce additional ionization and heating to affect the chemistry and dynamics of these regions. This paper will discuss the global energy portioning in the high-latitude ionosphere and in the inner magnetosphere based on various direct and indirect observations, together with the aid of numerical simulations. We will also assess and compare the impact of different energetic particles (e.g., auroral precipitating particles of less than 30 keV versus radiation belt and ring current particles of greater than 30 keV) on the ionosphere and thermosphere.

Name: Gian Luca Delzanno

Title: Future beam experiments in space with plasma contactors: how do we get the charge off the spacecraft?

Author(s): Gian Luca Delzanno[1], Joseph Borovsky[2], Michelle Thomsen[1], David Moulton[1], Elizabeth MacDonald[3], Brian Gilchrist[4]

Affiliation(s): 1 Los Alamos National Laboratory, 2 Space Science Institute, 3 NASA Goddard, 4 University of Michigan

Abstract:
The idea of using a high-intensity electron beam to actively probe magnetic field line connectivity in space has been discussed since the 1970's. However, its experimental realization onboard a magnetospheric spacecraft has never been accomplished because of serious spacecraft charging problems. Unlike the case of beam experiments in the ionosphere, the tenuous magnetospheric plasma cannot provide the return current necessary to keep the spacecraft charging under control and alternative pathways must therefore be sought. One such idea uses a high-density contactor plasma to aid beam emission.

We perform Particle-In-Cell simulations to investigate when a high-intensity electron beam can be emitted from a magnetospheric spacecraft. We study the release of a contactor plasma before and after beam emission, with contactor current larger than the beam current. After an initial transient controlled by the size of the initial contactor cloud, the spacecraft potential can settle into conditions that allow beam emission. A physical explanation in terms of the Child-Langmuir law is presented: the spacecraft can emit net positive charge off the quasi-spherical contactor cloud, thus overcoming the space-charge limitations typical of ion beam emission. We conclude that this scenario offers a pathway for future electron beam experiments in the low-density magnetosphere.

Name: John Lyon

Title: Understanding Flow Channels

Author(s): John Lyon[1], Michael Wiltberger[2], Viacheslav Merkin[3], Mikhail Sitnov[3]

Affiliation(s):1- Dartmouth College, 2- HAO/NCAR, 3-Applied Physics Laboratory

Abstract:
Flow channels are one name for the high speed, transient flows seen usually in the mid tail also known as bursty bulk flows (BBF). The head of the BBF/Flow channel is a dipolarization front (DF). It is now generally understood that the flow channels are regions where the flux-tube volume is reduced, leading to an interchange instability that sends plasma from the deeper tail toward the inner magnetosphere. Global MHD simulations have reproduced many of the features of BBF's, but leave a number of questions unanswered. What is the relation of reconnection to their formation, are BBF's unique events or do they create conditions for subsequent BBF's to follow the same channel, what controls how far the flow channels penetrate the magnetosphere, and what effect does ionospheric oxygen have of the channels? We will highlight agreements and disagreements between simulations, both MHD and kinetic, and observations. We will discuss how the simulations have enhanced our understanding and the areas in which uncertainty and further work are needed.

Name: Larry Lyons

Title: The day-night connection: Extent of driving via meso-scale flow channels?

Author(s): Larry Lyons, Toshi Nishimura, Ying Zou, Boyi Wang, Bea Gallardo-Lacourt

Affiliation(s): Department of Atmospheric and Oceanic Sciences, UCLA

Abstract:
It is now reasonably well known that meso-scale channels of fast flow, consisting of reduced entropy plasma, make a major contribution to nightside space weather disturbances along nightside plasma sheet field lines. New evidence from ground-based radars and all-sky imagers (ASIs) is now suggesting that such flow channels are driven by channels of enhanced flow that impinge upon the nightside plasma boundary, leading to localized region of localized, driven reconnection. Furthermore, we have obtained preliminary evidence from radars, ASIs, and polar orbiting spacecraft that the polar cap flow channels can originate from localized reconnection occurring on the dayside. If the above suggestions are found to be true, it would imply that a dayside-nightside connection via flow channels makes a major contribution to the driving of Space Weather.

