AGU CHAPMAN CONFERENCE

Reykjavik, Iceland | 10–15 March 2013

Fundamental Properties and Processes of Magnetotails

AGU Chapman Conference on
Fundamental Properties and Processes of Magnetotails

Reykjavik, Iceland
10-15 March 2013

Conveners

Andreas Keiling, University of California, Berkeley, USA
Caitriona Jackman, University College London, U.K.
Peter Delamere, University of Alaska Fairbanks, USA

Program Committee

Colin Forsyth, Mullard Space Science Laboratory, U.K.
Denis Grodent, University of Liège, Belgium
James Slavin, University of Michigan, USA
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Larry Kepko, NASA/GSFC, USA
Mervyn Freeman, British Antarctic Survey, U.K.
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Norbert Krupp, Max-Planck-Institute, Germany
Tsugunobu Nagai, Tokyo Institute of Technology, Japan
Xianzhe Jia, University of Michigan, USA

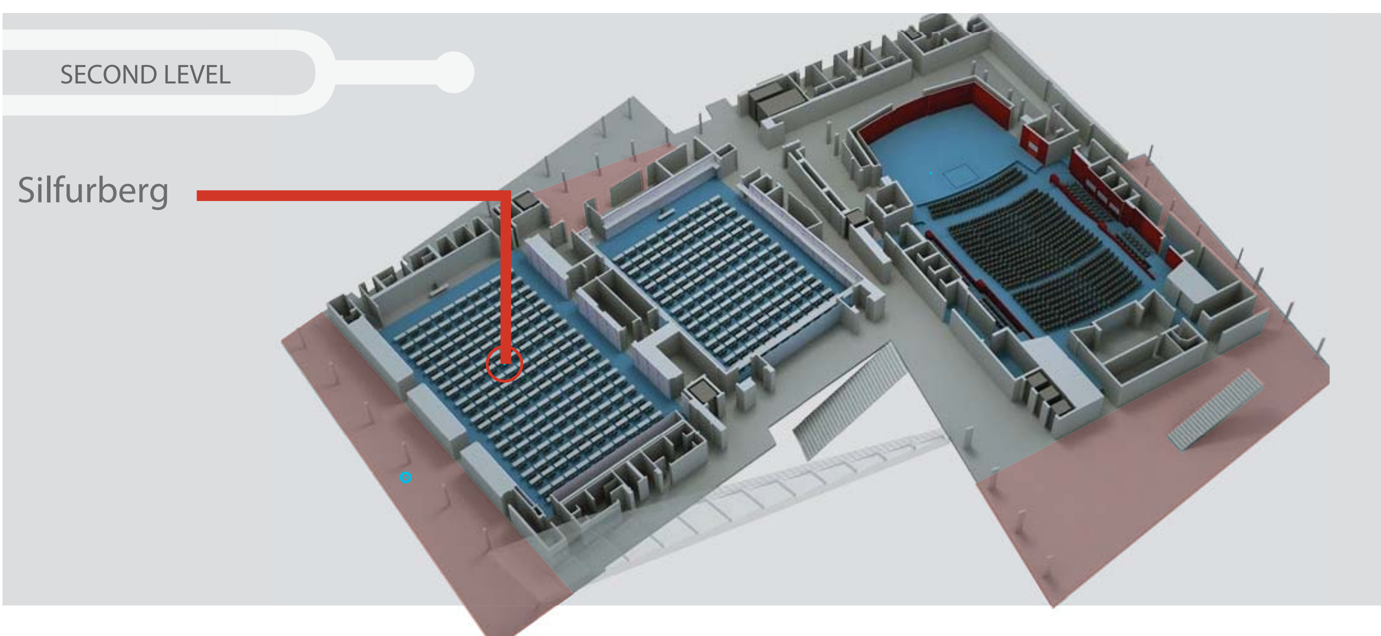
Supporters

The conveners wish to acknowledge the generous support for this conference.

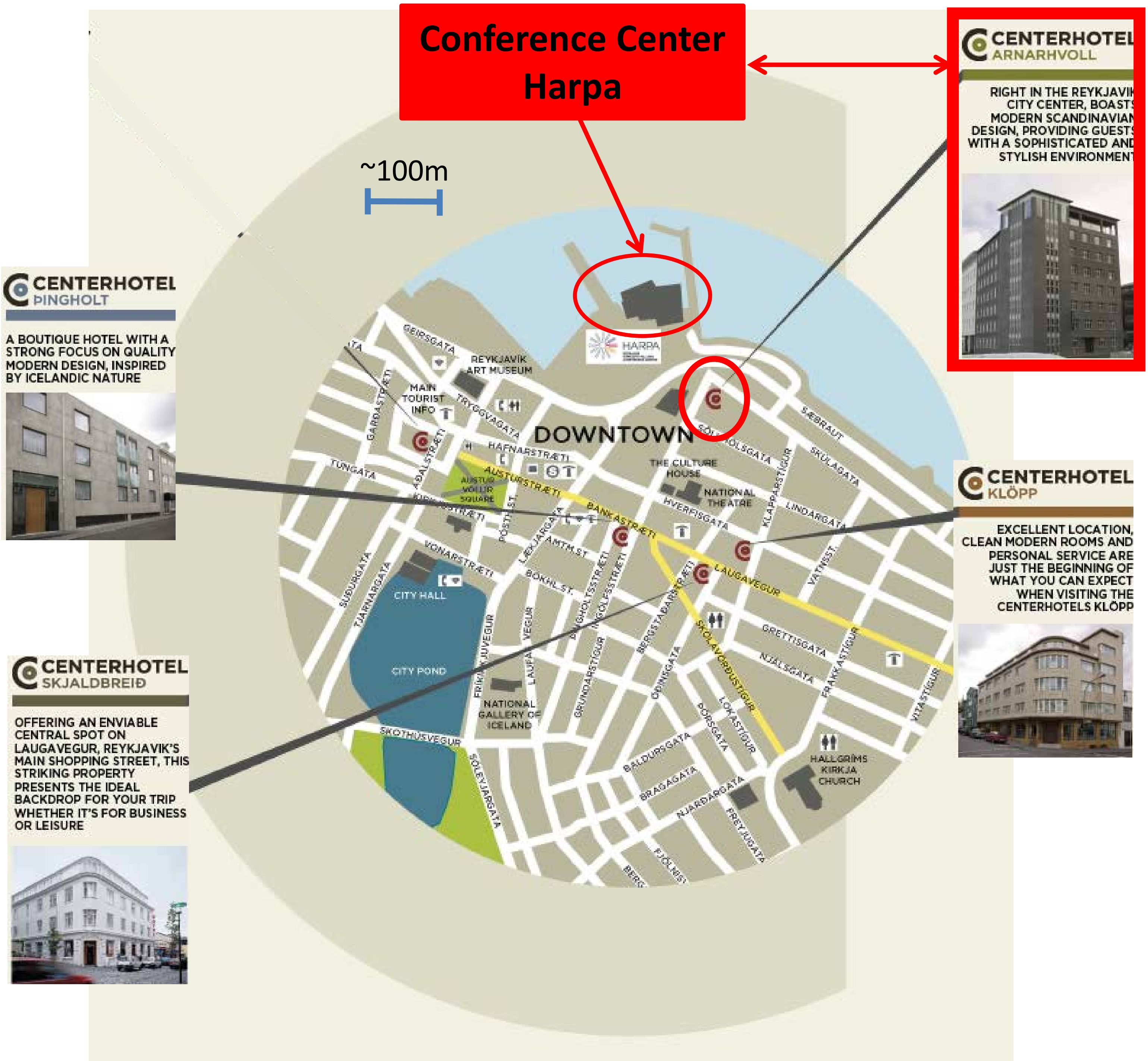
Note: Attendees at the Chapman conference may be photographed by AGU for archival and marketing purposes. No photography will be permitted during scientific sessions.

Harpa Concert Hall and Conference Center

Meeting Room: Silfurberg, Second Level



Center of Reykjavik



Meeting At A Glance

Sunday, March 10

1700h – 1900h	Welcome Reception at Arnarhvoll Hotel

Monday, March 11

0930h – 0945h	Welcome and Conference Information
0945h – 1115h	General Session – Tutorials I
1115h – 1145h	Coffee Break
1145h – 1330h	General Session – Tutorials II
1330h – 1430h	Lunch at the conference center
1430h – 1615h	General Session – External Drivers I
1615h – 1715h	Poster Session I/Coffee Break
1715h – 1730h	Special Session – Aurora Forecasts in Iceland
1730h – 1830h	Iceland Documentary

Tuesday, March 12

0930h – 0940h	Conference Information
0945h – 1115h	General Session – External Drivers II
1115h – 1145h	Coffee Break
1145h – 1310h	General Session – External Drivers III
1310h – 1330h	Discussion I
1330h – 1430h	Lunch at the conference center
1530h – 1800h	Guided City Walk
1815h – 1915h	Social Hour in center

Wednesday, March 13

0930h – 0940h	Conference Information
0945h – 1115h	General Session – Internal Responses I
1115h – 1145h	Coffee Break
1145h – 1330h	General Session – Internal Responses II
1330h – 1430h	Lunch at the conference center
1430h – 1630h	Poster Session II/Coffee Break
1630h – 1740h	General Session – Internal Responses III
1845h – 2130h	Banquet Dinner at the Perlan Restaurant

Thursday, March 14

0915h – 1330h	Field Trip 1: Golden Circle
1330h – 1430h	Lunch at the Geysir Hotel
1430h – 1530h	Geyser Walk
1545h – 1715h	General Session – Internal Reponses IV
1715h – 1730h	Coffee Break
1730h – 1845h	General Session – Internal Responses V
1845h – 1915h	Discussion II
1915h – 2100h	Dinner at the Geysir Hotel
2100h – 2230h	Bus ride back to hotels

Friday, March 15

0930h – 0940h	Conference Information
0945h – 1115h	General Session – Inner Coupling I
1115h – 1145h	Coffee Break
1145h – 1330h	General Session – Inner Coupling II
1330h – 1430h	Lunch at the conference center
1430h – 1520h	General Session – Inner Coupling III
1520h – 1550h	Discussion/Closing
1700h – 2100h	Field Trip 2: Blue Lagoon

Time	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Time
9:15							9:15
9:30		Welcome	Info (10 min)	Info (10 min)		Info (10 min)	9:30
9:45							9:45
10:00				Internal			10:00
10:15		**Tutorials I**	**External**	**Responses**		**Inner**	10:15
10:30			**Drivers II**	**I**	**Field Trip 1:**	**Coupling I**	10:30
10:45							10:45
11:00					**Golden Circle**		11:00
11:15		Coffee	Coffee	Coffee		Coffee	11:15
11:30		Break	Break	Break		Break	11:30
11:45							11:45
12:00			**External**	**Internal**			12:00
0:15		**Tutorials II**	**Drivers III**	**Responses**		**Inner**	0:15
0:30				**II**		**Coupling II**	0:30
0:45							0:45
1:00			**Discussion**				1:00
1:15							1:15
1:30 -		Lunch at	Lunch at	Lunch at	Lunch at	Lunch at	1:30 -
2:30		Harpa	Harpa	Harpa	Geysir hotel	Harpa	2:30
2:30							2:30
2:45					**Geyser**	**Inner**	2:45
3:00		**External**			**walk**	**Coupling III**	3:00
3:15		**Drivers I**		**Posters II**			3:15
3:30						**Discussion/**	3:30
3:45						**Closing**	3:45
4:00					**Internal**		4:00
4:15			**Guided**		**Responses**		4:15
4:30		**Posters I**	**city walk**		**IV**		4:30
4:45				**Internal**			4:45
5:00				**Responses**			5:00
5:15				**III**	Coffee Break	**Bus**	5:15
5:30	**Welcome**	**Iceland:**					5:30
5:45	**Reception**	**Aurora &**			**Internal**		5:45
6:00		**Documentary**			**Responses**		6:00
6:15					**V**	**Field Trip 2:**	6:15
6:30			**Social hour**				6:30
6:45			**in center**	**Bus**	**Discussion**	**Blue Lagoon**	6:45
7:00							7:00
7:15							7:15
7:30			**"Guided"**				7:30
7:45			**dinner**	**Banquet**	**Dinner**		7:45
8:00			**in center**	**at**	**at**		8:00
8:15			**(pay yourself)**	**"The Perl"**	**Geysir hotel**	**Meal box**	8:15
8:30						**in bus**	8:30
8:45							8:45
9:00					**Bus ride to**		9:00
9:15					**hotels**		9:15
9:30				**Bus**			9:30

SCIENTIFIC PROGRAM

SUNDAY, 10 MARCH

5:00 p.m. – 7:00 p.m. **Welcome Reception and Conference Information**

7:00 p.m. – 9:00 p.m. **Dinner on Your Own (Sunday)**

MONDAY, 11 MARCH

9:30 a.m. – 9:45 a.m. **Welcome Remarks**

General Session - Tutorials I
Presiding: Colin Forsyth
General Session

9:45 a.m. – 10:15 a.m. **Vytenis M. Vasyliunas** | The Magnetotail: An Unsolved Fundamental Problem of Magnetospheric Physics ***(INVITED)***

10:15 a.m. – 10:45 a.m. **Torbjorn Sundberg** | Tutorial: Mercury's Magnetotail ***(INVITED)***

10:45 a.m. – 11:15 a.m. **Vassilis Angelopoulos** | Perspectives of Earth's Magnetotail from an Integrated Heliophysics System Observatory ***(INVITED)***

11:15 a.m. – 11:45 a.m. **Morning Coffee Break (Monday)**

General Session - Tutorials II
Presiding: Michelle F. Thomsen
General Session

11:45 a.m. – 12:15 p.m. **Barry H. Mauk** | Jupiter's Magnetodisc: How is it Formed and Maintained? ***(INVITED)***

12:15 p.m. – 12:45 p.m. **Caitriona M. Jackman** | Saturn Tutorial ***(INVITED)***

12:45 p.m. – 1:15 p.m. **Christopher S. Arridge** | The Twisted Time-Dependent Magnetotails of Uranus and Neptune ***(INVITED)***

1:30 p.m. – 2:30 p.m. **Lunch (Monday)**

General Session - External Drivers I

Presiding: Mervyn P. Freeman
General Session

2:30 p.m. – 2:50 p.m.	**Simon Wing** | Solar Wind Entry and Transport at Earth's and Other Planetary's Magnetotail ***(INVITED)***
2:50 p.m. – 3:05 p.m.	**Andrew P. Walsh** | The Influence of IMF Conditions on Plasma Sheet Electron Pitch Angle Distributions
3:05 p.m. – 3:20 p.m.	**Theodore A. Fritz** | What Happens to the Cusp Electrons?
3:20 p.m. – 3:40 p.m.	**Michael Hesse** | Magnetic Reconnection in Different Environments: Similarities and Differences ***(INVITED)***
3:40 p.m. – 3:55 p.m.	**Suzanne M. Imber** | MESSENGER observations of dayside flux transfer events: Do they drive Mercury's Dungey cycle?
3:55 p.m. – 4:10 p.m.	**Norbert Krupp** | Energetic Particles in the Magnetotails of Jupiter and Saturn: A Comparison Using Galileo/EPD and Cassini/Mimi Data

4:15 p.m. – 5:15 p.m. Poster Session I/Coffee Break

Poster Hall

M-1	**Paul Cassak** | Reconnection with a Shear Flow and Applications to Solar Wind-Magnetospheric Coupling
M-2	**Shobhit Garg** | Dynamics of the Magnetosphere during an Extended CIR/HSS Storm Event
M-3	**Anita Kullen** | Non-Conjugate Polar Arcs - Auroral Observations and Tail Models
M-4	**Robert Fear** | The Formation of Transpolar Arcs by Magnetotail Reconnection
M-5	**Christopher M. Fowler** | Affects of Solar Wind and IMF Variability on the Magnetotail of Jupiter
M-6	**William Ames** | The lunar plasma wake in Earth's magnetotail
M-7	**Caitriona M. Jackman** | Investigating the Dynamics of Planetary Magnetotails: An overview of the work of ISSI Team Number 195
M-8	**Tanja Rollett** | Orientation of Magnetic Clouds and their Energy Input into the Magnetosphere

Special Session: Aurora Forecasts in Iceland

Presiding: Andreas Keiling
General Session

5:15 p.m. – 5:30 p.m.	**Pordur Arason** | Aurora Forecasts of the Icelandic Meteorological Office

5:30 p.m. – 6:30 p.m. **Iceland Documentary**

7:00 p.m. – 9:00 p.m. **Dinner On Your Own (Monday)**

TUESDAY, 12 MARCH

9:30 a.m. – 9:40 a.m. **Conference Information (Tuesday)**

General Session - External Drivers II
Presiding: Norbert Krupp
General Session

9:45 a.m. – 10:05 a.m. **Tamas I. Gombosi** | Simulations of Mercury's Magnetosphere ***(INVITED)***

10:05 a.m. – 10:20 a.m. **Stephen E. Milan** | The Role of the Ring Current in Determining Magnetotail Structure During Periods of Strong and Weak Solar Wind-Magnetosphere Coupling

10:20 a.m. – 10:35 a.m. **Marissa F. Vogt** | Reconnection in Jupiter's Magnetotail: Plasmoid Structure and Statistical Properties

10:35 a.m. – 10:55 a.m. **Peter A. Delamere** | Solar Wind Interaction with the Giant Magnetospheres ***(INVITED)***

10:55 a.m. – 11:10 a.m. **Nicolas André** | Effects of a Corotating Interaction Region on the structure and dynamics of the Saturnian magnetotail

11:15 a.m. – 11:45 a.m. **Morning Coffee Break (Tuesday)**

General Session - External Drivers III
Presiding: Caitriona M. Jackman
General Session

11:45 a.m. – 12:05 p.m. **Hiroshi Hasegawa** | Kelvin-Helmholtz Instability at Planetary Magnetopauses: An Overview and Comparison ***(INVITED)***

12:05 p.m. – 12:20 p.m. **Tsugunobu Nagai** | Structure of magnetic reconnection in the Earth's Magnetotail

12:20 p.m. – 12:40 p.m. **Xianzhe Jia** | Satellites' Magnetotails ***(INVITED)***

12:40 p.m. – 12:55 p.m. **Mitsue Den** | Global structure of the substorm depending on magnetotail reconnection model

12:55 p.m. – 1:10 p.m. **Edward Dubinin** | Magnetotails of Mars and Venus: Mars Express and Venus Express Observations

1:10 p.m. – 1:30 p.m. **Discussion I**

1:30 p.m. – 2:30 p.m.	**Lunch (Tuesday)**
3:30 p.m. – 6:00 p.m.	**Guided City Walk**
6:15 p.m. – 7:15 p.m.	**Social Hour**
7:15 p.m. – 9:00 p.m.	**“Guided” Dinner in Center (pay yourself)**