Name: Ian R. Mann

Title: Impacts of inward and outward ULF wave radial diffusion on the Van Allen belts: In, out, in, out, you shake it all about…… that's what it's all about!

Author(s): I.R. Mann[1,2], L.G. Ozeke[1], K.R. Murphy[2], I.J. Rae[3].

Affiliation(s):

[1]University of Alberta, Department of Physics, Edmonton, Canada.
[2]NASA, Goddard Space Flight Center, Greenbelt, USA.
[3]University College London, Mullard Space Science Laboratory, Holmbury St. Mary, United Kingdom.

Abstract:

During geomagnetic storms, the power in ultra-low frequency (ULF) waves can be orders of magnitude larger than that predicted by statistics determined from an entire solar cycle. This is especially true during the main phase and early recovery phase. These periods of enhanced storm-time ULF wave power can have significant impacts on the morphology and structure of the Van Allen belts. Either fast inward or outward radial diffusion can result, depending on the profiles of the electron phase space density and the outer boundary condition at the edge of the belts. Small changes in the time sequence of powerful ULF waves, and the time sequence of any magnetopause shadowing and the recovery of plamasheet sources relative to the ULF wave occurrence, has a remarkable impact on the resulting structure of the belts. The overall impact of the enhanced ULF wave power is profound, but the response can be very different depending on the available source flux in the plasmasheet. We review these impacts by examining seemingly different storms during the Van Allen Probe era and whose dynamics can largely be characterised by changes in the time sequence described above.

Name: A. Masson

Title: A few unresolved problems in magnetopsheric Physics uncovered by Cluster

Author(s): **A. Masson**[1], C.P. Escoubet[2], H. Laakso[2]

Affiliation(s):
[1] ESAC/ESA, Madrid, Spain
[2] ESTEC/ESA, Noordwijk, The Netherlands

Abstract:
Needless to say that over the last 15 years, the ESA/NASA Cluster mission has revolutionized magnetospheric Physics. Data collected by the first constellation of four magnetospheric spacecraft flying in formation has indeed enabled a leap forward in our knowledge of the cusp region, magnetotail dynamics, magnetic reconnection at the magnetopause and in the tail, bow shock structure and dynamics, foreshock cavities, solar wind turbulence, auroral acceleration region dynamics, the role and dynamics of oxygen outflow, the estimation and the role of cold plasma, kelvin-helmholtz waves at the magnetopause and their role in plasma entry etc...
But of course, this leap forward does not mean that everything is solved, as always: more questions than answers. This talk will focus on a few unresolved problems in magnetopsheric Physics uncovered by Cluster, or at least where Cluster has contributed significantly, including: solar wind turbulence, magnetic reconnection, ion outflow and auroral acceleration region.

Name: Robert L. McPherron

Title: What determines when and where reconnection begins”

Author(s):
Robert L. McPherron

Affiliation(s):
Department of Earth, Planetary, and Space Sciences
University of California Los Angeles
Los Angeles, CA 90095-1567

Abstract:
Statistical studies of auroral breakup and ground magnetic perturbations show that substorm onset usually occurs near 23 local time. If one accepts that reconnection and associated flows are the cause of substorm onset, then an answer to the question of where, when and why reconnection occurs in the tail is essential to understanding geomagnetic activity. Studies in the tail indicate that the most probable location for reconnection is in a thin current sheet ~22 Re behind the Earth about 7 Re towards the dusk flank. Substorms typically occur within one hour after a southward turning and often at the time of a rapid northward turning of the IMF. In this presentation we will review evidence that supports these statements and discuss mechanisms postulated by authors of these works to explain their results.

Name: Steve Milan

Title: What controls the dayside reconnection rate?

Author(s): Steve Milan

Affiliation(s): University of Leicester

Abstract:
Magnetospheric dynamics are driven by the accumulation and release of open magnetic flux by magnetic reconnection at the dayside magnetopause and in the magnetotail. Understanding the rate at which magnetopause reconnection occurs, at both low latitudes during southward IMF and at high latitudes during northward IMF, is fundamental for predicting and quantifying all subsequent magnetospheric dynamics. This talk will explore what we know, and especially what we don't know, about the factors that control the magnetopause reconnection rate.

Name: Thomas Earle Moore

Title: How do solar wind and ionospheres interact via reconnection?

Author(s): T E Moore, G A Collinson, K S Garcia-Sage, G V Khazanov

Affiliation(s): NASA Goddard Sp. Flt. Ctr. Code 670

Abstract:
Dayside reconnection redirects momentum and energy from the solar wind into the ionosphere, driving super-thermal flows of plasma relative to atmospheric gas, dissipating energy in both, and producing upwelling and massive plasma backflows. This is essentially an “ion pickup” process, akin to solar wind ion pickup in the absence of a magnetosphere, but it has yet to be clearly observed, theoretically analysed or predictively simulated. Ion pickup taps bulk flow energy to create a source of plasma wave free energy, whereas mainstream thinking about ionospheric heating and outflow casts the ionosphere in the role of a simple wave energy sink. This fundamental Heliophysical process also appears to produce observed ion power law tails, or “kappa” distributions. In the reverse direction, the heating and backflow of ionospheric plasma injects into the magnetosphere a cooler and denser cloud of material that is predicted to have both bulk MHD and plasma physical impacts on dayside and nightside reconnection. New observations of this “feedback” on the configuration and rate of reconnection are anticipated from the NASA Magnetospheric Multiscale mission, commissioning of which is planned for completion by Sept. 2015.

Name: Pablo S. Moya

Title: On the relationship between geomagnetic storms and radiation belts dynamics: A Van Allen Probes study versus local time and geocentric distance during magnetic storms.

Author(s): Pablo S. Moya(1,2,3), Victor A. Pinto(4), Adolfo F. Viñas(1), and David G. Sibeck(1)

Affiliation(s):

(1) NASA Goddard Space Flight Center, Heliophysics Science Division, Greenbelt, MD, USA.
(2) Department of Physics, Catholic University of America, Washington, DC,USA.
(3) Departamento de Física, Facultad de Ciencias, Universidad de Chile, Santiago, Chile.
(4) Department of Atmospheric and Oceanic Sciences, University of California–LosAngeles, Los Angeles, CA, USA.

Abstract:
The response of the inner magnetosphere to different geomagnetic storm and solar wind conditions is still not fully understood. For example, electron fluxes in the outer radiation belt can be enhanced or depleted depending on the energy of the particles, and the phase or driver of the storm. In addition, the time scale of the process can vary from minutes to several days. Wave-particle interaction (such as stochastic diffusion or resonant acceleration) are believed to play an important role regulating the dynamics of the particles. However, despite decades of intense theoretical and observational studies, a definitive framework for the wave-particle interactions and the resulting effects in the magnetospheric dynamics remains an open problem. To progress towards a better understanding of the inner magnetosphere dynamics, a complete characterization of the electromagnetic fluctuations during storm should be relevant. Here, using Van Allen Probes observations we address the problem, present our findings and the questions arising from them, on the importance of possible relations between electrons in the outer belt and the properties of magnetic fluctuations during storms depending on local time, geocentric distance and storm phase.

Name: Kyle R. Murphy

Title: A study of storm-time ULF waves and radiation belt electrons during different solar wind drivers

Author(s): Kyle R. Murphy[1], Ian R. Mann[2,1], David G. Sibeck[1], Louis G. Ozeke[2], I. Jonathan Rae[3]

Affiliation(s):
[1] NASA Goddard Space Flight Centre
[2] University of Alberta
[3] Mullard Space Science Laboratory, University College London

Abstract:
ULF waves play an important role in the dynamics of radiation belt electrons during geomagnetic storms through the action of ULF wave radial diffusion and potentially through coherent drift-resonance interactions. Here we present a statistical study of the ULF wave power and the response of the radiation belts during two different types of geomagnetic storms, those driven by coronal mass ejections (CMEs) and those driven by co-rotating interaction regions (CIRs). Statistical studies of geomagnetic storms have typically concentrated on solar wind parameters and the response of geomagnetic indices, such as Dst, to energy input from the solar wind. Using an array of ground-based magnetometers and the low altitude SAMPEX satellite we investigate the magnetospheric response to storm-time driving, including ULF wave power, trapped radiation belt electrons and losses through magnetopause shadowing. Finally we characterise the timescales of both energization and loss during different types of geomagnetic storms for use in forecasting models of the radiation belts.