WEDNESDAY, 13 MARCH

9:30 a.m. – 9:40 a.m.	**Conference Information (Wednesday)**
	General Session - Internal Responses I Presiding: Tsugunobu Nagai General Session
9:45 a.m. – 10:05 a.m.	**Mervyn P. Freeman** | A Common Process for Magnetic Reconfigurations at Earth, Jupiter and Saturn ***(INVITED)***
10:05 a.m. – 10:25 a.m.	**Gerhard Haerendel** | Processes Governing the Entry of Plasma from Magnetic Tail into Magnetosphere During Substorms ***(INVITED)***
10:25 a.m. – 10:45 a.m.	**Jonathan P. Eastwood** | Origin and Evolution of Magnetic Flux Ropes in Planetary Magnetotails: General Properties and Perspectives from Earth and Mars ***(INVITED)***
10:45 a.m. – 11:00 a.m.	**Stefan Kiehas** | Flux rope observations near lunar orbit with ARTEMIS
11:00 a.m. – 11:15 a.m.	**Pontus C. Brandt** | Plasma Heating and Transport from the Magnetotail to the Inner Magnetosphere at Earth and Saturn
11:15 a.m. – 11:45 a.m.	**Morning Coffee Break (Wednesday)**
	General Session Internal Responses II Presiding: Larry Kepko General Session
11:45 a.m. – 12:05 p.m.	**Antonius Otto** | Current Sheets in Planetary Magnetotails ***(INVITED)***
12:05 p.m. – 12:20 p.m.	**I. Y. Vasko** | Thin Current Sheets in the Venus Magnetotail
12:20 p.m. – 12:35 p.m.	**Stefano Markidis** | Fully Kinetic 3D Simulations of Magnetotail Plasmoid Chain Dynamics
12:35 p.m. – 12:50 p.m.	**Tomas Karlsson** | Multi-point Measurements of Bursty Bulk Flows in Earth’s Magnetosphere

12:50 p.m. – 1:05 p.m.	**Robert G. Michell** | Exploring Tail Lobe Ion Signatures From THEMIS, Plasma Velocity Measurements and the Relation to the Upcoming MMS DIS Measurements
1:05 p.m. – 1:25 p.m.	**Masahiro Hoshino** | Magnetic Reconnection, Turbulence and Nonthermal Particles in Magnetotail ***(INVITED)***
1:30 p.m. – 2:30 p.m.	**Lunch (Wednesday)**
2:30 p.m. – 4:30 p.m.	**Poster Session II/Coffee Break** Poster Hall
W-1	**Martin Volwerk** | Temperature Anisotropy in Pre- and Post-Dipolarization Plasma Sheets
W-2	**Frederic Pitout** | Multi-instrument observations and simulation of CPS particle precipitation
W-3	**Ute V. Moestl** | MHD Modeling of the Double-Gradient Magnetic Instability (Kink Branch)
W-4	**Christopher S. Arridge** | Active Current Sheets in Saturn's Magnetosphere
W-5	**James M. Weygand** | A Statistical Comparison of Auroral Electrojet Indices in the Northern and Southern Hemispheres
W-6	**Gabriel Fruit** | Electrostatic "bounce" instability in a 2D current sheet - influence of untrapped electrons
W-7	**Xianzhe Jia** | Periodic modulations of Saturn's magnetotail as driven by vortical flows in the upper atmosphere/ionosphere
W-8	**Kate Goodrich** | Dissipation of Bursty Bulk Flows In The Earth's Magnetotail
W-9	**George Nikolaou** | Jupiter's Distant Magnetotail Explored by New Horizons' Solar Wind Around Pluto (SWAP) Instrument
W-10	**Jiang Liu** | On the current sheets surrounding dipolarizing flux bundles in the magnetotail: the case for wedgelets
W-11	**Dan Gershman** | MESSENGER Observations of Ion Pressures in the Plasma Sheet of Mercury
W-12	**Rumi Nakamura** | Near-conjugate Observations of THEMIS and Cluster During a Multiple-flow Burst Event
W-13	**Andreas Keiling** | Global Geomagnetic Pulsations Driven by Periodic Flow Bursts
W-14	**Giovanni Lapenta** | Global Fully Kinetic Magnetotail Simulation
W-15	**Jorg-Micha Jahn** | Cross-Tail View of the Dynamics of Earth's Magnetotail

General Session - Internal Responses III
Presiding: Peter A. Delamere
General Session

4:30 p.m. – 4:50 p.m.	**Fran Bagenal** | Large-scale Dynamics and Mass Transport in the Jovian Magnetotail ***(INVITED)***
4:50 p.m. – 5:05 p.m.	**Gina A. DiBraccio** | MESSENGER Observations of Plasmoids in Mercury's Magnetotail
5:05 p.m. – 5:20 p.m.	**Caitriona M. Jackman** | Interpreting flow characteristics in planetary magnetotails
5:20 p.m. – 5:35 p.m.	**Michelle F. Thomsen** | Cassini/CAPS Observations of Duskside Tail Dynamics at Saturn
6:45 p.m. – 9:30 p.m.	**Banquet Dinner**

THURSDAY, 14 MARCH

9:15 a.m. – 1:30 p.m.	**Field Trip 1: Golden Circle**
1:30 p.m. – 2:30 p.m.	**Lunch at Geysir Hotel**
2:30 p.m. – 3:30 p.m.	**Geyser Watch**

General Session - Internal Responses IV
Presiding: Denis C. Grodent
Geysir Hotel

3:45 p.m. – 4:05 p.m.	**Stanislav Sazykin** | Numerical Simulations of Plasma Convection in Saturn's and Earth's Magnetospheres ***(INVITED)***
4:05 p.m. – 4:20 p.m.	**Abigail M. Rymer** | Magnetic Pumping: a source of radial and azimuthal plasma heating
4:20 p.m. – 4:40 p.m.	**Donald G. Mitchell** | Injection, Interchange And Reconnection: Energetic Particle Observations In Saturn's Magnetotail ***(INVITED)***
4:40 p.m. – 4:55 p.m.	**Colin Forsyth** | A comparison of the electron polytropic indices in the magnetotails of Earth and Saturn
4:55 p.m. – 5:10 p.m.	**Ashok Rajendar** | Structure and Dynamics of Saturn's Magnetotail
5:15 p.m. – 5:30 p.m.	**Afternoon Coffee Break (Thursday)**

General Session - Internal Responses V
Presiding: Xianzhe Jia
Geysir Hotel

5:30 p.m. – 5:45 p.m.	**Maria Hamrin** | Cluster observations of energy conversion in plasma sheet vortex flows
5:45 p.m. – 6:00 p.m.	**Jennifer Kissinger** | The Importance of Stormtime Steady Magnetospheric Convection in Determining the Final Relativistic Electron Flux Level
6:00 p.m. – 6:15 p.m.	**Elizabeth E. Antonova** | Plasma Sheet of the Magnetosphere of the Earth as the turbulent Wake: Analysis of Properties and Modeling
6:15 p.m. – 6:30 p.m.	**Vladimir V. Kalegaev** | Geomagnetic Tail Large Scale Structure and Dynamics in Quiet Magnetosphere
6:30 p.m. – 6:45 p.m.	**Christine Gabrielse** | The effects of transient, localized electric fields on equatorial electron acceleration and transport towards the inner magnetosphere
6:45 p.m. – 7:15 p.m.	**Discussion II**
7:15 p.m. – 9:00 p.m.	**Dinner at the Geysir Hotel**

FRIDAY, 15 MARCH

9:30 a.m. – 9:40 a.m.	**Conference Information (Friday)**

General Session - Inner Coupling I
Presiding: Tsugunobu Nagai
General Session

9:45 a.m. – 10:05 a.m.	**Geoffrey D. Reeves** | Dynamics of the Earth's Radiation Belts and the Role of Spatial, Temporal, and Energy Coupling as Seen by RBSP and Other Satellites ***(INVITED)***
10:05 a.m. – 10:20 a.m.	**Thomas E. Moore** | "Snowplow" Injection by Dipolarization Fronts
10:20 a.m. – 10:35 a.m.	**Maria O. Riazantseva** | Enhanced quasi stationary fluxes of energetic electrons to the pole of the polar boundary of the outer radiation belt and the possibility of the existence of local particle traps in the geomagnetic tail
10:35 a.m. – 10:55 a.m.	**Michael J. Wiltberger** | Review of Global Simulations Studies of the Effect of Ionospheric Outflow on Magnetotail Dynamics ***(INVITED)***

10:55 a.m. – 11:10 a.m.	**Stein Haaland** | On the supply of cold plasma to the Earth's magnetotail
11:15 a.m. – 11:45 a.m.	**Morning Coffee Break (Friday)**
	General Session - Inner Coupling II Presiding: Michelle F. Thomsen General Session
11:45 a.m. – 12:00 p.m.	**Matthew O. Fillingim** | Observations of Ionospheric Oxygen and Magnetospheric Convection in the Vicinity of the Moon
12:00 p.m. – 12:15 p.m.	**Larry Kepko** | The Substorm Current Wedge at Earth... And Mercury?
12:15 p.m. – 12:30 p.m.	**Ian R. Mann** | Role of Magnetosphere-Ionosphere Coupling in Destabilisation of the Earth's Magnetotail
12:30 p.m. – 12:50 p.m.	**Jay R. Johnson** | Alfvénic Magnetotail-Ionosphere Coupling at Earth and other Planets ***(INVITED)***
12:50 p.m. – 1:05 p.m.	**Binzheng Zhang** | Magnetotail Origins of Auroral Alfvenic Power
1:05 p.m. – 1:20 p.m.	**Peter A. Damiano** | 2D Global gyrofluid-kinetic electron simulations of Magnetotail Alfven wave propagation
1:30 p.m. – 2:30 p.m.	**Lunch (Friday)**
	General Session - Inner Coupling III Presiding: Colin Forsyth General Session
2:30 p.m. – 2:50 p.m.	**Aikaterini Radioti** | Auroral Signatures of Ionosphere-magnetosphere Coupling at Jupiter and Saturn ***(INVITED)***
2:50 p.m. – 3:05 p.m.	**Laurent Lamy** | Earth based detection of Uranus aurorae
3:05 p.m. – 3:20 p.m.	**Denis C. Grodent** | Statistical analysis of Saturn's UV auroral outer emission
3:20 p.m. – 3:50 p.m.	**Discussion/Closing**
5:00 p.m. – 9:00 p.m.	**Field Trip 2: Blue Lagoon**

ABSTRACTS

listed by name of presenter

Ames, William

The lunar plasma wake in Earth's magnetotail

Ames, William[1, 2]; Brain, David[1, 2]; Poppe, Andrew[3]; Halekas, Jasper[3]; McFadden, James[3]; Glassmeier, Karl-Heinz[4]; Angelopoulos, Vassilis[5]

1. Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, Boulder, CO, USA
2. Colorado Center for Lunar Dust and Atmospheric Studies, University of Colorado, Boulder, Boulder, CO, USA
3. Space Sciences Laboratory, University of California, Berkeley, Berkeley, CA, USA
4. Institute for Geophysical and Space Physics, Technical University of Braunschweig, Braunschweig, Germany
5. Institute of Geophysics and Planetary Physics, University of California, Los Angeles, Los Angeles, CA, USA

The Moon does not have an intrinsic magnetic field and lacks the conductivity necessary to develop an induced magnetosphere. Therefore, the interaction of the Moon with the solar wind is dominated by impact absorption of solar wind particles on the day side and the generation of a plasma wake on the night side. A plasma density gradient forms between the flowing solar wind and the plasma wake, causing solar wind plasma to gradually refill the wake region. Electrons fill the wake first, pulling ions in after them via ambi-polar diffusion. As the Moon orbits around the Earth, it experiences varying plasma environments as it passes in and out of the Earth's magnetic influence, allowing us to observe changes in wake structure in different plasma conditions. While there has been substantial work on understanding the physics of the lunar wake in unperturbed solar wind, the structure of the lunar wake while the Moon is within Earth's magnetotail has received minimal attention. The ARTEMIS (Acceleration, Reconnection, Turbulence, and Electrodynamics of the Moon's Interaction with the Sun) spacecraft mission is a two-probe lunar mission derived from the THEMIS (Time History of Events and Macroscale Interactions During Substorms) mission, repurposed to study the lunar space and planetary environment. Over the course of the mission there have been hundreds of passes of the ARTEMIS spacecraft through the lunar wake, at distances of up to seven lunar radii from the Moon. Many of these crossings have occurred while the Moon was within Earth's magnetotail. We present a study of selected wake-crossing events of the ARTEMIS probes, selected when the Moon was within Earth's magnetotail. Using data primarily from the ARTEMIS fluxgate magnetometer (FGM) and electrostatic analyzers (ESAs), we determine the outer boundary of the lunar wake, identify any apparent internal structure, and measure the size and duration of typical wake features such as reduced ion densities and increased magnetic field magnitude. These results are then compared with wake crossings occurring while the Moon is in unperturbed solar wind.

André, Nicolas

Effects of a Corotating Interaction Region on the structure and dynamics of the Saturnian magnetotail

André, Nicolas[1]; Arridge, Christopher S.[2]; Jackman, Caitriona M.[3]; Lamy, Laurent[4]; Cecconi, Baptiste[4]

1. irap, Toulouse, France
2. MSSL, Holmbury Saint Mary, United Kingdom
3. UCL, London, United Kingdom
4. lesia, Meudon, France

In order to understand the response of the Saturnian magnetosphere to solar wind dynamic pressure enhancements, we investigate magnetic field and plasma variations observed in-situ by the Cassini spacecraft. We take advantage of two particular orbits (Rev. 26 and 27 in July and August 2006) with similar radial distance, latitude and local time coverage of the Saturnian magnetotail to examine the large-scale structure and dynamics of the nightside current sheet. The observations obtained during these two orbits differ remarkably and some of them present some similarities with the phases of loading/unloading observed during terrestrial substorms. During one of this orbit (Rev. 27), several increases of lobe magnetic pressure are observed, followed by a sudden change in the average position of the current sheet and variations in the longitudinal modulations of the magnetic, plasma and radio fluctuations (short-term dephasing). The deformation of the current sheet lasted for several days before it returned to its past position. Correlation with enhancements in Saturn Kilometric Radiation emissions suggests that solar wind disturbances may have triggered the observed reconfiguration of the Saturnian magnetotail by compressing and relaxing the magnetosphere. We test this hypothesis and provide a plausible interpretation of the observed event that illustrates the Solar-planetary magnetosphere coupling at Saturn.

Angelopoulos, Vassilis

Perspectives of Earth's Magnetotail from an Integrated Heliophysics System Observatory *(INVITED)*

Angelopoulos, Vassilis[1]

1. ucla, Los Angeles, CA, USA

The successful past deployment and continuation of a series of Heliophysics missions enables an unprecedented multi-point view of magnetospheric dynamics. Recent studies show that global phenomena such as substorms and convection bays are in reality a compilation of elemental activations whose intensity and recurrence build up the

global instability. The combination of mid-tail and inner magnetospheric missions are now able to show clearly the connection between the most geoeffective magnetotail activations and the ring current/radiation belts, and reveal the key role of mid-tail injections for storm-time dynamic and evolution. The combination of spacecraft in the mid- and distant tail enable a comprehensive look at the loading and unloading process and reveal how flux rope ejection occurs first within closed plasma sheet field lines, leading to large scale coalescence and global plasmoid formation. The critical role of bursty flows across large (system-wide) distances is evident. However, closer look shows that kinetic effects related to the rapid flux transport and the energy dissipation associated with these flows is critical to understanding the global flux and energy transport. Particle acceleration and heating within such kinetic scales is important to understand, as it will allow significant progress with understanding the process of energy conversion and transport enabling better and more efficient modeling as well as predictive capability.

Antonova, Elizabeth E.

Plasma Sheet of the Magnetosphere of the Earth as the turbulent Wake: Analysis of Properties and Modeling

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Geomagnetic tail is formed in the process of turbulent solar wind flow around the magnetic field of the Earth. The main difference of the geomagnetic tail in comparison with ordinary turbulent wake under the obstacle is connected with the scales of the turbulent wake. The scale of the turbulent wake in the direction transverse to flow is the same as the scale of the obstacle. The scale of the plasma sheet, which is the region of the turbulent flow in the magnetosphere of the Earth when Bz IMF<0, is the same as the scale of the magnetosphere in Y direction (~40Re) and much smaller in Z direction (~5 Re). The theory of the plasma sheet with medium scale turbulence explains these phenomena as the result of the existence of quasistationary dawn-dusk electric field. The theory is based on the suggestion of the existence of a total pressure balance across the plasma sheet and the assumption that the regular plasma transport, which is transverse to the plasma sheet and related to the dawn–dusk electric field, is compensated by the eddy diffusion turbulent transport. The theory predicted the value of eddy diffusion coefficient before it was measured on satellites. It gives the simple explanation of the plasma sheet thinning during substorm growth phase and expansion after start of substorm expansion phase, filling of tail lobes and theta-aurora formation when Bz IMF>0. The results of complex latest studies of magnetosheric turbulence in the tail region using THEMIS, CLUSTER and INTERBALL data are summarized with the aim of the determination of the properties, distribution and dependence on substorm phase of the eddy diffusion coefficient. It is shown, that the level of turbulence is considerably decreased at geocentric distances smaller than 10Re.

Arason, Pordur

Aurora Forecasts of the Icelandic Meteorological Office

Arason, Pordur[1]

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In October 2012, the Icelandic Meteorological Office (the national weather service) started aurora forecast services on its web in response to increased aurora turism in Iceland. In addition to information on darkness hours, the sun and the moon, forecasts are published on cloud cover and space weather for the next six nights. The space weather forecasts are based on predictions from NOAA's Space Weather Prediction Center, while the cloud cover forecast maps of Iceland are derived from the ECM 0.125 model of the European Centre for Medium-Range Weather Forecasts. Furthermore, a weather forcaster on duty implies possible deviations and the reliability of the forecast. In addition to a simple representation of the aurora forecast, detailed auxillary information is available. Apparently, this mixture of detailed local weather information with information on solar- and auroral activity is quite unique. Iceland is on the UTC timezone all year round, and because Reykjavík is at 22°W longitude, the local noon is about one and a half hour after 12 o'clock. Magnetic declination in Reykjavík is currently about -16°. During the conference week the true midnight will be at about 01:40 and the geomagnetic midnight at about 00:20. Sunset times in Reykjavík during the conference week of 10-15 March 2013, Sunday through Friday, varies between 19:14-19:29 (7:14-7:29 PM); end of civil twilight 20:02-20:17; and astronomical twilight 21:58-22:17. There is a new moon on Monday night, 11 March, so moonlight should not interfere with auroral viewing. The chanches of seeing a lively aurora over Reykjavík during the conference week will be discussed by reviewing local weather, cloud cover and space weather forecasts. The English version of the aurora forecast of the Icelandic Meteorological Office can be found at: http://en.vedur.is/weather/forecasts/aurora/

http://en.vedur.is/weather/forecasts/aurora/

Arridge, Christopher S.

The Twisted Time-Dependent Magnetotails of Uranus and Neptune *(INVITED)*

Arridge, Christopher S.[1, 2]

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The large obliquities and highly inclined internal magnetic fields of Uranus and Neptune lead to a wide variety of magnetospheric and magnetotail configurations over the rotation and orbital periods of these planets. Extreme cases include pole-on configurations, where the magnetotail is cylindrically symmetrical with the tail current sheet forming a cylinder, and oblique configurations, where different regions of tail field polarity are highly asymmetrical in the terminator plane. During solstice conditions the uranian tail becomes coiled up as a result of the finite travel time for Alfvén waves to propagate down the tail. In both magnetospheres there must be large changes in open flux content on diurnal timescales due to these configurations. Dynamical features have been observed in Uranus' tail - reminiscent of "substorm" activity in the terrestrial magnetotail. In this talk we will review observational and theoretical work on the magnetotails of Uranus and Neptune and consider what new understanding from the last 15 years of solar system magnetotail research can be applied to these unique configurations.

Arridge, Christopher S.

Active Current Sheets in Saturn's Magnetosphere

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5. Department of Physics and Astronomy, University College London, London, United Kingdom
6. Johns Hopkins Applied Physics Laboratory, Laurel, MD, USA
7. Max Planck Institute for Solar System Research, Katlenberg-Lindau, Germany
8. LESIA, Obs. de Paris, Paris, France
9. Office for Space Research, Academy of Athens, Athens, Greece
10. University of Michigan, Ann Arbor, MI, USA
11. ESTEC, Noordwijk, Netherlands

Hot electron distributions are often found in Saturn's plasma sheet and have been associated with magnetic reconnection in Saturn's outer magnetosphere. Typically the electrons are at least an order of magnitude more energetic than the surrounding electron populations and abrupt transitions are observed between the two regimes. Sometimes these energetic populations are observed as part of a bi-modal distribution with more typical warm plasma sheet electrons. In this poster we present case studies of some intervals in Saturn's outer magnetosphere where these hot electrons are present and examine the surrounding structure. We show significant changes in the current and plasma sheet on the timescale of hours and disruptions in the current sheet which appear to persist for more than one rotation of the plasma sheet around the planet.

Bagenal, Fran

Large-scale Dynamics and Mass Transport in the Jovian Magnetotail *(INVITED)*

Bagenal, Fran[1]

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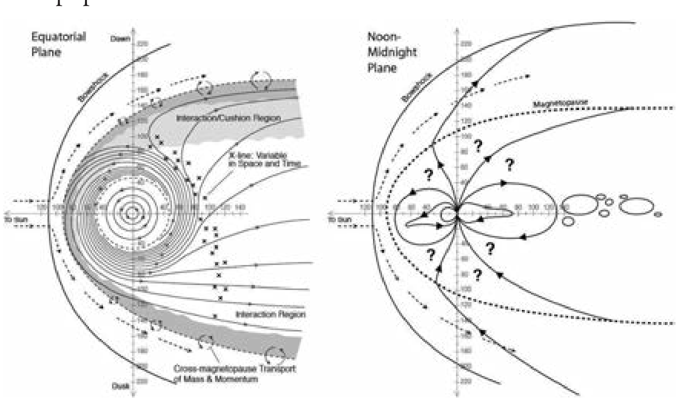
The giant magnetosphere of Jupiter has a magnetotail that was observed in 1982 by Voyager 2 to extend out to the orbit of Saturn, over 4 AU downstream in the solar wind. Jupiter's moon Io spews out ~ 1 ton/second of material, about half of which becomes ionized and moves out into the magnetosphere and is eventually lost, primarily down the tail. If we approximate a plasmoid as a disk of plasma sheet 2RJ thick having diameter 25RJ and density of 0.01 cm−3, so that each plasmoid has a mass of about 500 ton. Ejecting

one such plasmoid per day is equivalent to losing 0.006 ton/s. Increasing the frequency to once per hour raises the loss rate to 0.15 ton/s. Thus, on the one hand, even with optimistic numbers, the loss of plasma from the magnetosphere due to such plasmoid ejections cannot match the canonical plasma production rate, 0.5 ton/s. On the other hand, a steady flow of plasma of density 0.01 cm-3, in a conduit that is 5RJ thick and 100RJ wide, moving at a speed of 200 km/s would provide a loss of 0.5 ton/s. Such numbers suggest that a quasi-steady loss rate is feasible. The question of the mechanism remains unanswered. I propose three options: a diffusive “drizzle” across weak, highly stretched, magnetotail fields; a quasi-steady reconnection of small plasmoids, below the scale detectable via auroral emissions; or a continuous but perhaps gusty magnetospheric wind. In the spring of 2007, the New Horizons spacecraft flew past Jupiter, getting a gravitational boost on its way to Pluto, and made an unprecedented passage down the core of the jovian magnetotail, exiting on the northern dusk flank. For over 3 months, while covering a distance of 2,000RJ, the spacecraft measured a combination of iogenic ions and ionospheric plasma (indicated by H+ and H3+ ions) flowing down the tail. The fluxes of both thermal and energetic particles were highly variable on time scales of minutes to days. The tailward fluxes of internally generated plasma led McComas and Bagenal (2007) to argue that perhaps Jupiter does not have a complete Dungey cycle but that the large time scale for any reconnection flow suggests that magnetic flux that is opened near the subsolar magnetopause re-closes on the magnetopause before it has traveled down the tail. They suggested that the magnetotail comprises a pipe of internally generated plasma that disconnects from the planetary field and flows away fromJupiter in intermittent surges or bubbles, with no planetward Dungey return flow. Delamere and Bagenal (2010) argue that, due to the viscous processes on the magnetopause boundary, along the flanks of the magnetotail, solar wind plasma becomes entrained and mixed with the ejected iogenic material (see Figure). This paper will review these ideas.



Brandt, Pontus C.

Plasma Heating and Transport from the Magnetotail to the Inner Magnetosphere at Earth and Saturn

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At Earth, recent observations and theoretical work have cast doubt on the idea that a global, laminar process is responsible for the transport and heating of plasma from the magnetotail to the inner magnetosphere. A picture is evolving in which meso-scale processes (flow channels, bursty bulk flows, bubbles) are the conduits for the heating and transport. Somehow, these meso-scale processes lead to large-scale injections of plasma that are clearly observed in Energetic Neutral Atoms (ENA) and display a very high correlation with the Auroral Kilometric Radiation (AKR). At Saturn, similar meso- and large-scale phenomena have been observed. Meso-scale injections are usually observed in-situ in the inner magnetosphere (<12 RS) and have been proposed to be related to interchange instabilities although their exact nature is not clear. Large-scale injections are usually observed in ENAs from about 9 RS out beyond Titan’s orbit at about 20 RS and also display correlations with Saturn Kilometric Radiation. In this paper, we discuss what the large-scale injections at both planets can tell us about the nature of transport and heating from the magnetotail and the inner magnetosphere. We first review the large-scale injections in the terrestrial magnetosphere and their relation to AKR. Second, we present new observations of two, seemingly different, types of large-scale injections in Saturn’s magnetosphere: In addition to large-scale injections in the regions beyond 9 RS, we have also observed large-scale injections in to about 5 RS appearing with no apparent propagation from the tail. This may imply that two different transport processes are responsible for the inward plasma transport in Saturn’s magnetosphere. SKR appear to be correlated with both types, but with possibly different signatures. We will discuss both in-situ and remote ENA observations in these two regions in attempt to shed light of the transport and heating mechanisms.

Cassak, Paul

Reconnection with a Shear Flow and Applications to Solar Wind-Magnetospheric Coupling

Cassak, Paul[1]

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There is increasing evidence that solar wind-magnetospheric coupling is strongly influenced by reconnection at the magnetopause rather than solely by the conditions in the solar wind as had previously been assumed. Borovsky [1] developed a nearly first-principles coupling function based on local physics at the reconnection site, and this function correlates with the data as well as the best previously obtained empirical relations. This suggests that understanding the local physics of reconnection is important for solar wind-magnetospheric coupling. The Borovsky coupling function includes the effects of asymmetries on reconnection [2], but does not include the effect of shear flow because comparatively little is known about how reconnection properties quantitatively depend on shear flow. A shear flow occurs during reconnection when there is a bulk plasma flow parallel to the reconnecting magnetic field, which naturally occurs at the magnetopause due to the solar wind. A quantitative analysis of shear flow effects on reconnection is presented, including the scaling of the reconnection rate, outflow speed, and dissipation region geometry as a function of shear flow speed for systems with the same and different shear flow speeds on either side of the reconnection site. Large-scale Hall magnetohydrodynamics (Hall-MHD) numerical simulations are presented. The decrease in reconnection efficiency with shear flow is discussed in the context of solar wind-magnetospheric coupling. [1] J. E. Borovsky, J. Geophys. Res., 113, A08228, 2008. [2] P. A. Cassak and M. A. Shay, Phys. Plasmas, 14, 102114, 2007.

Damiano, Peter A.

2D Global gyrofluid-kinetic electron simulations of Magnetotail Alfven wave propagation

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It is widely recognized that dispersive scale Alfven waves are the source of broadband aurora (such as seen at substorm onset). It is an open question though whether the dispersive scale structuring is imposed at the onset site or is determined by other effects such as phase mixing or wave-wave coupling (after mode conversion from dipolarization induced fast compressional modes). In order to help elucidate the details behind the structuring and the coupling of Alfven wave energy to electrons that power the broadband aurora, we present 2D simulations of magnetotail Alfven wave propoagation in a non-uniform magnetic field topology using a hybrid gyrofluid-kinetic electron model for realistic plasma sheet electron and ion temperatures. This model is an extension of the self-consistent hybrid MHD-kinetic electron model in curvilinear coordinates (Damiano et al., 2007) that has been generalized to include ion gyroradius effects based on the kinetic-fluid model of Cheng and Johnson (1999) where the ion pressure tensor is computed using a solution of the linear gyrokinetic equation. We present results of the form of the precipitating electron distribution function for a range of parallel and perpendicular scale length Alfven wave perturbations sourced in the plasma sheet. We contrast simulations with and without perpendicular density gradients to help elucidate the role of phase mixing in the cross-scale coupling. Published measurements and data from the FAST and THEMIS missions are used to constrain the model parameters and contrast with and interpret the simulation results.

Delamere, Peter A.

Solar Wind Interaction with the Giant Magnetospheres ***(INVITED)***

Delamere, Peter A.[1]

1. Geophysical Institute, University of Alaska Fairbanks, Fairbanks, AK, USA

Jupiter's and Saturn's immense magnetospheres differ considerably from Earth's. These magnetospheres are generated in part by a strong planetary dynamo and by rapid rotation (~10 hour period). However, key differences lie in the internal sources of plasma (100s kg/s) provided by Io and Enceladus. Centrifugal stresses acting on the corotating, low-beta plasma in the inner magnetosphere leads to radial transport of plasma via a centrifugally-driven flux tube interchange instability. Instead of cooling on adiabatic expansion, the plasma is observed to be hotter at larger radial distances. In the outer magnetosphere the systems are governed by high-beta, centrifugally-confined plasma sheets. The loss of this magnetospheric plasma to the solar wind is fundamental to understanding giant planet magnetotails and begs the question, "Are Jupiter and Saturn really just colossal comets?" To address this question, we will discuss three models for driving magnetospheric dynamics at Jupiter and Saturn. The solar wind drivers include the Dungey cycle of magnetic reconnection and the tangential drag ("viscous") model of Axford and Hines. At the giant magnetospheres, the rapid rotation of the planet can give rise to the Vasyliunas cycle where plasma-laden tubes of magnetic flux are stretched out on the nightside to the point where they pinch down and reconnect, breaking off a plasmoid. All three models will be discussed in the context of auroral signatures and the open flux content of the polar cap. We will then focus on specific conditions at the magnetopause boundary related to the models of Dungey and Axford and Hines (e.g. Kelvin-Helmholtz instability) and how these models might be coupled to the internally-driven Vasyliunas cycle and the related loss of magnetospheric plasma down the magnetotail.

Den, Mitsue

Global structure of the substorm depending on magnetotail reconnection model

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3. Kyushu University, Fukuoka, Japan
4. Meteorological College, Kashiwa, Japan

The substorm is multi-scale phenomenon since magnetic reconnection in magnetotail plays an important role in dynamics of global structure. Based on particle-in-cell

(PIC) simulation results of collisionless driven reconnection in a steady state, an effective resistivity model is developed for a global magnetohydrodynamic (MHD) simulation in order to bridge over huge gap between macro and micro physics of magnetic reconnection. The PIC simulation reveals that reconnection electric field sustained by microscopic physics is found to evolve so as to balance flux inflow rate which is determined by global dynamics in a macroscopic system. We apply this effective resistivity model to MHD phenomena in the substorm. Although this model does not include any adjustable parameters relating to kinetic dissipation processes, some global phenomena such as onset indicated in electrojets in the ionosphere, propagation of flux rope, and dipolarization, detailed processes of which are longstanding questions, are well reproduced in a global MHD simulation and consistent with the observations.

DiBraccio, Gina A.

MESSENGER Observations of Plasmoids in Mercury's Magnetotail

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4. Goddard Planetary Heliophysics Institute, University of Maryland, Baltimore County, MD, USA
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Magnetic field observations by the MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) spacecraft during passes through Mercury's magnetotail frequently contain signatures of large-scale magnetic reconnection in the form of plasmoid-type magnetic flux ropes. Plasmoids form in the current sheet separating the north and south lobes of the magnetotail and are ejected away from the planet. These structures are identified in the magnetic field data on the basis of their strong core field in the east–west direction coincident with a bipolar variation in the north–south magnetic field due to the outer helical wraps of magnetic flux. The MESSENGER observations show that, just as at Earth and the other planets with internal fields, plasmoids may be observed as temporally isolated events or as "chains" of closely spaced events. In both cases, the duration of plasmoids at Mercury is shown to be only ~1–3 s and, in the case of chain events, the interval between successive plasmoids is ~5–10 s. When MESSENGER passes near the central axes of these flux ropes, their strong core fields cause the total magnetic field magnitude to increase by a factor of ~2 relative to the background field in the tail lobes. The closely spaced chains of plasmoid-type flux ropes in Mercury's tail appear to mirror the "showers" of closely spaced flux transfer events observed by MESSENGER at the magnetopause. Together these types of events indicate that intense magnetic reconnection occurs frequently, not only at the dayside magnetopause but also in the cross-tail current layer of this small but extremely dynamic magnetosphere.

Dubinin, Edward

Magnetotails of Mars and Venus: Mars Express and Venus Express Observations

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3. IRAP, Toulouse, France
4. Swedish Institute of Space Physics, Kiruna, Sweden

Mars and Venus have no global magnetic field and solar wind interacts directly with their ionospheric shells inducing the magnetosphere by a pileup and draping of the interplanetary magnetic field lines around the planets. The magnetotails of Mars and Venus consist of two lobes of opposite polarity of the magnetic field separated by plasma sheet. The recent Mars Express and Venus Express missions provided us a lot of new information about the characteristics of the magnetic tails in induced magnetospheres. The magnetic normal and tangential stresses push the planetary plasma tailward acting like a jet engine and supplying the plasma sheet by planetary ions (O+, 02+) accelerated up to keV energies. The interesting feature of the plasma jets is their bursty behavior. A period of bursts is about of 1-2 min. Their occurrence can be related to large-amplitude waves propagating on the plasma sheet surface and launched by reconnection. We will discuss also mechanisms of ion acceleration in the tails and its variability with solar wind parameters. The tail lobes are also supplied by the ionospheric plasma although its characteristic energy occurs much less than that in the plasma sheet (Ei ~ 10 eV) implying the existence of 'polar wind' at these nonmagnetic planets. Crustal magnetic fields on Mars add complexity and variability to the Martian tail including possible auroral features.

Eastwood, Jonathan P.

Origin and Evolution of Magnetic Flux Ropes in Planetary Magnetotails: General Properties and Perspectives from Earth and Mars *(INVITED)*

Eastwood, Jonathan P.[1]; Phan, Tai D.[2]; Oieroset, Marit[2]; Drake, James F.[3]; Brain, David A.[4]; Halekas, Jasper S.[2]; Borg, Anette L.[5]; Shay, Michael A.[6]

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2. Space Sciences Laboratory, UC Berkeley, Berkeley, CA, USA
3. Physics/ IPST, University of Maryland, College Park, MD, USA
4. LASP, University of Colorado, Boulder, CO, USA
5. Norwegian Defence Research Establishment, Kjeller, Norway
6. Bartol Research Institute/ Physics and Astronomy, University of Delaware, Newark, DE, USA

A fundamental process in magnetotail physics is magnetic reconnection, which enables the circulation of mass, energy and magnetic flux through the magnetosphere. In particular, magnetic reconnection may result in the formation of magnetic flux ropes, which can be used to probe the properties and dynamics of magnetotail reconnection. In this presentation, we first discuss the basic properties and characteristics of flux ropes that might be applicable to generic magnetotails. In particular, we examine the taxonomy of flux ropes, the diverse nomenclature that is used in the literature, and the difficulties of establishing whether a flux rope has even been observed. At Earth, recent multi-point data from several space missions, including Cluster and THEMIS, has proved crucial in determining flux rope properties. In particular, we will discuss evidence showing that flux ropes can be generated either through reconnection onset at multiple points in the magnetotail, or through secondary instabilities once magnetic reconnection has been initiated. At Mars, we describe how lessons learned at Earth have been applied in new settings. Observations from Mars Global Surveyor (MGS), in combination with simulations of reconnection, indicate that MGS has observed secondary islands indicating the presence of reconnection. We will also examine in more detail the role reconnection plays in bulk transport at Mars, and in particular how reconnection of the crustal magnetic fields leads to the formation of large flux ropes, and chains of flux ropes in Mars' magnetotail.

Fear, Robert

The Formation of Transpolar Arcs by Magnetotail Reconnection

Fear, Robert[1]; Milan, Steve[1]; Maggiolo, Romain[2]

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2. Belgian Institute for Space Aeronomy, Brussels, Belgium

Transpolar arcs are auroral features which extend from the night side of the Earth's main auroral oval into the polar cap. Recent statistical studies have shown that they are formed by the closure of magnetic flux in the magnetotail during intervals when the IMF is northward and there is a cross-tail (B_Y) component of the lobe magnetic field (due to the earlier IMF conditions). Under these circumstances, newly closed flux in the midnight sector has northern and southern hemisphere footprints that straddle the midnight meridian; this prevents the closed flux from returning to the day side in a simple manner. As tail reconnection continues, the footprints of closed field lines protrude into the polar cap, and the auroral emissions on these footprints form the transpolar arc. This mechanism predicts that closed flux should build up on the night side, embedded within the lobe. We present *in situ* observations of this phenomenon, taken by the Cluster spacecraft on 15th September 2005. Cluster was located at high latitudes in the southern hemisphere lobe (far from the typical location of the plasma sheet), and a transpolar arc was observed by the FUV cameras on the IMAGE satellite. Cluster periodically observed plasma similar to a typical plasma sheet distribution, but at much higher latitudes - indicative of closed flux embedded within the high latitude lobe. Each time that this plasma distribution was observed, the footprint of the spacecraft mapped to the transpolar arc (significantly poleward of the main auroral oval). These observations are consistent with closed flux being trapped in the magnetotail and embedded within the lobe, and provide further evidence for transpolar arcs being formed by magnetotail reconnection.

Fillingim, Matthew O.

Observations of Ionospheric Oxygen and Magnetospheric Convection in the Vicinity of the Moon

Fillingim, Matthew O.[1]; Halekas, Jasper S.[1]; Poppe, Andrew R.[1]; Angelopoulos, Vassilis[2]

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2. Institute of Geophysics and Planetary Physics, University of California, Los Angeles, Los Angeles, CA, USA

Using data from the ARTEMIS spacecraft, we report on observations consistent with the detection of ionospheric oxygen ions in the terrestrial magnetosphere at lunar altitudes. Since there is no mass spectrometer onboard, oxygen can only be detected when the outflow velocities are sufficient to separate oxygen from hydrogen in energy (for

the same velocity, oxygen will appear to have a higher energy). We catalog the occurrence of such signatures. Additionally, we are able to determine the magnetotail convection velocity, hence electric field, from lunar shadowing. As the ARTEMIS spacecraft orbit the Moon, high energy Earthward-traveling particle are absorbed by the solid body of the Moon. Simultaneously, low energy photoelectrons are emitted from the lunar day side. Both of these populations mirror near Earth and return to the vicinity of the Moon with their paths displaced by the convection electric field. By measuring this displacement, the convection velocity and electric field can be determined. We relate the detection, number density, and velocity of ionospheric oxygen ions to the measured magnetospheric convection electric field. The results of this work will relate magnetospheric convection (driven by the solar wind) to ionospheric outflow reaching lunar altitudes.