Name: N. Østgaard

Title: Unanswered questions regarding solar wind - magnetosphere interaction.

Author(s): N. Østgaard (1), J.P. Reistad (1), P. Tenfjord (1), K. M. Laundal (1), S. Haaland (1,2), K. Snekvik (1), S. Milan (1,3)

Affiliation(s):

1) Birkeland Centre for Space Science, Department of Physics and Technology, University of Bergen, Allegt 55, N-5007, Norway

2) Max-Planck Institute, Gottingen, Germany

3) Department of Physics and Astronomy, University of Leicester, UK

Abstract:
From simultaneous conjugate auroral imaging we have learned that when IMF has a By component, the auroral features in the two hemispheres will not be at the nominal conjugate foot points. The displacement of foot points are strongly correlated to the IMF By or clock angle, which implies that there is a By component on the closed field line as well. From modeling efforts we have learned that the By component in the closed magnetosphere is not a result of IMF By ´penetration´ but is induced by the asymmetric pressure in the lobes when the IMF has a By component. Some studies indicate that it will take an hour or more to induce this By component and consequently asymmetric foot points. Our own investigations based on auroral imaging and modeling indicate that this is established after 10-20 minutes. So this raises the question, what is the actual response time of the magnetosphere-ionosphere to changes in the dawn-dusk component of the IMF. The question is important because such an induced By component controls convection patterns and possibly strength of Alfven generated aurora and currents.

Auroral imaging of the two hemispheres has also shown that there is a statistical significant brightness difference in the dusk side polar aurora correlated with an IMF Bx component. We have interpreted this difference in terms of a difference in solar wind dynamo in the two hemispheres. From auroral imaging we can only establish this for upward Birkeland (region 1) current (precipitating electrons) in the dusk side. This difference means that the energy input in the two polar caps will be different, but we do not know how large this difference can be, and we do not know if a similar difference exists for the downward Birkeland (region 1) currents in the dawn sector.

Polar arcs or theta aurora have been known to be a phenomenon that exists during northward IMF conditions.
Recently, it was shown by Fear et al., 2015 (Science) that the electrons producing the polar arc were on closed field lines. However, polar arcs have also been shown to be a non-conjugate phenomenon (e.g., Ostgaard et al. 2007), which raises the question: Are polar arcs on closed or open field lines?

Name: Jonathan Rae

Title: What causes substorm onset?

Author(s): I. J. Rae [1], C. E. J. Watt [2], C. Forsyth [1], K. R. Murphy [3], N. M. E. Kalmoni [1], I. R. Mann [4]

Affiliation(s): [1] Mullard Space Science Laboratory, University College London, UK [2] Department of Meteorology, University of Reading, UK, [3] Goddard Space Flight Center, NASA, USA, [4] Department of Physics, University of Alberta, Canada.

Abstract:
The magnetospheric substorm is arguably the major mode of variability in near-Earth Space which, apparently unpredictably, dissipates a considerable and variable amount of energy into the near-Earth magnetosphere and ionosphere. What process or processes determine substorm onset and its evolution is a key unresolved problem in magnetospheric physics, although it is evident that both near-Earth plasma instability and magnetotail reconnection play a role in this energy conversion process.

Recent work has highlighted that the growth and structuring of the substorm onset arc has all the hallmarks of a plasma instability operating in space. We present both specific case studies and statistics of the conditions for plasma instability in the magnetotail using THEMIS and Cluster conjunctions with ground-based instrumentation. We use these observations to diagnose the source of the instability and suggest ways to provide a unique solution to the substorm onset problem.