Forsyth, Colin

A comparison of the electron polytropic indices in the magnetotails of Earth and Saturn

Forsyth, Colin[1]; Arridge, Christopher[1]; Fazakerley, Andrew[1]

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Comparing the variations in plasma density and pressure provides an insight into the energy transfer processes within that plasma. Previous studies of Earth's magnetotail plasma have concentrated on the ion population, showing that the ions tended to have and adiabatic "ground state", becoming more lossy with increased geomagnetic activity. In contrast, the electrons in Saturn's magnetotail are, on average, isothermal, although also showed "lossy adiabatic" states on occasion. Given that recent a recent study by Walsh et al. (2009) showed that the electron plasma sheet and ion plasma sheet at Earth showed distinctly different distribution functions, it cannot be assumed that the electrons and ions act in the same manner. In this study, we use data from Cluster at Earth and Cassini at Saturn to compare the electron polytropic indices observed in the magnetotails of these planets. By comparing the polytropic indices at Earth with geomagnetic activity levels, we endeavor to explain the results at Saturn using Earth as an exemplar.

Fowler, Christopher M.

Affects of Solar Wind and IMF Variability on the Magnetotail of Jupiter

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Ulysses measurements at 5AU show very different solar wind conditions than those at Earth. Solar wind speed, density and temperature show high values in the tails of their distributions (which are not Gaussian), with the variability of flow speed and density causing changes of greater than a factor of 10 in the solar wind dynamic pressure between the 10% and 90% levels. This variation in dynamic pressure leads to the large compressibility of the jovian magnetosphere, which has magnetopause and bow shock mean locations of 75RJ and 85RJ, with 10% and 90% values of 55-95 RJ and 60-115 RJ respectively. The winding up of the Parker spiral at 5AU means the IMF points close to the azimuthal direction at Jupiter, switching (eastward vs. westward) several times per rotation. The IMF out of the ecliptic plane has 10% and 90% values of ±40°, meaning that unlike at Earth the IMF is aligned anti-parallel to Jupiter's magnetic field only on very rare occasions. Not only does the orientation of the IMF limit large-scale, steady magnetic reconnection at Jupiter's magnetopause, but the large Alfven Mach number of the solar wind and high change in beta across the magnetopause further reduces the reconnection rate. At the same time, strong velocity shears likely makes large regions of the magnetopause unstable to the Kelvin-Helmholtz instability, producing a viscous-like interaction of the solar wind with Jupiter's magnetosphere. One possible consequence is that the jovian magnetotail is less like Earth and more like a comet. Changes in the solar wind IMF direction could trigger large disconnection events whereby most of the magnetotail is disconnected from the planet. In this paper we examine Ulysses solar wind data from 5AU, derive statistical descriptions of conditions experienced by the jovian magnetosphere during (a) the New Horizons flyby in spring 2007, and (b) the approach and capture orbit of Juno in summer 2016. We also evaluate how often Jupiter's tail could be disconnected at different phases of the solar cycle.

Freeman, Mervyn P.

A Common Process for Magnetic Reconfigurations at Earth, Jupiter and Saturn ***(INVITED)***

Freeman, Mervyn P.[1]; Jackman, Caitriona M.[2]; Vogt, Marissa F.[3]

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3. University of Leicester, Leicester, United Kingdom

Repeatable magnetic reconfigurations (MRs) appear to be common to the magnetotails of the magnetised planets Mercury, Earth, Jupiter, Saturn, and Uranus. Close to the magnetotail current sheet, they can be identified by a unipolar or bipolar fluctuation of the magnetic field component parallel to the planetary magnetic dipole, which has been interpreted as a signature of magnetic reconnection that changes the magnetic topology and relaxes a stressed magnetotail magnetic field. MRs are also correlated with a variety of particle and radio signatures throughout the magnetosphere, highlighting their importance to the transport, energisation, and loss of magnetospheric plasma. Whilst MRs at different planets have morphological similarities, the very different physical regimes of the planets have led to uncertainty and controversy as to whether, or to what extent, they can be considered signatures of a common dynamical and physical process. Here we show that MRs at Jupiter and Saturn are both consistent with an integrate-and-fire process, comprising specifically a random walk with mean drift and stochastic innovations between two barriers. This places them in the same category of process as MRs at Earth. However, the details of the process are found to differ at each planet. Thus, at least, we have identified a unifying mathematical process by which the dynamical properties of MRs can be quantitatively compared. Moreover, we discuss how this provides clues and constraints for the underlying physics.

Fritz, Theodore A.

What Happens to the Cusp Electrons?

Fritz, Theodore A.[1]; Walsh, Brian M.[2]

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Using a survey of over seven years of Cluster data Walsh and Fritz (2011) established that the population of energetic electrons >37 keV within the magnetospheric cusp is produced in-situ by a process or processes in which these electrons are accelerated locally. Energetic electrons have been observed on the magnetopause surface streaming tailward by a number of authors at locations from above the poles to distances many 10s of Re along the flanks. The role these electrons are examined as a population that can couple via gradient drift entry into the magnetosphere along the extended dusk flank. Such a population would produce a distinctive pitch angle distribution as they drift eastward in the geomagnetic field of the magnetotail. Such distributions have been reported frequently but not interpreted in a manner consistent with this explanation. A series of Cluster and ISEE observations of pitch angle distributions (PADs) recorded at the field reversal region of the magnetotail will be reviewed. These PADs indicate that these drifting electrons are fully capable of carrying the cross-tail current.

Fruit, Gabriel

Electrostatic "bounce" instability in a 2D current sheet - influence of untrapped electrons

Fruit, Gabriel[1]; Louarn, Philippe[1]; Tur, Anatoly[1]

1. IRAP, Toulouse, France

In the general context of understanding the possible destabilization of the magnetotail before a substorm, Tur et al. (2010) developed a kinetic model for electrostatic instabilities in resonant interaction with trapped particles. Using a 2D quasi-parabolic equilibrium state (as Lembège and Pellat's model), the linearized gyrokinetic Vlasov equation is solved for electrostatic fluctuations with period of the order of the electron bounce period. The dispersion relation for electrostatic modes is then obtained through the quasineutrality condition. This model has been refined here by introducing a distinction between trapped and untrapped electrons. The former consitutes the main current sheet described by a Harris distribution function. The latter fills in the loss cone and may have a different density/temperature. It is found that no electrostatic modes can exist when a cold permanent untrapped population is present in the sheet whereas an instability may develop quite rapidly when these "passing" particles have been removed or been energized. Hence, boundary conditions at the ionosphere seem to play an important role in triggering this instability.

Gabrielse, Christine

The effects of transient, localized electric fields on equatorial electron acceleration and transport towards the inner magnetosphere

Gabrielse, Christine[1]; Angelopoulos, V.[1]; Runov, A.[1]; Turner, D. L.[1]

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Motivated by recent observations of intense electric fields and elevated energetic particle fluxes within flow bursts beyond geosynchronous altitude [Runov et al., 2009; 2011], we apply modeling of particle guiding centers in prescribed but realistic electric fields to improve our understanding of energetic particle acceleration and transport towards the inner magnetosphere through model-data comparisons. Representing the vortical nature of an earthward traveling flow burst, a localized, westward-directed transient electric field flanked on either side by eastward fields related to tailward flow is superimposed on a nominal steady-state electric field. We simulate particle spectra observed at multiple THEMIS spacecraft located throughout the magnetotail and fit the modeled spectra to observations, thus constraining properties of the electric field model. We find that a simple potential electric field model is capable of explaining the presence and spectral properties of both geosynchronous altitude and "trans-geosynchronous" injections at L-shells greater than 6.6 RE in a manner self-consistent with the injections' inward penetration. In particular, despite the neglect of the magnetic field changes imparted by dipolarization and the inductive electric field associated with them, such a model can adequately describe the physics of both dispersed injections and depletions ("dips") in energy flux in terms of convective fields associated with earthward flow channels and their return flow. The transient (impulsive), localized, and vortical nature of the earthward-propagating electric field pulse is what makes this model particularly effective.

Garg, Shobhit

Dynamics of the Magnetosphere during an Extended CIR/HSS Storm Event

Garg, Shobhit[1]; Peroomian, Vahé[1]; El-Alaoui, Mostafa[1]

1. University of California, Los Angeles, Los Angeles, CA, USA

In this study, we investigate the dynamics of the magnetosphere to the highly variable solar wind and interplanetary magnetic field during the 8 – 9 March 2008 geomagnetic storm event. This two-day event began with the arrival of a density plug associated with a corotating interaction region (CIR) at ~0730 UT on 8 March, and was followed by the arrival of a high-speed stream (HSS) at ~1830 UT on that same day. Minimum Dst occurred at ~0530 UT on 9 March. We examine this storm in detail by carrying out a high-resolution global magnetohydrodynamic (MHD) simulation of the event using upstream solar wind and interplanetary magnetic field data from the WIND spacecraft, then use the global, time-dependent electric and magnetic fields obtained from the MHD simulation to carry out a large-scale kinetic (LSK) particle tracing study of the event. Ion launches from the solar wind and from the ionosphere began at 0400 UT on 8 March and continued through 0800 UT on 9 March. We detail the effect of the highly variable solar wind and IMF on the energization of ions in the magnetotail and their access to the plasma sheet and nightside ring current. We also show comparisons of our MHD and LSK results to observations by the THEMIS-B and -C spacecraft.

Gershman, Dan

MESSENGER Observations of Ion Pressures in the Plasma Sheet of Mercury

Gershman, Dan[1]; Slavin, James A.[1]; Raines, Jim[1]; Zurbuchen, Thomas H.[1]; Anderson, Brian J.[2]; Korth, Haje[2]; Solomon, Sean C.[3]

1. Univ of MI-AOSS, Ann Arbor, MI, USA
2. The Johns Hopkins University Applied Physics Laboratory, Laurel, MD, USA
3. Lamont-Doherty Earth Observatory, Columbia, Palisades,, NY, USA

While in orbit about Mercury, the MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) spacecraft transits through the plasma sheet whenever its highly inclined orbit passes through the planet's magnetotail. The Fast Imaging Plasma Spectrometer (FIPS) sensor on MESSENGER, in addition to analyzing the dominant H+ population, measures the properties of heavier, less abundant planetary ion species (e.g., Na+) through mass-per-charge discrimination. We present the first targeted study of Mercury's magnetotail plasmas using data from ~60 spacecraft passes through the plasma sheet at distances of 2–3 RM (where RM is Mercury's radius, or 2440 km) down the tail from the center of the planet. The average density and temperature of H+ in the tail are found to be 6 ± 4 cm-3 and 12 ± 5 MK, respectively. In the plasma sheet, solar wind ions, namely He2+ and (O6+ + C5+), maintain near-solar wind abundances with respect to H+ and exhibit mass-proportional ion temperatures. Conversely, planetary ion species such as He+, O+, and Na+ appear nearly thermalized with temperatures similar to that of H+, suggesting that strong wave–particle interactions must be present to scatter these pickup ions from ring to Maxwellian distributions within relatively short intervals. It is estimated that heavy ions contribute up to ~30% of the total plasma pressure in the plasma sheet.

Gombosi, Tamas I.

Simulations of Mercury's Magnetosphere *(INVITED)*

Gombosi, Tamas I.[1]; Jia, Xianzhe[1]; Slavin, James[1]; Daldorff, Lars[1]

1. Center for Space Environment Modeling, University of Michigan, Ann Arbor, MI, USA

Mercury's comparatively weak intrinsic magnetic field and its close proximity to the Sun give rise to a mini-magnetosphere that undergoes more direct space-weathering interactions than other terrestrial planets. The recent measurements acquired by MESSENGER provide interesting new data about Mercury's magnetosphere, including first in-situ measurements of planetary heavy ions in the magnetosphere (e.g., Zurbuchen et al., 2008, 2011) and observations of magnetospheric dynamics dominated by effects of magnetic reconnection, such as flux transfer events on the magnetopause and strong loading/unloading events in the magnetotail (e.g., Slavin et al., 2008, 2009, 2010). Global simulation models, including both MHD and hybrid models, have been developed to understand the roles of the solar wind and planetary ions in determining the global structure and driving dynamics of Mercury's magnetosphere. These global models provide global context for interpreting and linking measurements obtained in various parts of the system, thereby extending our knowledge of Mercury's magnetospheric environment beyond that available from localized spacecraft observations. In this presentation, we will review recent advances in the global modeling of Mercury's magnetosphere, and present simulation results from a newly developed Mercury global MHD model based on the Michigan BATSRUS code that electromagnetically couples the interior region of the planet to the magnetosphere allowing for self-consistently characterizing the dynamical response of the Mercury system to time-varying external solar wind, such as the effects of induction from the planet's highly conducting core on the global magnetic field.

Goodrich, Kate

Dissipation of Bursty Bulk Flows In The Earth's Magnetotail

Goodrich, Kate[1]; Ergun, Bob[1]; Andersson, Laila[1]

1. Laboratory for Atmospheric and Space Physics, University of Colorado at Boulder, Boulder, CO, USA

Bursty bulk flows are created in response to changes in the magnetosphere. In the stretched-out tail configuration, plasma can flow reasonably freely. As bursty flows move towards the Earth, the magnetic topology changes due to the flow interaction with the Earth's magnetic dipole. As the flows reach the stronger, dipole-like magnetic fields, the flows will break and dissipate. This occurs often at 8-12 Earth radii. How these flows are dissipated is still unknown. The presented study analyzes the electromagnetic characteristics within the breaking region in order to determine the Alfvenic nature of the turbulence therein.

Alfven waves can leave the region carrying both information and energy. As for the ionosphere-magnetosphere coupling, Alfven waves are created from the bursty bulk flow and can be the dominant process that couples the two regions. It is therefore important to investigate the wave types that are created in the dissipation region to understand when significant coupling to the ionosphere occurs.

Grodent, Denis C.

Statistical analysis of Saturn's UV auroral outer emission

Grodent, Denis C.[1]; Radioti, Aikaterini[1]; Schippers, Patricia[2]; Gustin, Jacques[1]; Gérard, Jean-Claude[1]

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2. LESIA, Observatoire de Paris, Paris, France

Recent observations of Saturn's aurora with the UVIS spectrograph on-board Cassini not only confirm the presence of a quasi-permanent partial ring of emission equatorward of the main auroral oval, but they also increase the number of positive cases and allow for a statistical analysis of the characteristics of this outer emission. This faint but distinct auroral feature appears at both hemispheres in the nightside sector. It magnetically maps to relatively large distances in the nightside magnetosphere, on the order of 9 RS. It was initially thought that pitch angle scattering of electrons into the loss cone by whistler waves would be responsible for the outer auroral emission. Rough estimates suggested that a suprathermal electron population observed with Cassini in the nightside sector between 7 and 10 RS might power this process. However, a new analysis of 7 years of Cassini electron plasma data indicates the presence of layers of upward and downward field aligned currents. They appear to be part of a large-scale current system involving dayside-nightside asymmetries as well as trans-hemispheric variations. This system comprises a net upward current layer, carried by warm electrons, limited to the nightside sector which may as well generate the outer UV auroral emission. The growing dataset of UVIS spectro-images is used to find any such asymmetries in the outer auroral emission.

Haaland, Stein

On the supply of cold plasma to the Earth's magnetotail

Haaland, Stein[1, 2]; Li, Kun[1, 3]

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2. Department of Physics and Technology, University of Bergen, Bergen, Norway
3. Graduate University of Chinese Academy of Sciences, Beijing, China

The importance of ion outflow as a source of plasma for the terrestrial magnetosphere has been recognized for decades. Due to spacecraft charging effects, it has been difficult to measure the low energy part of the ionospheric contribution, and the impact of cold plasma on fundamental plasma properties and processes in the magnetotail has therefore often been ignored. Recent advances in instrumentation and methodology now provide better opportunities to access the role of cold ions in the magnetotail. In this study, we have used measurements from the Cluster mission combined with particle tracing techniques to quantify the amount of cold plasma supplied to the magnetotail and to determine where in the magnetotail cold plasma of ionospheric origin will be supplied. We also discuss the implications of the cold ions for physical processes in the magnetotail. Our results show that cold ion outflow flux does not respond substantially to changes in geomagnetic activity or changes in the solar wind or interplanetary magnetic field (IMF), but can vary a factor 3 as a result of enhanced solar irradiance and subsequent ionospheric ionization. The fate of the ion, and the supply of cold plasma to the magnetotail, on the other hand, is largely controlled by convection. Our results indicate that a northward directed IMF and stagnant convection leads to a significant direct downtail loss of the cold plasma, and essentially no supply of ionospheric material to the magnetotail. Correspondingly, a southward IMF results in enhanced convection and enhanced supply of cold plasma to the magnetotail. Under such conditions, there is a also a substantial loss of magnetospheric plasma through the ejection of plasmoids.

Haerendel, Gerhard

Processes Governing the Entry of Plasma from Magnetic Tail into Magnetosphere During Substorms ***(INVITED)***

Haerendel, Gerhard[1]

1. Extraterrestrial Physics, Max-Planck-Institute for, Garching, Germany

The plasma and magnetic field ejected from tail reconnection and, under dipolarization, piling up at the nightside boundary of the magnetosphere, would remain there in force balance with tail lobes and outer magnetosphere, were it not for the current exchange with the ionosphere. By virtue of these currents, magnetic shear stresses are transferred to the atmosphere, with the result of generating a westward electric field, thus allowing earthward convection and entry into the magnetosphere. The accompanying losses of internal energy by balancing both auroral particle energization and ionospheric current dissipation are instrumental in avoiding the "pressure catastrophy" due to the shrinking flux tube volume. Auroral structures, like the poleward expanding auroral bulge, the westward travelling surge, the eastward propagating arcs, and the Alfvénic arcs along the poleward border, will be analyzed with respect to their role in the entry process. Attention will also be drawn to the less understood processes playing at the central and morning-side borders of the substorm auroral oval.

Hamrin, Maria

Cluster observations of energy conversion in plasma sheet vortex flows

Hamrin, Maria[1]; Norqvist, Patrik[1]; Karlsson, Tomas[2]; Nilsson, Hans[3]

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2. Space and Plasma Physics, Royal Institute of Technology, Stockholm, Sweden
3. Swedish Institute of Space Physics, Kiruna, Sweden

The plasma flow signature in and around a bursty bulk flow (BBF) is often rather complicated. Return flows and plasma vortexes are expected to exist at the the flanks of the main flow channel. Such return flows have been predicted from simulations and have been observed in situ in the magnetotail. BBFs play an important role for the mass, energy and magnetic flux transport in the plasma sheet, and the detailed flow pattern in and around a BBF may have important consequences for the localized energy conversion between electromagnetic and plasma mechanical energy forms. Here we present Cluster measurements of BBF vortex flows in the mid-tail plasma sheet. For the first time, the detailed energy conversion properties during various stages of the BBF evolution have been observed. Our observations are compared to recent simulation results, and we discuss the flow pattern in relation to the observed energy conversion as measured by $\mathbf{E}\cdot\mathbf{J}$, where $\mathbf{E}$ is the observed electric field and $\mathbf{J}$ the current density estimated by the curlometer method.

Hasegawa, Hiroshi

Kelvin-Helmholtz Instability at Planetary Magnetopauses: An Overview and Comparison *(INVITED)*

Hasegawa, Hiroshi[1]; Masters, Adam[1]; Nakamura, Takuma[2]; Sundberg, Torbjorn[3]

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3. Heliophysics Sci Div, NASA Goddard Space Flight Center, Greenbelt, MD, USA

Kelvin-Helmholtz instabilities (KHIs) are known, or suggested, to grow along the magnetopause of a magnetized planet such as Earth, Mercury, Jupiter, and Saturn, and could play a key role in the transfer of mass, momentum, and energy across the magnetopause. We present an overview of in situ observations of magnetopause Kelvin-Helmholtz (KH) or surface waves at the Earth, Mercury, and Saturn, with an aim of making clear the similarities and differences among these planets in their properties, such as local time and interplanetary magnetic field dependence of the occurrence probability and period/wavelength. The comparison is made by taking into account various factors that may affect the properties of the KHI: the size of the magnetosphere (which may determine the predominance of MHD or sub-MHD processes and KHI growth time), rotation of the planet (which may lead to local time dependence of the magnitude of velocity shear and field-line deformation), presence/absence of internal plasma sources (which may affect the shear layer thickness and the bulk flow energy on the magnetospheric side), coupling to the near-surface layer (which may reduce the KHI growth rate), and upstream solar wind conditions (which may control the excitation and persistence of the KH waves). Several single-spacecraft methods for identification of KH waves/vortices are also discussed, for further investigations of planetary surface waves.

Hesse, Michael

Magnetic Reconnection in Different Environments: Similarities and Differences *(INVITED)*

Hesse, Michael[1]; Aunai, Nicolas[1]; Birn, Joachim[2]

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2. Space Science Center, Boulder, CO, USA

Magnetic reconnection is arguably the most important driver of dynamical evolutions in magnetospheres. Magnetic reconnection facilitates energy transfer from the external, solar wind into magnetospheres, and it plays a key role in the conversion and dissipation of this energy inside of magnetospheres. Typically, plasma conditions vary where reconnection operates, but even more so between different reconnection sites. Because of the fundamental role reconnection plays in the overall dynamics, it is of interest to understand its modes of operations under different physical conditions. In this presentation, we present a combined review and analysis of the present knowledge pertaining to this question. We will focus of issues such a rate dependence on external parameters, and whether reconnection operates in a steady or unsteady fashion. The presentation will focus on results from both theory and modeling, but present linkages to observed features of reconnection in and around magnetospheres.

Hoshino, Masahiro

Magnetic Reconnection, Turbulence and Nonthermal Particles in Magnetotail *(INVITED)*

Hoshino, Masahiro[1]

1. Dept Earth & Planetary Science, University of Tokyo, Tokyo, Japan

In the earth's magnetotail, energetic electrons with more than several 10 keV are often observed in association with fast plasma flow events. Magnetic reconnection and plasma turbulence are believed to be responsible for generating energetic particles, and those energetic particles are known to play an important role on plasma dynamics in the magnetotail. However, the mechanism of particle acceleration and the role of turbulence during reconnection has not been understood yet. In this presentation, we review our recent progress on particle acceleration and MHD turbulence during reconnection by using PIC simulation, MHD-turbulence simulation and Geotail/Cluster data

analyses. Specifically we discuss several fundamental aspects of turbulent reconnection focusing on turbulent diffusivity in plasma sheet and stochastic particle acceleration among multiple magnetic islands. We also argue that turbulence self-generated during the nonlinear evolution of reconnection plays an important role not only on particle acceleration but also on enhancement of reconnection rate.

Imber, Suzanne M.

MESSENGER observations of dayside flux transfer events: Do they drive Mercury's Dungey cycle?

Imber, Suzanne M.[1, 2]; Slavin, James A.[2]; Boardsen, Scott A.[3, 4]; Anderson, Brian J.[5]; Korth, Haje[5]; Baker, Daniel N.[6]; McNutt, Ralph L.[5]; Solomon, Sean C.[7]

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5. The Johns Hopkins University Applied Physics Laboratory, Johns Hopkins University, Laurel, MD, USA
6. Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO, USA
7. Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY, USA

The large-scale dynamics of Mercury's highly compressed magnetosphere appear to be predominantly driven by magnetic reconnection, which allows the transfer of energy and momentum from the solar wind to the magnetosphere. Reconnection also drives Mercury's Dungey cycle, which circulates magnetic flux through the system. The rate of reconnection taking place at any given time can be determined by observations of reconnection-related signatures such as plasma jets, large magnetic field components normal to the magnetopause, and flux transfer events (FTEs). FTEs are flux ropes formed by reconnection at Mercury's magnetopause and transport magnetic flux from the dayside to the lobes of the tail. Fifty-eight FTEs were identified during February and May 2012, when the MESSENGER orbit was near a noon–midnight configuration with core fields stronger than the planetary field just inside the magnetopause. The FTEs were mostly formed during periods of southward interplanetary magnetic field (IMF). Field orientations during such events were determined by minimum variance analysis, and the results suggest that the FTEs were formed by multiple X-line reconnection at low latitudes on the dayside magnetopause. We show that these large-amplitude FTEs can carry substantial quantities of magnetic flux, driving a cross-polar-cap potential of tens of kV. On average the Dungey cycle takes a few hours at Earth, but studies of loading and unloading events in Mercury's magnetotail indicate that at Mercury the timescales are several minutes. We show that these large-amplitude FTEs contain sufficient magnetic flux, and are moving with sufficient speed, to drive such short Dungey-cycle times, and we suggest that FTEs play a more dominant role in Mercury's magnetospheric dynamics than at Earth.

Jackman, Caitriona M.

Saturn Tutorial ***(INVITED)***

Jackman, Caitriona M.[1, 2]

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2. Centre for Planetary Sciences, University College London/Birkbeck, London, United Kingdom

The Pioneer 11 (1979), Voyager 1 (1980) and Voyager 2 (1981) spacecraft glimpsed Saturn's magnetotail on their flybys and provided the first clues as to its character and extent. Subsequently the Cassini spacecraft at Saturn (2004-2017 as currently planned) has shed huge light on this fascinating and complex environment. In particular the deep tail orbits of 2006 provided an opportunity to study dynamics such as magnetic reconnection in the tail, and to sample injections and changing plasma flows in situ. Plasma periodicities are also a topic of huge interest throughout Saturn's magnetosphere. I will provide a tutorial review of the current state of knowledge of Saturn's magnetotail, listing open questions for the future.

Jackman, Caitriona M.

Investigating the Dynamics of Planetary Magnetotails: An overview of the work of ISSI Team Number 195

Jackman, Caitriona M.[1]; Arridge, C. S.[2]; Andre, N.[3]; Bagenal, F.[4]; Birn, J.[5]; Freeman, M. P.[6]; Jia, X.[7]; Kidder, A.[8]; Milan, S. E.[9]; Radioti, A.[10]; Slavin, J. A.[7]; Vogt, M. F.[11]; Volwerk, M.[12]; Walsh, A. P.[13]

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8. University of Washington, Seattle, WA, USA
9. Physics and Astronomy, University of Leicester, Leicester, United Kingdom
10. Universite de Liege, Liege, Belgium
11. Space Research Centre, University of Leicester, Leicester, United Kingdom
12. Austrian Academy of Sciences, Graz, Austria
13. ESTEC, Noordwiik, Netherlands

Spacecraft observations have established that all magnetised planets interact with the solar wind and possess well-developed magnetic tails. In 2010 we set up an international team at the International Space Science Institute (ISSI) to study reconnection, convection, and charged particle acceleration in the magnetic tails of Mercury, Earth, Jupiter and Saturn. These fundamental physical processes are common to all these planetary environments and relate to a complex chain of events that ultimately release mass and energy in magnetised configurations. The great differences in solar wind conditions, planetary rotation rates, ionospheric conductivity, and physical dimensions from Mercury's small magnetosphere to the giant magnetospheres of Jupiter and Saturn, provide an outstanding opportunity to extend our understanding of the influence of these factors on the basic physical processes inside planetary magnetotails. We have drawn together data analysis experts and global modellers to build up a full picture of small- and large-scale dynamics. We report some of the highlights of our team's work over the past two years. We also outline the content of our large review paper entitled "Large-scale structure and dynamics of the magnetotails of Mercury, Earth, Jupiter and Saturn", to be submitted to Space Science Reviews by the end of 2012.

Jackman, Caitriona M.

Interpreting flow characteristics in planetary magnetotails

Paranicas, Chris[1]; Jackman, Caitriona M.[2]

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2. Department of Physics and Astronomy, University College London, London, United Kingdom

In situ evidence of magnetotail reconnection and associated plasmoid release has been presented at Saturn using magnetic field and plasma data. Here we employ the energetic particle detectors on the Cassini spacecraft to build on previous work, and to take advantage of the remote sensing capability of the instrument. Cassini/MIMI detects energetic ions and we use these to calculate plasma flow vectors in Saturn's tail region. Our goal is to understand the loss of plasma from the magnetosphere and whether this is more likely to occur sporadically or in a steady-state manner. Energetic charged particle data can be used to create flow vectors via the so-called Compton-Getting effect. Here fluxes into the sensor can vary based on the orientation of the sensor to the plasma flow. Plasma flow vectors obtained in this manner can tell us the steady-state and transient nature of the flow field. This talk will be a progress report on this work. We plan to combine observations of flows with in situ magnetometer data, to build up a picture of the changing morphology of the magnetotail region.

Jahn, Jorg-Micha

Cross-Tail View of the Dynamics of Earth's Magnetotail

Jahn, Jorg-Micha[1]; Al Dayeh, Maher[1]; Elliott, Heather[1]

1. Space Sci Dept, Southwest Research Inst, San Antonio, TX, USA

The size of Earth's magnetotail makes it comparatively difficult to obtain a comprehensive picture of tail dynamics from localized in situ observations alone. Energetic neutral atom (ENA) observations from the IBEX spacecraft provide a means to observe the longer-duration (> 24hours) spatio-temporal development of the tail in a cross-sectional fashion. We are presenting uninterrupted multi-day observation periods covering the near- to midtail region. Tail emissions, although being weak and therefore typically requiring up to 20 minutes of integration time, can be reliably made up to at least 25 Earth radii distance downtail. As expected, ENA emissions predominantly emanate from the center of Earth's tail, being overwhelmingly emitted from the plasma sheet region. While the nature of the measurements precludes identification of structures smaller than approximately one Earth radius as well as preclude the direct measurement of Earth- or tailward flows, our observations nonetheless confirm the picture of a highly time-variable tail. Due to the integrating nature of the measurements, 'variability' denotes changes across the whole cross-section of the tail rather than local variations due to localized plasma variations or local plasma flows. Even outside geomagnetic storms there is a rich short-term (one hour or more) variability of tail emissions, coupled at times with variability of the ENA energy spectrum. These short-term variations are poorly correlated with solar wind driving of the magnetosphere. On top of these highly dynamic variations, we observe significant orbit-to-orbit differences of the large-scale background ENA intensity profile of the tail. This points to solar wind driven long-duration variations of the total content of the tail region, which can be much better correlated with solar wind conditions.

Jia, Xianzhe

Satellites' Magnetotails ***(INVITED)***

Jia, Xianzhe[1]

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Like planets, planetary satellites can also be considered to possess magnetotails. Here for satellites, "magnetotail" refers to the wake region behind a moon formed as a result of its interaction with the ambient flowing plasma within the magnetosphere of its parent planet or the solar wind. How the plasma and fields are distributed in satellites' magnetic tails differ greatly depending on their magnetic properties (magnetized vs. unmagnetized), their roles as source of neutrals/plasma (whether or not they possess atmosphere/ionosphere), and the conditions of the ambient plasma flowing onto them (sub- vs. super-magnetosonic). In this presentation, we will use the major satellites of the two giant planets, Jupiter and Saturn, as examples to illustrate the diversity of ways in which planetary satellites interact with their surroundings and the properties of their resulting magnetic tails as inferred from spacecraft measurements and numerical modeling. Special attention will be given to the magnetotail of Jupiter's moon, Ganymede, the only known satellite with strong intrinsic field in the solar system.

Jia, Xianzhe

Periodic modulations of Saturn's magnetotail as driven by vortical flows in the upper atmosphere/ionosphere

Jia, Xianzhe[1]; Kivelson, Margaret G.[2, 1]; Gombosi, Tamas I.[1]

1. 1411B Space Research Building, University of Michigan, Ann Arbor, MI, USA
2. Dept. of Earth and Space Sciences, University of California at Los Angeles, Los Angeles, CA, USA

Despite the high degree of axial symmetry in its intrinsic magnetic field, Saturn's electromagnetic radiation (SKR), its magnetic perturbations and its particle populations all exhibit rotation-associated modulations at periods close to the planet's rotation period. Furthermore, recent Cassini observations indicate that the electromagnetic period not only drifts slightly over a time scale of years but also differs for sources at high latitudes in the north and south. Identifying the cause of the periodicities has proved challenging because drivers internal to Saturn are inconsistent with the drifting period and rotating magnetospheric asymmetries lack the inertia to remain stable in phase. The upper atmosphere/ionosphere, with low enough inertia to allow drift and high enough inertia to maintain phase coherence, is a plausible source region. Ionospheric properties affect the global magnetosphere most strongly by generating field-aligned currents, and vortical flows in the ionosphere are an effective source of such currents. We have carried out global simulations using the MHD model, BATSRUS, to investigate how Saturn's magnetosphere would respond to vortical flows in the ionosphere. We have initially focused our investigation on the magnetospheric modulations at the dominant southern period by including a localized vortical flow structure in the southern high-latitude ionosphere that rotates at roughly the rate of planetary rotation. The model is found to reproduce nearly quantitatively a host of observed magnetospheric periodicities associated with the period of the dominant southern SKR. Emboldened by the initial success of our model, we have extended our model to investigate the contributions of northern hemisphere perturbations at a different period by including an additional vortical structure in the northern ionosphere rotating at the northern SKR period observed during the southern summer. This presentation will focus on the magnetotail where the model is shown to reproduce many well-documented results of Cassini data analysis, such as periodic plasmoid releases in the tail that we associate with observed periodic bursts of energetic neutral atoms (ENAs), current sheet flapping and modulation of the tail plasma sheet thickness, and the periodic structure of density enhancements at high latitudes at different periods in the north and the south.

Johnson, Jay R.

Alfvénic Magnetotail-Ionosphere Coupling at Earth and other Planets ***(INVITED)***

Johnson, Jay R.[1]; Damiano, Peter[1]; Delamere, Peter[2]; Wing, Simon[3]; Chaston, Chris[4]

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It is widely recognized that Alfven waves are a significant source of electron acceleration in the magnetospheres of Earth and other planets. Alfven waves are also associated with intense ion outflows indicative of the importance of their role in magnetosphere-ionosphere coupling. We review the typical sources of Alfven waves, such as solar wind variability, substorms, and the interaction of Io with Jupiter's magnetosphere. We discuss the physical processes responsible for electron acceleration in Alfven waves and the role of cross-scale coupling, which is required for efficient acceleration of particles. We review the observational signatures of wave aurora based on DMSP satellites, which shows significant enhancement at the time of substorms. Finally, we discuss how Alfven waves produce ion outflows and consequences for magnetosphere-ionosphere coupling processes.

Kalegaev, Vladimir V.

Geomagnetic Tail Large Scale Structure and Dynamics in Quiet Magnetosphere

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On the base of simultaneous measurements from the five THEMIS satellites, the radial profile of the magnetic field and the position of the inner edge of the magnetospheric tail were determined during selected events in geomagnetically quiet 2009. The magnetic field produced by the tail current was obtained by subtracting the internal magnetic field and the contributions from ring current and Chapman-Ferraro currents calculated in terms of a paraboloid model of the Earth's magnetosphere from satellite measurements. It was found that during quiet times the inner edge of the tail current sheet is located in the night-side magnetosphere, at distances of about 10 Re. In the vicinity of the inner edge of the tail current the magnetic field Bx and Bz components were about -20 nT, while in the distant tail, at Xgsm ~ -30 Re, these values were about -10 nT. During small geomagnetic disturbances due to solar wind pressure pulses the inner edge of the tail current sheet shifted towards the Earth to a distance of about 7 Re. At the same time strong currents in the magnetotail were detected. During the disturbance of February 14, 2009 (Dst_min ~ -35

nT), the Bx component of the magnetic field near the inner edge of the tail current sheet was about 70 nT, and the Bz component was about -50 nT. However, strong currents, measured in the geomagnetic tail did not cause the expected Dst-effect. Actually, the magnetospheric current systems (magnetopause and cross-tail currents) were located at larger geocentric distances than typical during the 2009 extremely quiet epoch. Very small disturbance on the Earth's surface was detected consistent with an "inflated" magnetosphere.

Karlsson, Tomas

Multi-point Measurements of Bursty Bulk Flows in Earth's Magnetosphere

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We present Cluster multi-point measurements of burst bulk flows (BBF's) in Earth's magnetotail. When the satellite separation is small (of the order of 100 km), we can use the curlometer method to calculate local currents associated with BBF's and possibly co-located dipolarization fronts. We present for the first time current calculations that are used to directly determine the jxB force at various regions of the BBF's. The magnetic force is important, since together with the pressure gradient force it will determine the dynamics of the BBF's as they enter the near-Earth region. For time periods with larger satellite separations, the three-dimensional morphology of BBF's can be addressed. This helps to untangle spatial and temporal variations, which affects the determination of the energy and mass flux associated with BBF's. We present some first results regarding this.

Keiling, Andreas

Global Geomagnetic Pulsations Driven by Periodic Flow Bursts

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Global geomagnetic pulsations, such as field line and cavity resonances, are eigenmodes of the system. Ground observations of such pulsations in the nightside have been attributed to broadband pressure pulses launched during substorm onset. Here we report an event that is observed globally over more than 10 hrs MLT and from low to high latitudes. In-situ observations from THEMIS and GOES suggest a poloidal mode extending to the plasma sheet, i.e., the mode is not limited to the plasmasphere. Furthermore, it is shown that the source, providing energy and periodicity, lies in the plasma sheet, ruling out the broadband-driven global mode mentioned above. Instead, a possible candidate is forced oscillations by magnetotail BBFs, of which observational evidence is given. The period of the pulsations lies in the Pi2 range. Although no substorm occurred, a large-scale dipolarization did occur surrounding this event. The event is likely to be classified as a pseudo-breakup; albeit the global extent of the pulsations is remarkable.

Kepko, Larry

The Substorm Current Wedge at Earth... And Mercury?

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The substorm current wedge has been a central component of substorm dynamics for decades. At Earth, the

importance of the substorm current wedge lies in its ability to link ionospheric and magnetospheric processes during the dynamic collapse of the near-Earth current sheet under a single, coherent phenomenological picture. It is generated by the impact of high-speed plasma flows in the near-Earth region and maintained by the resultant pressure gradients and vorticity, and this high-pressure region of dipolarized magnetic field deflects subsequent flow bursts towards the dayside. Recent results from MESSENGER show strong loading and unloading cycles, similar to substorms in Earth's magnetosphere, only on much more rapid timescales. Yet the substorm cycle in Mercury's magnetosphere occurs in the absence of an appreciable ionosphere. Since the initial description, it is has become clear that the SCW is not a simple wire circuit. There is, for example, strong evidence that a large fraction of the diverted current does not flow into the ionosphere. Rather, it is closed just above and below the current sheet, in the magnetotail itself, which may have implications for substorm dynamics at Mercury. In this talk, we present results obtained from THEMIS showing quantitatively the relative current closing through the ionosphere vs current closing in the magnetotail. We apply this knowledge to the results obtained in Mercury.