Name: Geoff Reeves

Title: Energy dependent dynamics of keV and MeV electrons in the slot and inner zone

Author(s): Geoffrey D. Reeves, Reiner H. W. Friedel1 Brian A. Larsen, Ruth M. Skoug Herbert O. Funsten, Seth G. Claucepierre, Joseph F. Fennell, Drew L. Turner, Mick Denton, and J. Bernard Blake

Affiliation(s): 1) Space Science and Applications Group, Los Alamos National Laboratory, Los Alamos, NM 87545
2) The New Mexico Consortium, Los Alamos, NM 87544
3) The Aerospace Corp., P.O. Box 92957, Los Angeles CA 90009
4) The University of Colorado, Boulder CO, 80303

Abstract:
We have analyzed the evolution of the radiation belts as a function of energy and time during transitions from quiet to active/enhanced times and their return from enhanced to quiescent states. The quiet state shows a triangle-shaped inner zone that extends to higher L at lower energies and a "wave-like" outer zone with an energy-dependent inner boundary. The active state shows that the slot is filled with electrons at energies up to some threshold (typically hundreds of keV but, by times, many MeV). For energies that do not penetrate the slot the inner zone is unchanged and the outer zone shows an energy-dependent inner boundary that approximates a straight line in log(energy) vs L. Our analysis of these deep particle injections shows several striking features: (1) In the outer zone, at lower energies there tend to be more electron enhancements than at higher energies. Or, said another way, a given event is more likely to produce an enhancement of lower energy electrons than it is to produce an enhancement at the higher energies. (2) Events that fill the slot region are more common at lower energies. While there were no slot-filling events in 2013 at 1.5 MeV there were approximately 7 slot-filling events at 459 keV there were at least 24 seen at 234 keV. Another feature is that at lower energies the fluxes in the inner zone become comparable to or greater than the fluxes in the outer zone. (3) Enhancements of electrons in the inner zone are more common at lower energies. In addition, at lower energies, the inner zone extends to higher L-shells and consequently the slot region is also at higher L-shells. (4) Even when events to not fully fill the slot region, enhancements at lower-energies tend to extend to lower L-shells than higher energies.
The return of the radiation belts from their enhanced state to their quiescent state is dominated by losses that have energy- and L- dependencies that are consistent with loss due to hiss. We discuss the implications of these new observations for our understanding of radiation belt acceleration and transport.

Name: Craig J. Rodger

Title: What causes precipitation of radiation belt electrons into the atmosphere?

Author(s): Craig J. Rodger (1), Mark A. Clilverd (2), Aaron Hendry (1), Bonar Carson (1), and Jason J. Neal (1)

Affiliation(s): (1) Department of Physics, University of Otago, Dunedin, New Zealand
(2) British Antarctic Survey (NERC), Cambridge, United Kingdom

Abstract:
During geomagnetic storms there is strong precipitation of energetic and relativistic electrons into the polar atmosphere. This is expected, and supported by theory where whistler-mode and EMIC waves pitch angle scattering through strong diffusion. However, different theoretical approaches seem to predict significantly different precipitation characteristics. For example, there seems little agreement amongst theorists if EMIC waves can indeed drive significant relativistic precipitation. The lower-energy for EMIC wave-electron interactions varies from values so high as to be unrealistic in terms of the electrons present in the belts, down to just a few hundred keV. As another example, the literature contains suggestions that whistler mode chorus can drive rapid strong diffusion to produce relativistic electron microbursts, but also evidence that chorus can only lead to weak diffusion of relativistic electrons. In this presentation we will review some of these apparent inconsistencies.