Kiehas, Stefan

Flux rope observations near lunar orbit with ARTEMIS

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Each month the ARTEMIS probes cross the magnetotail near lunar orbit for a period of four days. This region of the magnetotail is critical for the understanding of transient tailward propagating phenomena like flux ropes and plasmoids and the interplay of the distant neutral line with a near Earth neutral line. With two-point spacecraft observations we have the first-time opportunity to determine the size of flux ropes/plasmoids in this region directly. The changing spacecraft separation allows us to investigate the thickness, azimuthal extent and cross section of flux ropes. The size of flux ropes has direct consequences for mass-, flux- and energy transportation during substorms. Particle beams observed in the plasmoid boundary layer indicate the simultaneous activity of two reconnection lines, one tailward, and one earthward of lunar orbit.

Kissinger, Jennifer

The Importance of Stormtime Steady Magnetospheric Convection in Determining the Final Relativistic Electron Flux Level

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Although about half of all geomagnetic storms result in relativistic electron flux enhancements, we do not understand whether any particular storm will produce an increase or decrease in relativistic electron flux. Radiation belt fluxes depend on a complex balance between transport, loss, and acceleration, and understanding this system behavior is the goal of the recently launched RBSP mission. A critically important aspect of radiation belt enhancements is the role of the 'seed' population—plasma sheet particles heated and transported earthward by magnetotail processes. We present a previously unexplored connection between a quasi-steady mode of magnetotail response called steady magnetopsheric convection (SMC) and the behavior of relativistic electron fluxes during magnetic storms. SMC events are long-duration intervals of enhanced convection without any substorm expansions, and are an important mechanism in coupling magnetotail plasma populations to the inner magnetosphere. We find that a storm is more likely to increase geosynchronous relativistic electron flux levels if an SMC occurs in the recovery phase of the storm, suggesting that seed particle energization and transport is an important determinant of the final relativistic flux level. We explore this correlation further using particle measurements from the SAMPEX and THEMIS missions, as well as recent measurements from RBSP. We investigate the behavior of the 'seed' electron population that is thought to become accelerated to relativistic energies, in addition to the relativistic electrons themselves, during SMC-associated magnetic storms.

Krupp, Norbert

Energetic Particles in the Magnetotails of Jupiter and Saturn: A Comparison Using Galileo/EPD and Cassini/Mimi Data

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We present an overview of energetic particle measurements obtained in the magnetotails of Jupiter and Saturn. Galileo covered parts of the Jovian magnetotail out to about 150 RJ while Cassini flew through regions beyond 65 RS. More than 240 (partially periodic) reconnection events have been identified in data collected during the 7 years that Galileo was in orbit around Jupiter. However, at Saturn only 35 similar events have been found. We report changes in the energetic particle composition in the magnetotail and discuss whether heavy ions are more efficiently energized during tail reconnection at both giant planets. The location of those events in the magnetosphere can be traced back to the planet using magnetic field models. Correlations to auroral emissions observed with both the spacecraft and HST will be also discussed.

Kullen, Anita

Non-Conjugate Polar Arcs - Auroral Observations and Tail Models

Kullen, Anita[1]

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Large-scale polar auroral arcs are often connected to sunward convecting plasma and have particle characteristics which indicate these arcs lie on closed field lines originating in the tail plasma sheet or its boundary layer. Thus, polar arcs have often been assumed to appear as conjugate phenomena on both hemispheres. That assumption fits well with interhemispheric observations of conjugate polar arcs as well as MHD simulations, showing a conjugate topology of northern and southern magnetotail during polar arc events. However, in recent years these assumptions have been questioned. There exist several studies reporting polar arc events where the arc lies partly on sunward, partly on anti-sunward convection plasma. Other observations show that also non-conjugate polar arc events exist. In the present study, we reinvestigate some of the non-conjugate polar cases, and discuss how these non-conjugate arcs could be possibly linked to large-scale magnetotail changes. The second part of the study is based on DMSP measurements of 73 TPA crossings. The selected DMSP orbits are approximately along the dawn-dusk meridian. We present statistical results of polar arcs appearing simultaneously in both hemispheres and examine the typical solar wind conditions during which conjugate and non-conjugate events appear. We draw conclusions on how these typical solar wind conditions may affect the magnetotail topology and discuss how certain magnetotail changes may affect the conjugacy of polar arcs.

Lamy, Laurent

Earth based detection of Uranus aurorae

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This study is based on multi-planet multi-wavelength observations of planetary aurorae throughout the heliosphere, acquired along the propagation path of a series of consecutive interplanetary shocks. The underlying motivation to track the shocks was to increase the probability of detection of auroral emissions at Uranus. Despite several Earth-based attempts in the past few years, at Far-UV (FUV) and Near-IR (NIR) wave- lengths, such emissions have never been unambiguously re- observed since their discovery by Voyager 2 in 1986. Here, we present a campaign of FUV observations of Uranus obtained in November 2011 with the Hubble Space Telescope (HST) during active solar wind conditions. We positively identify auroral signatures in several of these HST measurements, together with some obtained in 1998, representing the first images of Uranus' aurorae. We analyze their characteristics and discuss the implications for the asymmetric Uranian magnetosphere and its highly variable interaction with the solar wind flow from near-solstice (1986) to near-equinox (2011) configurations.

Lapenta, Giovanni

Global Fully Kinetic Magnetotail Simulation

Lapenta, Giovanni[1]; Markidis, Stefano[3]; Vapirev, Alex[1]; Amaya, Jorge[1]; Goldman, Martin[2]; Anderson, Laila[2]; Newman, David[2]; Eriksson, Stefan[2]

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3. KTH, Stockholm, Sweden

We report global simulations where a large portion of the magnetosphere is modelled fully kinetically (i.e. both electrons and ions are treated as particles with PIC). The model centers on the magnetotail, including the dipole field of the Earth and has a size of 80 Earth radii in the tailward direction, and 20 RE in in north-south and dawn dusk direction. The model required the used of advnaced implicit modelling methods (based on the iPic3D code) and a large allocation on the Curie supercomputer via the PRACE Tier-0 EC-funded program and on Pleiades via the NASA MMS misison. Indeed the anbalysis focuses on the energy transfer

during the process of reconnection in conditions expected for the MMS mission. We focus on the propagation of infromation and energy away from the reconneciton regions formed in the tail and towards the Earth. We look at the speed of such transfer, comparing it with the local Alfven speed and evaluating the process in terms of Kinetic Alfven wabves. We study the structure of the reconneciton region and identify waves that can be measured by the MMS mission and their nature in terms of whistler and KAW. The impact on the ionosphere of tail processes can be directly mesured thanks to the large domain of the simulation. Finally we identify processes of "turbulent" reconnection where multiple islands are created even in a initially laminar system.

Liu, Jiang

On the current sheets surrounding dipolarizing flux bundles in the magnetotail: the case for wedgelets

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Using THEMIS observations from four tail-seasons, we study the three-dimensional structure of the dipolarization front current sheet (DFCS), which demarcates the magnetic boundary of a dipolarizing flux bundle (DFB, the strong magnetic field region led by a dipolarization front) in Earth's magnetotail. An equatorial cross section of the DFCS is convex; a meridional cross section is consistent with a dipolarized field line. The magnetic field perturbations are consistent with local fieldaligned current generation of region-2 sense ahead of the front and region-1 sense at the front. The median thickness of the DFCS increases from 800 to 2000 km with increasing distance from the neutral sheet, indicating bundle compression near the neutral sheet. On a meridional cross section, the linear current density (1.2 - 1.8 nA/m) peaks ~±0.55l from the neutral sheet (where l is the ambient cross-tail current sheet half-thickness, l ~1.5 RE in our database). This peak, reminiscent of active-time cross-tail current sheet bifurcation noted in past studies, suggests that the intense but thin DFCS (10 to 20 nA/m2) may be produced by redistribution (diversion) of the extended but weaker cross-tail current (~1 nA/m2). Near the neutral sheet the average DFCS current over the DF thickness is perpendicular to both the magnetic field interior to the flux tube bundle and the average field direction over the DF thickness. Away from the neutral sheet the average current becomes progressively parallel to the internal field and the average field direction. The average current directions are indicative of region-1-sense current at the DF. As few as ~3 DFBs can carry sufficient total current that, if redirected into the auroral ionosphere, can account for the substorm current wedge's peak current for a sizable substorm (~1MA). A collapsing DFB could thus be an elemental substorm current wedge, or "wedgelet", that can divert a sizable portion of the cross-tail current into the auroral ionosphere.

Mann, Ian R.

Role of Magnetosphere-Ionosphere Coupling in Destabilisation of the Earth's Magnetotail

Mann, Ian R.[1]; Murphy, Kyle[1]; Rae, Iain J.[1]; Anderson, Brian[2]; Waters, Colin[3]; Milling, David[1]; Korth, Haje[2]

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Recent combined ground-based and satellite observations of the magnetic (Pi1-2) and optical disturbances surrounding auroral substorm onset have suggested a close correspondence between both their temporal evolution and frequency content. A challenge for determining whether there is a causal role for such near-Earth disturbances and/or instabilities in triggering the onset process relates to the extension and magnetic mapping of the auroral onset region into the magnetotail. Wave propagation, as well as field-aligned current (FAC) structures, enable the timing and energy transport between the magnetotail and the ionosphere to be examined. Using data from the AMPERE experiment on-board the Iridium satellite constellation, combined with optical and Pi1-2 magnetic waves observed from the ground, we present analysis of the FAC structure during substorm expansion phase onset. Our results show, at least for some substorms, a clear local decrease in FAC strength in a small region co-located with – but observed several minutes prior to - the auroral onset in the ionosphere. Our results suggest that M-I coupling, and perhaps more likely de-coupling, may play a strong role in destabilising the magnetotail. In particular, our results indicate the potential importance of M-I coupling via FACs in triggering the destabilisation of the tail. Certainly our observations are very difficult to reconcile with auroral poleward boundary intensification (PBI) related onset hypotheses and paradigms. Our results may also provide a natural answer to the rarely asked question "what determines the localised region in the ionosphere where auroral onset is first initiated?" We present a series of examples of such FAC and M-I coupling onsets and examine their relationship to subsequent expansion phase magnetotail destabilisation. We further offer a strawman physical model for a plausible sequence of events creating M-I coupling destabilisation of the Earth's magnetotail and the triggering of the following sequence of substorm expansion phase dynamics.

Markidis, Stefano

Fully Kinetic 3D Simulations of Magnetotail Plasmoid Chain Dynamics

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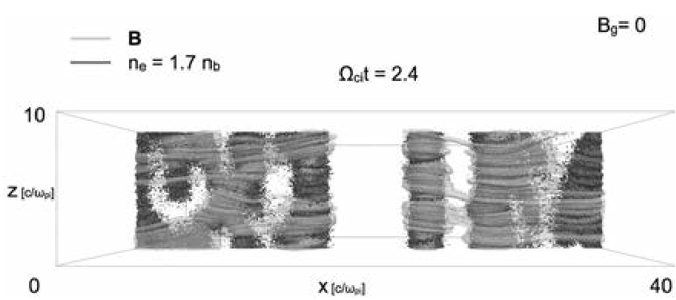
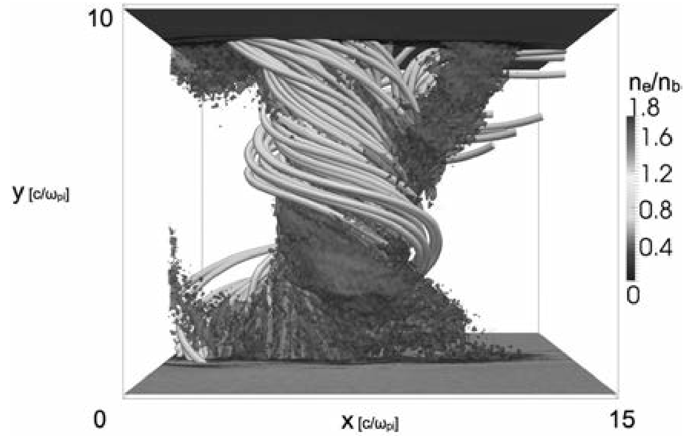
The dynamics of a magnetotail plasmoid chain is studied with three dimensional fully kinetic Particle-in-Cell simulations. The evolution of the system with and without a uniform guide field, whose strength is 1/3 the lobe magnetic field, is investigated in a configuration that mimics the Earth's magnetotail. The plasmoid chain forms by spontaneous magnetic reconnection: the tearing instability rapidly disrupts the initial current sheet generating several small-scale plasmoids, that rapidly grow in size coalescing. It is found that the presence of guide field strongly influences the evolution of the plasmoid chain. Without a guide field, a main reconnection site dominates and smaller reconnection regions are included in larger ones, leading to an hierarchical structure of the plasmoid dominated current sheet. On the contrary in presence of a guide field, plasmoids have approximately the same size and the hierarchical structure does not emerge. In addition in this case, a strong core magnetic field develops in the center of the plasmoid in the direction of the existing guide field while it is not observed when the guide field is not present. The two stream instability, that leads to the formation of electron holes, is detected along the magnetic reconnection separatrices. Lower hybrid waves are present in proximity of the boundary between the plasmoids and background plasma in both simulations.



Magnetic field lines superimposed to the electron density iso-surface at time Ωcit = 4.8 in the simulation with no guide field. The magnetic field loops surround the plasmoids.



A blow-up of a region enclosing a flux rope in guide field reconnection, showing the magnetic field lines, superimposed to electron density isosurfaces.

Mauk, Barry H.

Jupiter's Magnetodisc: How is it Formed and Maintained? ***(INVITED)***

Mauk, Barry H.[1]

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One of the great mysteries of Jupiter's huge magnetosphere is how the extended magnetodisc is formed and maintained. As compared to the near-equatorial neutral sheets at many planetary magnetospheres, existing primarily within the magnetotails in the anti-solar directions, Jupiter's magnetic neutral sheet extends all the way around the planet from about 20 RJ out to many 10's of RJ before merging into the magnetotail on the night side at distances beyond 100 RJ. Jupiter's magnetosphere is known to be powered primarily by planetary rotation acting on the copious mixed composition plasmas generated in the inner magnetosphere from materials removed from the volcanically active satellite Io at 5.9 RJ and from the much less active satellite Euorpa at ~9.4 RJ. Early on in the study of Jupiter's magnetosphere in the early 1980's following the Voyager encounters, it was concluded that Jupiter's magnetodisc is generated and maintained by the centripetal acceleration associated with the rapidly rotating and dense iogenic plasmas as those plasmas are slowly transported from the Io regions to the middle magnetosphere. However, more recent work in the late 1980's and 1990's demonstrated that just at the middle of the neutral sheet, the centripetal accelerations are as much as a factor of 30 too low to balance the shear magnetic forces within the magnetodisc. It was found that combinations of hot plasma pressure gradient and pressure anisotropies provided the forces needed to balance the magnetic forces. It thus appeared that particle acceleration was closely bound up with the processes needed to create and maintain the magnetodisc. Because the centripetal acceleration hypothesis is so simple and compelling, the finding that hot plasma pressure effects may dominate the maintenance of the magnetodisc has been highly controversial. In this paper I present and discuss the evidences associated with both sides of the argument and try to establish the status of our present understanding of this issue. I then discuss how upcoming missions like Juno and JUICE may resolve these issues. I also discuss possible implications for Saturn's less persistent magnetodisc configuration.

Michell, Robert G.

Exploring Tail Lobe Ion Signatures From THEMIS, Plasma Velocity Measurements and the Relation to the Upcoming MMS DIS Measurements

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During 2009, two of the THEMIS satellites made crossings of the magnetospheric tail lobes. We present lobe ion signatures from THEMIS observations where we have identified times of measurable low energy ion fluxes. The apparent energy of the ions can be used to measure the plasma flow velocities inside the lobes, a region where the overall ion flux is too low to accurately compute the plasma flow velocity by means of a moment calculation. In some cases, the ion signatures of two separate species, both hydrogen and oxygen, can be identified, and the plasma velocity measurements from each species are found to be consistent with one another. The MMS spacecraft will make high-resolution ion measurements with the DIS instrument and will have active instrumentation to reduce the spacecraft potential, enabling accurate measurement of the cold lobe ion inflow velocities. The MMS science goals require accurate measurements of the cold lobe ion velocity and therefore this technique of measuring their inflow velocities will be crucial. Making use of this technique using THEMIS ion measuremnts adds lobe ion science to the THEMIS mission and provides a scientific context for the upcoming MMS mission.

Milan, Stephen E.

The Role of the Ring Current in Determining Magnetotail Structure During Periods of Strong and Weak Solar Wind-Magnetosphere Coupling

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Large-scale magnetospheric structure and dynamics can be monitored from the ground by observing the size and morphology of the auroral zone and polar cap regions. For instance, there is a growth and contraction of the polar cap region during substorms as the proportion of the terrestrial dipole that is open increases through dayside magnetic reconnection and then decreases through nightside reconnection. It is also observed that the proportion of flux that is open tends to be greater during magnetic storm conditions, as measured by the Sym-H index. Two effects may contribute to this tendency. It is known that the magnetotail plasma sheet becomes loaded with oxygen during disturbed conditions, and this may quench reconnection rates in the tail. At the same time, the presence of an enhanced ring current and its associated magnetic perturbation modifies the tail structure, dipolarizing the tail in the region where reconnection may be expected to occur. In this case, the tail lobes must become more loaded with open flux to overcome the dipolarizing effect and allow reconnection to commence. In this study we will present a test of the second scenario. We perform superposed epoch analyses of Cluster observations of the orientation of the lobe magnetic field in the X-Z plane before and after substorm onset, for storm and non-storm intervals. Ramifications for the influence of the ring current magnetic field perturbation on tail dynamics will be discussed.

Mitchell, Donald G.

Injection, Interchange And Reconnection: Energetic Particle Observations In Saturn's Magnetotail *(INVITED)*

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The Saturn and Jupiter magnetotails comprise regions where plasma from internal sources ultimately escapes from the systems. The primary active plasma processes involved in that transport are flux tube interchange, and reconnection. Both processes likely produce phenomena that are labeled as "injections" because of their abrupt onsets in energetic particle and plasma data. We discuss where in Saturn's magnetosphere these processes may be important for transport and energization of plasma ions and electrons, and how they may be recognized in energetic particle and ENA data.

Moestl, Ute V.

MHD Modeling of the Double-Gradient Magnetic Instability (Kink Branch)

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7. Theoretical Physics Division, Petersburg Nuclear Physics Institute, Gatchina, Russian Federation
8. PDC Center for High Performance Computing, KTH Royal Institute of Technology, Stockholm, Sweden

We present a numerical investigation of the double-gradient mode, which is believed to be responsible for the magnetotail flapping oscillations – the fast vertical oscillations of the Earth's magnetotail plasma sheet (quasi-period ~100–200 s). It is known that this mode has an unstable solution in the region of the tailward-growing normal magnetic field component. The kink branch of the mode is the focus of our study. The initial equilibrium for our numerical simulation is fixed by the approximate solution of the Grad-Shafranov equation. The results of our linearized MHD code agree with the theory, and the growth rate is found to be close to the peak value provided by an analytical estimate. Also, the eigenfunctions, calculated analytically, are very similar to the perturbations obtained numerically. Our linearized MHD numerical analysis is complemented with full 3D MHD simulations. Latter are initialized with the same initial magnetotail configuration as the one adopted for the linear study, but are more relaxed numerically. The calculations show that the double-gradient mode is excited in a region of small radii of the magnetic field lines curvature, which is in accordance with the analytical predictions. In contrast to the linearized MHD simulations, non-local interactions are involved; hence, the overall growth rate turns out to be close to the theoretical estimate averaged over the computational domain.