Name: David G. Sibeck

Title: SMILE: The Solar wind Magnetosphere Ionosphere Link Explorer

Author(s): D. G. Sibeck[1], M. R. Collier[1], B. Walsh[2], G. Branduardi-Raymont[3], C. Wang[4], and the SMILE team

Affiliation(s):
[1] NASA Goddard Space Flight Center, Greenbelt, MD, USA
[2] Boston University, Boston, MA, USA
[3] Co-PI, UCL MSSL, Holmbury St. Mary, Dorking, Surrey, UK
[4] Co-PI, NSSC, State Key Laboratory of Space Weather, Beijing, China

Abstract:
Understanding the nature of the solar wind-magnetosphere interaction is central to heliophysics. The size, shape, and structure of the magnetopause, cusp, and auroral ovals provide crucial information concerning the evolving nature of this interaction. SMILE, the Solar wind Magnetosphere Ionosphere Link Explorer mission will employ a wide field-of-view soft X-ray imager (SXI) to track the global location, motion, and structure of the bow shock, magnetopause, and cusps and an ultraviolet imager (UVI) to track the size, shape, and structure of the entire auroral oval. A top hat light ion electrostatic plasma analyser (LIA) and a pair of three-axis fluxgate magnetometers (MAG) will provide the simultaneous solar wind plasma and interplanetary magnetic field observations needed to make the three-year long high-inclination, high-apogee mission self-standing. The soft X-ray imager relies on novel lobster-eye optics to detect the soft X-rays generated when high charge state solar wind ions exchange charges with exospheric neutrals in the cusps and dayside magnetosheath. In concert with the other instruments, the science problems to be addressed include the location and rate of reconnection on the dayside magnetopause as a function of solar wind conditions, the nature of the substorm cycle, and the development of geomagnetic storms. This joint ESA-China mission is currently in its initial study phase. If approved, launch is scheduled for 2021. The mission will enable a host of correlative studies with ground- and space-based observatories, which this talk seeks to initiate.

Name: Marina Stepanova

Title: Turbulent transport and evolution of kappa distribution in the plasma sheet

Author(s): M. Stepanova(1), E.E. Antonova(2,3)

Affiliation(s): (1) Physics Department, Universidad de Santiago de Chile (USACH), Santiago, Chile
(2) Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University, Moscow, Russia.
(3) Space Research Institute, Russian Academy of Science, Moscow, Russia.

Abstract:
We studied the evolution of ion and electron distribution functions, approximated by kappa distributions, in the plasma sheet with the distance from the Earth using the data of the THEMIS spacecraft mission. Five events were used to calculate the main parameters of the kappa distribution. For these events at least four spacecraft were aligned along the tail between approximately 7 and 30 Earth radii. It was found that for the majority of events the values of kappa increase tailwards. The observed radial profiles could be related to the inner magnetosphere sources of particle acceleration and to the net tailward transport of particles. This net transport is the result of a balance between the average regular bulk transport toward the Earth and the turbulent transport by eddies in the tailward direction.

Name: Michelle F. Thomsen

Title: Outstanding Questions in Saturn's Magnetosphere

Author(s): Michelle F. Thomsen

Affiliation(s): Planetary Science Institute, Tucson, AZ, USA

Abstract:
Nearly eleven years after the insertion of the Cassini spacecraft into orbit around Saturn, we have learned a great deal about the structure and dynamics of the second-largest planetary magnetosphere in our solar system. In many ways similar to Earth's magnetosphere but in several crucial ways quite different, Saturn broadens our understanding of the range of physical processes that can govern magnetospheric behavior. In particular, we see how plasma sources internal to the magnetosphere can combine with rapid planetary rotation to produce interesting modes of transport, acceleration, and loss. However, there remain fundamental questions about these processes at Saturn: where they operate, what triggers them, whether they can quantitatively account for necessary plasma shedding, how they are regulated, and what the influence of the solar wind and of the ionosphere might be. At least some of the many open questions about Saturn's magnetosphere will be described in this talk.

Name: Drew L Turner

Title: Do magnetospheric scientists take the magnetosheath for granted?