Moore, Thomas E.

"Snowplow" Injection by Dipolarization Fronts

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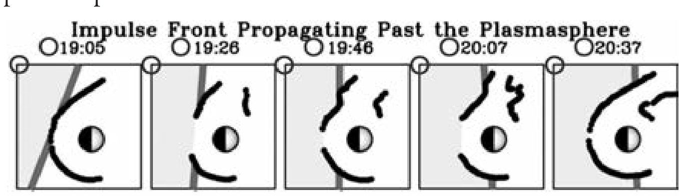
As the Polar spacecraft apogee precessed through the magnetic equator in 2001, Polar encountered numerous substorm injection events in the region between geosynchronous orbit and 10 Re geocentric distance; most of them in the plasma sheet boundary layers. Of these, a few were recorded in the central plasma sheet in the evening sector. These events exhibited a strongly damped wavelike character, with cycles of radially outward and inward flow having a period of several minutes and a flow amplitude of ~ 50 km/sec, resulting in a outward displacement amplitude as large as 1 Re. After one or two cycles, these disturbances culminated in an inward displacement associated with a hot plasma electron and ion injection, similar to those observed at synchronous orbit. The outward flow cycles were consisted of cold plasma characteristic of the outer plasmasphere, while the inward flow cycles were characterized by counterstreaming field-parallel cold plasmas, characteristic of lobal wind plasmas. We interpret the observed structure as the approach of a substorm injection front that drives an outward displacement ahead of itself, in a "snowplow" effect, as it moves radially and azimuthally over the spacecraft in the evening to dusk sector, and then accomplishes a radial inward displacement of freshly injected plasmas. By implication, azimuthally limited injection flow fronts may have far broader effects when they reach the interface with the inner magnetosphere and plasmasphere.



Nagai, Tsugunobu

Structure of magnetic reconnection in the Earth's Magnetotail

Nagai, Tsugunobu[1]

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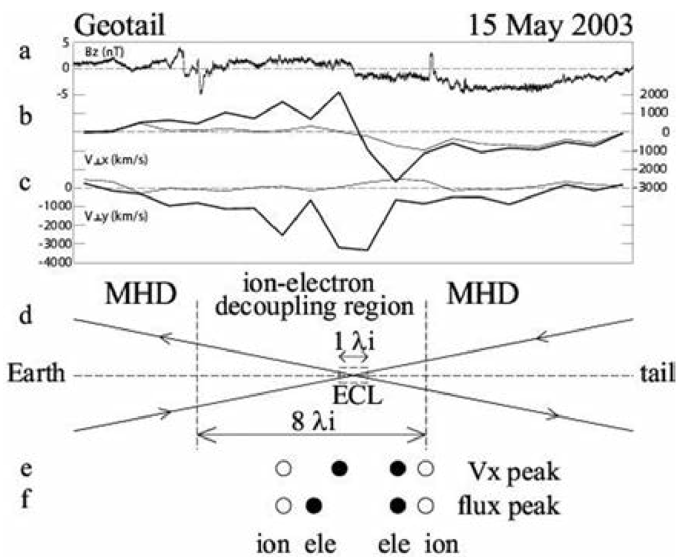
Magnetic reconnection produces dynamics processes in the Earth's magnetotail. The spacecraft Geotail has revealed various characteristics of magnetic reconnection from observations over 20 years. Magnetic reconnection in association with substorm onsets usually takes place in the

near-Earth magnetotail at radial distances of 18-30 Re. The radial distance of its site is controlled by solar wind conditions. Magnetic reconnection occurs close to (far from) the Earth under strong (weak) solar wind dawn-dusk electric field conditions. In the site of magnetic reconnection, ion-electron decoupling region forms, in which fast electron jets flow earthward ad tailward and fast dawnward electron flows provide the dawn-dusk electric current in its center. In the ion-decoupling region, speed of ion flows is much smaller than that of these electron flows. The size of the ion-decoupling region in the Earth-tail direction is estimated to be 8 ion inertial lengths, which usually correspond to 1500 km. The size of the electron decoupling region (the diffusion region) is less than 1 ion inertial length, and the elongation of the electron jet layer is not observed. It is difficult to evaluate the dawn-dusk length of the magnetic reconnection site in present satellite observations. Occurrence of magnetic reconnection appears to be confined in the premidnight region of the near-Earth magnetotail, suggesting that the dawn-dusk extent of the magnetic reconnection site is less than 10 Re.



Nakamura, Rumi

Near-conjugate Observations of THEMIS and Cluster During a Multiple-flow Burst Event

Nakamura, Rumi[1]; Hamrin, Maria[2]; Karlsson, Tomas[3]; Nilsson, Hans[4]; Marghitu, Octav[5]; Amm, Olaf[6]; Bunescu, Costel[5]; Constantinescu, Vlad[5]; Frey, Harald[7]; Keilling, Andreas[7]; Semeter, Joshua[8]; Sorbalo, Eugen[9]; Vogt, Joachim[9]

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During near-conjugate observations of Cluster and THEMIS, multiple flow bursts with ion velocities up to 800 km/s are observed in the magnetotail, at the time of a large-scale dipolarization. The multiple bursts may be either multiple activations or oscillatory flow braking. At lower altitudes, Cluster 1 shows bursts of low-energy, counterstreaming electrons with a broad energy distribution, and a narrow pitch-angle distribution, coinciding in time with the flow-bursts in the tail. This type of electron distribution has been associated with acceleration and modulation of Alfvén waves. We propose that episodes of Alfvénic acceleration are due to kinetic Alfvén waves launched from the flow bursts. That such radiation is launched from fast flows has been established lately, and the unique observations presented here can be taken both as corroboration of those findings and a first direct observation of the effects of fast flows on the near-Earth magnetospheric plasma on auroral latitudes.

Nikolaou, George

Jupiter's Distant Magnetotail Explored by New Horizons' Solar Wind Around Pluto (SWAP) Instrument

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3. University of Colorado, Boulder, Boulder, CO, USA

The Solar Wind Around Pluto (SWAP) instrument on New Horizons (NH) obtained in situ observations of ions in Jupiter's distant magnetotail and magnetosheath during its

2007 flyby. NH observed 16 magnetopause crossings between 1654 and 2429 RJ (1 RJ = 1 Jovian Radii) that were identified by transitions between magnetotail, boundary layer and magnetosheath plasma (McComas et al. [2007], Ebert et al. [2010]). We have developed a method to calculate the fluid properties of ions, such as density, velocity and temperature, in these regions based on a forward model of the SWAP instrument response and fitting the observations to a kappa distribution. In this study we describe our technique and present the results for Jupiter's distant magnetosheath. We discuss the characteristics of the derived fluid properties and compare these results to previously developed gas dynamic models for magnetospheres of giant planets.

Otto, Antonius

Current Sheets in Planetary Magnetotails ***(INVITED)***

Otto, Antonius[1]

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Magnetotails provide an important reservoir for the storage of magnetic energy, which plays a central role for instance in storms, substorms, and steady magnetospheric convection in the terrestrial magnetosphere. Charcteristic of all planetary magnetotails is the presence of a current sheet where the intensity of the cross tail current is indicative for magnetic field energy stored in the tail. However, at most times these current sheets are rather thick and stable, and convection in the tail is slow compared to Alfven speeds. A typical tail property is an intermittent instability which leads to magnetic reconnection and phenomena such as plasmoids, bursty bulk flows and dipolarization fronts. The onset of reconnection requires an instability such as a tearing mode and to the best of our knowledge this is possible only if the current sheets develop down to kinetic scales. The dynamics that causes the formation of such thin current sheets depends strongly on the physical properties of the system. Various processes can generate thin current sheets such as interchange instabilities, localized compression, or the local depletion of magnetic flux. We review the physics of such processes for different planetary magnetospheres ranging from Mercury to Jovian type magnetospheres. Flux tube entropy provides an important constraint for convection in the Earths magnetotail and we will examine this concept particularly also for large magnetospheres where tail dynamics is significantly dominated by internal drivers such as mass loading.

Pitout, Frederic

Multi-instrument observations and simulation of CPS particle precipitation

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Since winter 2010-2011, we have run the EISCAT radars in conjunction with the THEMIS and CLUSTER satellites near magnetic midnight. The main goals of those campaigns are : 1) to observe and model energetic particle precipitation in the auroral ionosphere, in particular populations with a non-maxwellian energy spectrum, 2) to identify the physical processes that give birth to those populations in a wider M-I coupling framework. We present results of one of those coordinated observations. On 18 February 2011, the instruments on board ARTEMIS-P2 detected an earthward plasma flow in the Central Plasma Sheet (CPS) accompanied by a rotation of the Z component of the magnetic field, while the EISCAT radars measured strong precipitation of energetic particles in the auroral ionosphere, ionizing the atmospheric gas down to the E-region. While electrons of ~300eV are detected at ARTEMIS-P2, modelling of the ionosphere with TRANSCAR reveals that electrons with typical energy of 1keV are necessary to reproduce the electron density profiles observed by EISCAT.

Radioti, Aikaterini

Auroral Signatures of Ionosphere-magnetosphere Coupling at Jupiter and Saturn ***(INVITED)***

Radioti, Aikaterini[1]

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Auroral emissions are the visible signature of a long chain of interactions and provide a picture of the magnetospheric processes and dynamics. This talk reviews the auroral signatures of ionosphere-magnetosphere coupling at Jupiter and Saturn. Firstly, the main auroral features at Jupiter and Saturn are discussed. Special emphasis is given on the auroral counterparts of magnetic reconnection, dipolarization, injections and instabilities. For example periodic ejected plasma flow during magnetic reconnection in Jupiter's tail couples with the ionosphere and creates periodic auroral features. At Saturn, plasma flow produced by consecutive reconnection events in the flank of the magnetopause creates transient auroral emissions at the end of the ionospheric footprint of the newly open field lines. Dipolarization at Saturn's tail leaves a signature in the nightside aurora. Injected plasma populations in the magnetosphere, possibly associated with magnetic reconnection, trigger auroral features located equatorward of the main auroral emission at Saturn. Finally, Kelvin-Helmholtz instabilities at Saturn's magnetopause could be associated with observed UV auroral substructures.

Rajendar, Ashok

Structure and Dynamics of Saturn's Magnetotail

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Saturn's magnetotail is highly dynamic, displaying both forcing from the solar wind as well as internally driven behavior. The former involves the compression and expansion of the magnetosphere due to variations in the solar wind dynamic pressure, and the erosion and tailward advection of dayside magnetic flux during periods of antiparallel IMF and planetary magnetic field. The latter involves the effects of corotation and mass-loading in the inner magnetosphere: field-aligned currents enforce partial corotation out to a certain distance, while the effects of new plasma sourced from Enceladus result in deviations from corotation further out in the magnetosphere. This newly-created plasma moves outwards under the influence of centrifugal stresses, eventually departing from corotation as it flows downtail, stretching out the magnetic field associated with it. In both cases, these phenomena eventually result in magnetic reconnection in the tail and the production of plasmoids that advect downtail, carrying magnetospheric plasma away. Saturn's main plasma source is a distributed cloud of neutral OH created from the dissociation of water molecules sourced from Enceladus and the E-ring that occupies much of the inner magnetosphere. By including this distributed mass source in our global multifluid simulation, we investigate the dynamics of Saturn's magnetotail in response to realistic mass- and momentum-loading. The multifluid model enables the incorporation of multiple ion species, and thus allows us to account for the combination of protons and water group ions that populate Saturn's magnetosphere. We use the neutral cloud data of Jurac et al. [2002] to construct an empirical representation of the neutral cloud that we incorporate in our simulation as a mass source, as well as a source of momentum-loading from elastic and charge-exchange collisions. We also apply a realistic, latitudinally-varying ionospheric Pedersen conductivity based on data from Moore et al. [2010] in order to produce accurate magnetosphere-ionosphere coupling via field aligned currents. We employ our multifluid model to investigate the dynamics of Saturn's magnetotail during southern solstice. By simulating more realistic mass- and momentum-loading, we examine the rate of plasmoid production triggered both by solar wind forcing and by the outward flow of inner-magnetosphere plasma. We also examine the geometry and location of plasmoid production as a function of solar wind forcing.

Reeves, Geoffrey D.

Dynamics of the Earth's Radiation Belts and the Role of Spatial, Temporal, and Energy Coupling as Seen by RBSP and Other Satellites ***(INVITED)***

Reeves, Geoffrey D.[1]; Spence, Harlan[2]; Funsten, Herb[1]; Skoug, Ruth[1]; Blake, Bern[3]; Fennell, Joseph[3]; Baker, Daniel[4]; Kanekal, Shri[5]; Henderson, Michael[1]; Friedel, Reiner[1]; Larsen, Brian[1]; Jordanova, Vania[1]; Zaharia, Sorin[1]

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2. University of New Hampshire, Durham, NH, USA
3. Aerospace Corp., Los Angeles, CA, USA
4. University of Colorado, Boulder, CO, USA
5. Goddard SFC, Greenbelt, MD, USA

Planetary magnetospheres are highly coupled systems across a broad range of spatial, temporal, and energy scales. The inner magnetosphere plays a central role in all magnetospheric systems. Magnetotail particles and fields are fundamental sources for the ring current and radiation belts but the coupling goes both ways with inner magnetospheric processes also driving magnetotail configuration and dynamics. Observations and models of magnetotail-inner magnetosphere coupling at Earth provide the opportunity to test, quantitatively, theories that are broadly applicable across planetary and astrophysical systems. Models of the Earth's ring current system have become quite sophisticated - including self-consistent ring current geomagnetic field models of the inner magnetosphere that are coupled to, and driven by, global MHD models. Models of the Earth's radiation belts are undergoing rapid development and are also being coupled to ring current and geomagnetic field models. A topic of strong current interest is the internal acceleration of MeV electrons by resonant electromagnetic waves. A leading scenario, being tested now, has magnetotail electrons being injected into the inner magnetosphere providing a source of free energy for whistler waves (as well as a seed population of electrons). The waves act as an intermediary to transfer energy across many decades in energy to produce a relativistic electron population that, otherwise, would not exist in the magnetosphere. Critical tests of this coupling across space, time, and energy are only now possible thanks to observations from the Living With a Star (LWS) Radiation Belt Storm Probes (RBSP) mission along with other complementary observations. We will report on the current state of understanding and tantalizing new results.

http://www.rbsp-ect.lanl.gov

Riazantseva, Maria O.

Enhanced quasi stationary fluxes of energetic electrons to the pole of the polar boundary of the outer radiation belt and the possibility of the existence of local particle traps in the geomagnetic tail

Riazantseva, Maria O.[1, 2]; Myagkova, Irina N.[1]; Antonova, Elizaveta E.[1, 2]; Marjin, Boris V.[1]; Karavaev, Michael V.[1]; Stepanova, Marina V.[3]

1. Scobeltsyn Inst Nuclear Phys., Moscow State University, Moscow, Russian Federation
2. Space Research Institute RAS, Moscow, Russian Federation
3. Universidad de Santiago de Chile (USACH), Santiago, Chile

Geomagnetic tail is the region in which intense processes of electron acceleration take place. Variations of electron fluxes with energies >200-300 keV at the polar boundary of the outer electron radiation belt are studied using data of low orbiting CORONAS-F and CORONAS-FOTON satellites. Results of observations demonstrate the existence of quasistationsry increases of fluxes of energetic electrons. The enhanced fluxes with very similar characteristics are observed at two or more consecutive orbits, i.e. have a life time of a few hours. The analysis of relative location of enhanced fluxes and auroral particle precipitations, measured simultaneously by the low orbiting METEOR-3M, METEOR-M and DMSP satellites, showed that the enhanced fluxes are located inside the auroral oval, i. e. poleward from the external boundary of the outer electron radiation belt. This fact was also confirmed comparing these fluxes with the auroral oval boundaries provided by the OVATION model of auroral precipitations. The nature of the observed events is discussed. Analysis of distribution of isolines Bmin=const, where Bmin is the minimal value of magnetic field at the magnetic field line, using different models of magnetic field, demonstrates the possibility of formation of local particle traps in the tail in which trajectories of energetic particles do not surround the Earth. It is shown that the formation of such local magnetic traps can help to explain the results of CORONAS-F and CORONAS-FOTON observations demonstrating the comparatively stable azimuthally asymmetric increases of fluxes of energetic electrons to the pole of the external boundary of the external electron radiation belt.

Rollett, Tanja

Orientation of Magnetic Clouds and their Energy Input into the Magnetosphere

Rollett, Tanja[1]; Möstl, Christian[1]; Veronig, Astrid M.[1]; Leitner, Martin[1]; Farrugia, Charles J.[2]; Temmer, Manuela[1]

1. IGAM-Kanzelhöhe Observatory, Institute of Physics, University of Graz, Graz, Austria
2. Space Science Center and Department of Physics, University of New Hampshire, Durham, NH, USA

Interplanetary coronal mass ejections (ICMEs) are known as the main origin of intense geomagnetic storms. Magnetic clouds (MCs) can be part of ICMEs and are characterized as intervals of enhanced, smoothly rotating interplanetary magnetic field, low plasma beta and temperature in spacecraft in situ data. We use a subgroup of the MCs analyzed in Leitner et al. (2007, JGR), which were Earth directed and caused a negative Dst index. This set of about 50 MCs occurred between 1995 and 2002 and was measured in situ by the Wind spacecraft at 1 AU. The data were fitted with a force-free, constant-alpha flux rope model. The outcome of this fitting model, namely the orientation of the flux tube, is compared to the energy input into the magnetosphere derived by various coupling functions (e.g. the Akasofu epsilon parameter). Additionally, to set these results in relation to geomagnetic effects on the ground, we also show the comparison to the geomagnetic indices for high latitudes (Kp) and low latitudes (Dst). This work has received funding from the European Commission FP7 Project COMESEP (263252).

Rymer, Abigail M.

Magnetic Pumping: a source of radial and azimuthal plasma heating

Rymer, Abigail M.[1]; Livi, Roberto[2]; Mauk, Barry[1]; Hill, Thomas[3]

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2. University of Texas at Austin, Austin, TX, USA
3. Rice University, Houston, TX, USA

Rymer et al. [2008] described a radial heating cycle that operates in the inner, predominantly dipolar, magnetospheric region at Saturn. One particular element of the circulation was not well understood: the high temperature of plasma in the middle magnetosphere. So we were left with a mystery – what heats plasma in the middle magnetosphere? The same question at Jupiter has remained unanswered since the Voyager era [e.g. Hill et al., 1983]. To address this mystery we investigate an azimuthal heating cycle that might operate in the middle, non-dipolar magnetospheric region. This idea was first proposed as a mechanism to energise outer magnetospheric charged particles at Jupiter by Goertz [1978]. In this cycle "magnetic pumping" energises plasma by azimuthal transport in magnetic field configurations which are compressed at some local times (e.g. the dayside magnetosphere) and stretched at others (e.g. the tail-like nightside magnetosphere). Our hypothesis is that these two cycles (radial and azimuthal)

operate in concert at Saturn and in any rapidly rotating magnetosphere. Both processes make distinctive predictions for the plasma pitch angle and energy distributions which we test using Cassini electron data at Saturn.