Author(s): D. L. Turner1, M. Archer2, H. Hietala2, F. Plaschke3, L. B. Wilson III4, and N. Omidi5

Affiliation(s): 1. The Aerospace Corporation; 2. Imperial College London; 3. IWF Graz; 4. NASA Goddard Space Flight Center; 5. Solana Scientific

Abstract:
In this presentation, we will focus on unanswered questions concerning the physics of Earth's magnetosheath with the goal of addressing the more contemplative question of whether magnetospheric scientists take the magnetosheath for granted. Topics and outstanding questions that we will focus on include: i) differences between solar wind and sheath plasmas; ii) the nature and effects of turbulence in the magnetosheath and the effect this has on the magnetosphere; iii) mirror mode wave activity in the sheath and its affect on the magnetosphere; iv) differences between magnetosheath plasma downstream of the quasi-perpendicular vs. quasi-parallel bow shock; v) how pressure variations, both inherent in the solar wind and self-generated in the ion foreshock and magnetosheath itself, transmit through the sheath and impact the magnetopause; vi) the nature of the sheath and its interaction with magnetospheric plasma far down-tail. On each of these topics, we will ask how particular conditions and various structure scales in the sheath may lead to variations in reconnection at the magnetopause, plasma transport across the magnetopause, and ultimately, how the solar wind drives magnetospheric activity.

Name: Juan Alejandro Valdivia

Title: Relevance of the thermally induced fluctuations in the magnetosphere

Author(s): J. A. Valdivia[(1)], R. Navarro[(2)], M. Stepanova[(3)]

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Abstract:
Recently, there has been quite a lot of discussion about the relevance of thermally induced magnetic fluctuations in plasma, particularly in laboratory and solar wind plasmas. These fluctuations are produced by the random motion of particles in the plasma so that their understanding requires a kinetic treatment that relies on an extension of the fluctuation-dissipation theorem. In the solar wind, this treatment has been able to quantitatively describe their relevance to the observed magnetic fluctuations [Navarro et al., PRL, 2014] for anisotropic plasmas. This analysis brings the question as to the relevance of these thermally induced fluctuations in the magnetospheric setting, in particular related to situations where the anisotropy of the particles becomes relevant, such as the particle acceleration and wave propagation in the ring current, precipitation in auroras, anisotropic kappa-like distribution in the tail, etc. This analysis could be useful in the understanding of the turbulence and wave excitation in the magnetosphere.

Name: Vytenis M. Vasyliūnas

Title: Physical nature of near-Earth magnetotail reconnection events

Author(s): Vytenis M. Vasyliūnas

Affiliation(s): Max-Planck-Institut für Sonnensystemforschung

Abstract:
An important (and controversial) part of substorm development is the process known as near-Earth X-line formation, onset of magnetotail reconnection, plasmoid formation/ejection, and other names. The phenomenology of the associated changes in magnetic field, plasma flow, and energetic particle populations is reasonably well established from observations, but the underlying physical process itself is poorly understood. Outstanding open questions include: (1) What do we mean by reconnection when it is assumed to originate in the region of closed magnetic field lines? (2) What is the global magnetic topology of a plasmoid? of a magnetic flux rope? are they related? (3) Can the conventionally drawn two-dimensional plasmoid (with field lines that trivially close on themselves) be generalized to three dimensions? (4) How do we represent a magnetic topology that is intrinsically three-dimensional, has no plane of symmetry, and in general has only null points but no null lines? These questions involve fundamental issues about the meaning of magnetic topology and its role in reconnection.

Name: Brian Walsh

Title: The role (or lack there of) of the magnetosphere in solar wind-magnetosphere coupling

Author(s): B. M. Walsh[1], D. T. Welling[2]

Affiliation(s): [1]Boston University, [2]University of Michigan

Abstract:
Spanning back to the beginning of the space physics discipline, one of the primary goals has been to try to predict the occurrence and magnitude of geomagnetic disturbances. Over time, the thrust has matured, and recently a debate has developed as to whether parameters within a magnetosphere can impact the efficiency of coupling of energy from the solar wind into the magnetosphere. On one hand, it has been suggested that plasma properties within the magnetosphere may decrease the efficiency of reconnection and therefore the coupling of energy from the solar wind into the magnetosphere. Alternatively, some models predict the magnetosheath will adjust to accommodate the changes within the magnetosphere and will maintain the same reconnection rates and coupling of energy. Spacecraft observations from the THEMIS mission and global multi-fluid BATSRUS/MHD modelling will be presented to test these competing theories.

Name: Clare Watt

Title: Cross-energy coupling: how is energy transferred from low- to high-energy particles in the magnetosphere?