Sazykin, Stanislav

Numerical Simulations of Plasma Convection in Saturn's and Earth's Magnetospheres ***(INVITED)***

Sazykin, Stanislav[1]; Hill, Thomas[1]; Liu, Xin[1]; Wolf, Richard[1]

1. Physics and Astronomy Dept, Rice University, Houston, TX, USA

Saturn's magnetosphere is internally driven. Both the dominant energy source (Saturn's rotation) and the dominant plasma source (Saturn's small icy moon Enceladus) are deep within the inner magnetosphere. This is very different from Earth, whose magnetosphere is driven externally by the solar wind. Despite this difference, plasma circulation (convection) is well described in both cases by the Rice Convection Model (RCM), a numerical simulation tool that couples magnetospheric plasma drift currents to ionospheric Pedersen and Hall currents through Birkeland (magnetic-field-aligned) currents. Important magnetospheric currents at Saturn include the centrifugal current, whose J×B force balances the centrifugal force of (partial) corotation, the pick-up current, whose J×B force accelerates newly produced plasma up to partial corotation, and the Coriolis current, whose J×B force deflects and shapes the resulting convection system. These currents add to the gradient-curvature drift currents that are dominant in Earth's magnetosphere. The resulting convection system at Saturn is a small-scale flux-tube interchange process. By including all of these currents we are able to simulate the injection and drift dispersion of hot but tenuous plasma "fingers" from the outer magnetosphere and magnetotail. These injection-dispersion events are ubiquitous in Cassini spacecraft observations at Saturn. At Earth, interchange-driven processes, while not dominant in the convection, also play an important albeit different role in the transport of plasma from the magnetotail into the inner magnetosphere in the form of "entropy bubbles". This paper will review RCM simulation results of the convection in the magnetosphere of Saturn and will contrast it with interchange-related convection processes in the terrestrial inner magnetosphere.

Sundberg, Torbjorn

Tutorial: Mercury's Magnetotail ***(INVITED)***

Sundberg, Torbjorn[1]; Slavin, James A.[2]

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2. Atmospheric, Oceanic and Space Sciences, University of Michigan, Ann Arbor, MI, USA

Mercury's magnetosphere is in many aspects fundamentally different from that found at the Earth, Jupiter or Saturn. Observations by the MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) spacecraft have shown that the magnetosphere is extremely sensitive to the variable interplanetary conditions in the inner parts of the solar system. It is strongly driven by magnetopause reconnection with a reconnection rate an order of magnitude greater than at Earth, as estimated from the ratio of the normal magnetic field to the magnetospheric field. Dayside reconnection is shown to drive Dungey circulation of magnetic flux and plasma with a time scale of only a few minutes, and the entire magnetic flux content of the magnetotail can be replaced through as little as 3-10 flux transfer events. Reconnection also appears to occur far more frequently than at Earth due to its weak dependence on interplanetary magnetic field direction. Here we review MESSENGER measurements of Mercury's magnetotail with an emphasis on the most recent results. Special attention will be given to the nature and applicability of the concept of substorms at Mercury. Toward this end measurements of tail loading and unloading, magnetic dipolarization, plasmoid ejection, and changed particle acceleration will be reviewed and contrasted with what is observed at Earth and the other planets.

Thomsen, Michelle F.

Cassini/CAPS Observations of Duskside Tail Dynamics at Saturn

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The density and flow direction of plasmas in magnetospheric tails provide important clues to the tail structure and dynamics. The study of McAndrews et al. [Plasma in Saturn's nightside magnetosphere and the implications for global circulation, Plan. Sp. Sci. (2009)] examined the properties of magnetospheric plasma primarily in the pre-dawn equatorial region of Saturn's middle magnetosphere and tail. Using subsequent data from Cassini's continuing mission at Saturn, we update and extend this study. We address near-equatorial Cassini/CAPS plasma observations between mid-2007 and mid-2011. We focus on intervals when CAPS was able to view both inward and outward plasma flows, and we examine the spatial distribution and other properties of such flows.

Vasko, I. Y.

Thin Current Sheets in the Venus Magnetotail

Vasko, I. Y.[1]; Zelenyi, L. M.[1]; Artemyev, A. V.[1]; Petrukovich, A. A.[1]; Zhang, T. L.[2]; Malova, H. V.[1]; Popov, V. Y.[1]; Nakamura, R.[2]

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2. Space Research Institute of Austrian Academy of Sciences, Graz, Austria

The first missions to Venus showed that the planet does not possess an intrinsic magnetic field. The magnetotail has therefore accretion nature, i.e. it is formed by the flux tubes of interplanetary magnetic field convected on the night side [1]. Pioneer Venus Orbiter (PVO) mission has allowed to study the structure of the distant magnetotail current sheet [2,3,4]. However, the poor resolution of the plasma measurements in PVO mission has not allowed reconstructing the spatial scale of the Venus CS. D.J.McComas et.al. [1986] have estimated CS thickness to be about 1.5 RV. The characteristic feature of the Venus-solar wind interaction is the oxygen ion population picked up by the solar wind flux tubes during their convection around the Venus ionosphere [5,6]. This evidences of the picked up oxygen population were found in the Venus bow shock position [7,8], in the field lines draping asymmetry [9] and in the magnetosheath magnetic field asymmetry [10]. However, no study has been performed on the influence of the picked up population on the structure of the Venus CS. We use the data of Venus Express mission to study the structure of the Venus CS near the planet based on the statistics of 17 CS crossings observed during steady conditions in the solar wind in years 2006-2010. First, we have found out that the Venus CS can be actually rather thin (~300-1000 km). The CS thickness can be comparable with the particle Larmor radius. Second, we have found that the magnetic field profiles of the CS can be single-scale and double-scale. We have used plasma measurements to show that double-scale CSs are due to oxygen picked up population. Double-scale CSs are in fact thicker than single scale CSs. However, being rather thick (~RV/2) these CSs are still several oxygen gyroradii thick. Finally, the observed thin CSs can be satisfactorily interpreted in the frame of the thin anisotropic CS model [11]. The presented results can be important for the study of the distant tail CS as well. First, we suppose that thin CSs can be encountered in the distant tail, while the averaging procedure used by D.J.McComas et.al. [1986] did not resolve them. Second, we predict that double-scale CSs are present in the distant tail as well, since the oxygen population has not yet diffused from the CS. Finally, we note that the double-scale profile can serve as the sign of the presence of oxygen ions in the CS. References [1] E.G.Eroshenko,Cosmic Research,1979,17,77-87 [2] M.A.Saunders and C.T.Russel,J.Geophys.Res.,1985,91,5589-5604. [3] D.J.McComas et.al.J.Geophys.Res.,1986,91,7939-7953. [4] J.A. Slavin et.al.J.Geophys.Res.,1989,94,2383-2398. [5] M.I. Verigin et.al.J.Geophys.Res.,1978,83,3721-3728. [6] J.D. Mihalov et.al.J.Geophys.Res.,1980,85,7613-7624. [7] C.J. Alexander and C.T. Russell,Geophys.Res.Lett.,1985,12,369-371. [8] C.J. Alexander et.al.,Geophys.Res.Lett.,1986,13,917-920. [9] J.L. Phillips et.al.,J.Geophys.Res.,1987,92,9920-9930.

Vasyliunas, Vytenis M.

The Magnetotail: An Unsolved Fundamental Problem of Magnetospheric Physics ***(INVITED)***

Vasyliunas, Vytenis M.[1]

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Every planetary magnetosphere observed to date has on its nightside a region of magnetic field lines stretched out in the direction of solar wind flow to form a magnetospheric tail (magnetotail), extending over distances much longer than the extent of the magnetosphere on the dayside. How such a configuration is created and maintained represents a fundamental problem for which there is extensive empirical data (mainly at Earth) plus qualitative theoretical concepts, but (to my knowledge) as yet no predictive first-principles theory, comparable to the Chapman-Ferraro model for the dayside magnetosphere. Specifically, the problem is that of stress balance: the stretched-magnetic-field configuration implies a magnetic tension force at the inner (planetward) boundary of the magnetotail, which must be balanced by a tension-like force at the outer boundary, and the question is, what is the origin of this force? Ascribing the force to magnetic tension at the outer boundary does not solve the problem but merely displaces it outside the boundary. Ultimately the force can only be produced by the velocity change of an appropriate mass flow-through. There are several qualitative conceptual models for this, none developed into a quantitative theory yet: (1) solar-wind plasma entry on open field lines, slowed down (slightly) by magnetic force, (2) boundary layer flow, produced by (unspecified) tangential drag from the magnetosheath, with field lines pulled out until the flow is stopped and reversed, (3) outflowing plasma from a source in the interior of the magnetosphere (e.g., Io at Jupiter, Enceladus at Saturn), slowed down by stretched field lines. Model (1) is generally considered the most probable explanation for the magnetotail at Earth, at least for periods with southward component of the interplanetary magnetic field. Model (2) has been proposed for Earth during prolonged periods with northward component of the interplanetary magnetic field; it has also been proposed for Jupiter, where it faces, however, the problem of reconciling the reversed (return) flow with the outward flow from the plasma source at Io. The relative importance of (1) and (2) in accounting for the magnetotail depends partly on the relative contributions to the magnetotail lobes of open flux from dayside reconnection and of closed flux transported in the boundary layers. Model (3) is of obvious interest for Jupiter, but whether it can plausibly account for the Jovian magnetotail depends on the mass ouflow rate (for which there are empirical estimates) and also on the *change* of mean ouflow velocity (for which there are as yet no observations and hardly any theory).

Vogt, Marissa F.

Reconnection in Jupiter's Magnetotail: Plasmoid Structure and Statistical Properties

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2. Department of Physics and Astronomy, University College London, London, United Kingdom
3. Department of Atmospheric, Oceanic, and Space Sciences, University of Michigan, Ann Arbor, MI, USA

Plasmoids and other reconnection signatures have been observed in Jupiter's magnetotail through analysis of magnetic field reconfigurations and flow bursts in the energetic particle data. Previous studies have established the spatial distribution and recurrence period of tail reconnection events, and identified the location of a statistical x-line separating inward and outward flow. Here we present new analysis focusing specifically on over 40 plasmoid signatures observed in magnetometer data in order to establish the average properties and structure of Jovian plasmoids. We will present statistics on the length scale, duration, and magnetic flux closed during a typical Jovian plasmoid. We also examine the interior structure of the plasmoids to determine whether they can be described as magnetic flux ropes or loops. Our findings will help us understand the potential importance of tail reconnection to the mass transport process at Jupiter.

Volwerk, Martin

Temperature Anisotropy in Pre- and Post-Dipolarization Plasma Sheets

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We study the temperature anisotropy (T⊥/T||)in the Earth's magnetotail plasma sheet as a function of parallel plasma beta (β|| = Pp,|| / PB = 2 μ0 n kB T|| / B2) for intervals before magnetotail dipolarization and after. Earlier studies have shown that in the quiescent magnetotail the ion temperature is isotropic, however, during fast flow times there is a strong anisotropy. Lately it has been shown, using THEMIS data, that this anisotropy in the magnetotail is structured in (T⊥/T||, β||)-space, strongly bound by temperature anisotropy driven instability thresholds (mirror mode, ion cyclotron mode and fire hose instability), and that the ion temperature isotropizes as the flow moves Earthward. In this study we use the dipolarizations from the ECLAT event database for the years 2001 though 2007, when the Cluster spacecraft were in an tetrahedral configuration. This enables the study of the temperature anisotropy over a broad range of local times, a narrow range of radial distances from the Earth and small scale structure on the size of the spacecraft separation (500 – 10000 km).

Walsh, Andrew P.

The Influence of IMF Conditions on Plasma Sheet Electron Pitch Angle Distributions

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The terrestrial magnetotail plasma sheet is known to be colder and denser when the magnetosphere has been exposed to periods of steady northward IMF. This is the result of a presence of a second, cold, component of ions that is thought to enter the magnetosphere through the flank magnetopause. The variation in properties of plasma sheet electrons with IMF conditions has been less well-studied. Here we present the results of a survey of Cluster PEACE data taken between 2001 and 2006. We compare the properties of electron pitch angle distributions measured when the magnetosphere had been exposed to steady (on a timescale of 3 hours) northward and southward IMF and during intervals when a two-component proton plasma sheet (identified using CIS-CODIF data) is and is not present. We find that the plasma sheet electron pitch angle distribution is better described using a two component kappa distribution than a single component kappa distribution 90% of the time the magnetosphere is exposed to steady northward IMF and the fits to the data were successful, compared to 70% for protons. We suggest, then, that the cold electron component does not necessarily have the same source as the cold proton component in the northward IMF plasma sheet.

Weygand, James M.

A Statistical Comparison of Auroral Electrojet Indices in the Northern and Southern Hemispheres

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The auroral electrojet (AE) index is traditionally calculated from a set of about 10 to 13 ground magnetometer stations located around the typical northern auroral oval location. Similar coverage in the southern hemisphere does not exist, so the AE calculation has only

been performed using northern hemisphere data. In the present study, we use seven southern auroral region ground magnetometers as well as their conjugate Northern Hemisphere data to calculate conjugate AE indices for about 270 days covering all four seasons. The correlation coefficient between the northern and southern AE indices for many of the intervals is 0.65, but in some intervals, it is close to 0. We compare our conjugate AE indices with the standard AE index and find a number of asymmetries because of station coverage gaps in the southern and northern arrays. When the southern AE index is compared with the standard AE index, we find that for most intervals the correlation is less than 0.7, and in some intervals, the correlation is about 0. The correlation between the conjugate northern AE index and the standard AE index is somewhat better, suggesting true inter-hemispheric asymmetries. The mean difference between the southern and northern AE indices is largest during northern summer season and corresponds to the smallest seasonal mean correlation of 0.56. The smallest mean difference occurred in the spring and corresponds to the largest seasonal mean correlation of 0.73. The mean differences between the southern and conjugate northern H component are of the order of 31 nT, with the largest differences occurring in the midnight magnetic local time (MLT) sector. We also find a difference in the southern and northern AE related to UT. We suggest that these differences may be related to seasonal effects, ionospheric effects, and MLT effects. The fact that a difference between the southern and northern AE indices exists indicates the importance of examining geomagnetic activity at both poles when considering magnetospheric phenomena such as substorms, storms, and poleward boundary intensifications.

http://www.igpp.ucla.edu/jweygand

Wiltberger, Michael J.

Review of Global Simulations Studies of the Effect of Ionospheric Outflow on Magnetotail Dynamics *(INVITED)*

Wiltberger, Michael J.[1]

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Since the detection of O+ ions by satellites in the 1970s it has been known that the ionosphere is an important source of plasma in the Earth's magnetotail. More recent observations from have shown that these ions can become a dominant component of the plasma in the plasmasheet. Early work in substorm research considered a role for O+ in the onset of plasma instabilities and their relationship to substorm onset. Theoretical analysis of reconnection in multi-fluid plasmas has shown that the presence of a heavy ion slows the reconnection rate raising interesting implications for occurrence rate of substorms. Global scale simulations have been used effectively to model the interaction of the solar wind with the tightly coupled magnetosphere-ionosphere-thermosphere system. These models are now beginning to utilize multi-fluid techniques to include mass outflows from the ionosphere. Techniques for including these outflows include both empirical and first principle models. In the empirical techniques the relationship between observed parameters such as Poynting flux and outflow are used to specify both the location and intensity of the outflow seen in the cusp and auroral regions. First principle models of the polar wind typical use a large set of single flux tubes simulations describe the out flowing plasma. In both approaches significant impacts on the state of the magnetosphere is seen when the ionospheric plasma is included. These affects include improved agreement with Dst observations, changes in polar cap potential, and alteration of the length of the magnetotail. Furthermore, some simulation results have demonstrated a role for O+ in the transition from steady magnetospheric convection into the sawtooth intervals containing multiple storage and release segments.

Wing, Simon

Solar Wind Entry and Transport at Earth's and Other Planetary's Magnetotail *(INVITED)*

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Plasma sheet populations originate from both the solar wind and the ionosphere. The most commonly invoked mechanisms for solar wind plasma entry during northward IMF conditions are reconnection at high latitudes, Kelvin-Helmholtz instability, and wave-induced diffusion. For northward interplanetary magnetic field (IMF) conditions, there is massive particle entry of magnetosheath material leading to the formation of a cold, dense plasma sheet that can precondition the magnetospheric response to geomagnetic storms. The plasma sheet ion cold component, which is similar to the magnetosheath ion population, is heated on the dawnside but not on the duskside, which can be attributed to different solar wind entry processes operating at the dawn and dusk flanks. On the other hand, the ion hot component is hotter on the duskside than the dawnside, which can be attributed to the transport processes internal to the magnetosphere such as curvature and gradient drifts. The dawn-dusk assymmetries may also originate from the magnetosheath. Entropy properties may provide insight into the transport processes across the magnetopause and from plasma sheet to the inner magnetosphere. Specific entropies ($p/\rho\gamma$) increase by an order of magnitude from magnetosheath to the LLBL, 1 – 2 order of magnitude from LLBL to the center of the plasma sheet. Nonconservation of specific entropy is expected to occur when nonadiabatic processes such as wave-particle interactions, heat flux, and dissipation are operating and when the fluid element loses its integrity as occurs when hot particles and cold particles move differently. Flux tubes having low total entropy ($PV\gamma$), bubbles, can lead to earthward fast flow and significant plasma transport from the magnetosphere to the inner magnetosphere. Fast flows have azimuthal structuring and dawn-dusk asymmetries. Substorm led fast flows can penetrate deeper into inner magnetosphere than steady magnetospheric convection (SMC) led fast flows. The temperature ratio of the ions to electrons appear to be roughly (not exactly) conserved during transport across the magnetopause and within the plasma sheet, 5.5 < Ti/Te < 11. Transports in other planetary magnetospheres are examined and compared.

Zhang, Binzheng

Magnetotail Origins of Auroral Alfvenic Power

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The generation of Alfvénic Poynting flux in the central plasma sheet and its polar distribution at low altitude are studied using three dimensional global simulations of the solar wind-magnetosphere-ionosphere interaction. Both event simulations and test simulations driven by ideal SW/IMF conditions are used to investigate the magnetotail origin of Alfvénic Poynting flux. A 24-hour event simulation (4–5 Feb 2004) driven by solar wind and interplanetary magnetic field data reproduces the global morphology of Alfvénic Poynting flux measured by the Polar satellite, including its dawn-dusk asymmetry. Controlled simulations show that during steady magnetosphere convection (SMC) the dawn-dusk asymmetry is regulated by the spatial variation in ionospheric conductance. The asymmetry disappears when the conductance is taken to be spatially uniform. The simulated Alfvénic Poynting flux is generated in the magnetotail by time-variable, fast flows emerging from nightside reconnection. The simulated fast flows are more intense in the premidnight sector as observed; this asymmetry also disappears when the ionospheric conductance is spatially uniform. Analysis of the wave propagation in the plasma sheet source region, near xGSM ≈ −15 RE, shows that as the fast flow brakes, a portion of its kinetic energy is transformed into the electromagnetic energy of intermediate and fast magnetohydrodynamic waves. The wave power is dominantly compressional in the source region and becomes increasingly Alfvénic as it propagates along magnetic field lines toward the ionosphere.