Author(s): C. E. J. Watt[1], C. Forsyth[2], I. J. Rae[2]

Affiliation(s): [1] University of Reading, UK [2] Mullard Space Science Laboratory, University College London, UK

Abstract:
One of the ways electrons can be accelerated to relativistic speeds in the Earth's Outer Radiation Belt is via the transfer of energy from ELF and VLF waves through wave-particle interactions. These waves are thought to be generated by sources of free energy in the plasma, e.g. anisotropy at lower energies (i.e. 1-100keV). The pockets of free energy in the magnetosphere develop due to particle drift through the inhomogeneous magnetic field, particle precipitation, magnetospheric compression or combinations of these processes. In other words, the sources of free energy driving electromagnetic wave instabilities, that in turn drive particle acceleration in the Outer Radiation Belt, are inextricably linked to the large-scale dynamics of the magnetosphere. We ask the question whether it would be better to construct wave models for Radiation Belt dynamics parameterised by the behaviour of 1-100keV plasma in the magnetosphere, rather than by using typical parameterisations such as magnetospheric activity. We use observations from Cluster, THEMIS and Van Allen Probes to make our case. We seek methods that can associate Radiation Belt dynamics more specifically to the unique evolution of the magnetosphere during each geomagnetic storm or geoeffective Space Weather event.

Name: Daniel Weimer

Title: Unsolved problems in ionospheric conductivity

Author(s): Daniel Weimer

Affiliation(s): Virginia Tech

Abstract:

This presentation will addresses the question of "What are the actual values of ionospheric conductivity and how do they vary?" The physical formulas that are used to calculate ionospheric conductivity are thought to be well understood, as well as the ionosphere models used to calculate the values of the Hall and Pedersen conductivity. On the other hand, the various numerical methods that require conductivity values, ranging from data assimilation to MHD models, seem to end up over or under-estimating the electric potentials or magnetic perturbations. There is also the question of how variations in conductivity in both hemispheres influences the coupling with the magnetosphere. A review summary of what is known, the problems, and what is unknown will be presented.

Name: Daniel Welling

Title: Ionospheric Outflow and the Magnetosphere: a Poorly Understood, Non-Linear Relationship

Author(s): Daniel Welling

Affiliation(s): University of Michigan

Abstract:
In-situ observations of heavy ions in the plasma sheet and ring current have repeatedly demonstrated the importance of the ionospheric source of magnetospheric plasma. Only recently, however, have first-principles-based global models included this dynamic plasma source. These studies have revealed a plethora of new processes that characterize the ionosphere not merely as a source of plasma, but as an integral part of the non-linear magnetosphere-ionosphere system. This presentation highlights the outstanding unsolved problems in this area, including the effects of outflow on reconnection and cross polar cap potential, the potential influence of heavy ion outflow on substorm and sawteeth oscillation development, and magnetosphere/outflow feedback loops.

Name: Lynn B. Wilson III

Title: Particle Acceleration through Wave-Particle Interactions

Author(s): Lynn B. Wilson III

Affiliation(s): NASA Goddard Space Flight Center

Abstract:
What is the relative importance of small-scale, microphysical plasma processes to those occurring on macroscopic scales? This is a fundamental and unresolved question in plasma and astrophysical research. In my talk, I will highlight and explore some work we have done showing the importance of wave-particle interactions in the macroscopic dynamics of the terrestrial radiation belts, interplanetary shocks, and the terrestrial bow shock. In each region, we find that small-scale waves can play an important role in the evolution of these large-scale regions and phenomena. For instance, in the radiation belts, we observed whistler mode waves with (peak-to-peak) amplitudes exceeding 8 nT. When we estimated the maximum kinetic energy gain, using the fully nonlinear equations, of an electron interacting with this wave mode, we found an energy change between ~30-70 MeV. When we compare to the linear estimate of the maximum energy gained by accelerating through the electric potential of one wavelength, we find values ≤ 3 keV. This example is illustrative of the importance of electromagnetic waves -- found in every heliospheric environment we have explored -- in the large-scale dynamics of many other heliospheric and astrophysical phenomena.