

SM12B CC: 518 C Monday 1030h
Magnetotail and Plasma Sheet

Presiding: J M Weygand, Institute of Geophysics and Planetary Physics UCLA; C Z Cheng, Princeton University

SM12B-01 1030h
Cluster observations of the tail lobe field response to the interplanetary shocks

Emilia Johanna Huttunen¹

(Emilia.Huttunen@helsinki.fi); James Slavin² (james.a.slavin.1@gsfc.nasa.gov); Michael Collier² (mcollier@pop600.gsfc.nasa.gov); Adam Szabo² (Adam.Szabo-1@nasa.gov); Hannu Koskinen^{1,3} (Hannu.Koskinen@fmi.fi); Eija Tanskanen² (etanskanen@lepvaax.gsfc.nasa.gov); Andre Balogh⁴ (s.balogh@ic.ac.uk); Elizabeth Lucek⁴ (e.lucek@ic.ac.uk); Henri Rème⁵ (henri.reme@cesr.fr)

¹Department of Physical Sciences, University of Helsinki, P.O. Box 64, FIN-00014 Helsinki, Finland

²NASA/Goddard Space Flight Center, NASA/GSFC, Code 696, Greenbelt, MD, United States

³Finnish Meteorological Institute, P.O. Box 503, FIN-00101, Helsinki, Finland

⁴Blackett Laboratory, Imperial College, Prince Consort Road, London, United Kingdom

⁵Centre d'Etude Spatiale des Rayonnements, 9 avenue du Colonel Roche, Toulouse, France

We have studied the tail lobe field response to the interplanetary shocks observed in the upstream solar wind by the ACE, WIND and GEOTAIL spacecraft. Cluster plasma and magnetic field data were analyzed for the interval July-November periods of 2001 and 2002. In total, we identified 10 events where an interplanetary shock was seen in the solar wind and Cluster, located at $X \lesssim -10 R_E$ in the tail lobe, observed a sudden (time scales of few minutes) increase in the tail lobe magnetic field. Examples of these lobe field sudden impulse (SI) events in the Cluster tail measurements will be presented. Specifically, we have performed timing analysis using the SI perturbation in the tail lobes and interplanetary shocks. Our results indicate that the SIs observed by Cluster are indeed consistent with a rapid response of the tail magnetic field, on the time scale of an Alfvén bounce time, to high solar wind pressure found behind interplanetary shocks.

SM12B-02 1045h
Magnetotail Convection mode Transitions During Prolonged Intervals of Southward IMF Bz

E. I. Tanskanen¹ (eija.tanskanen@gsfc.nasa.gov); J. A. Slavin¹; D. H. Fairfield¹; D. G. Sibeck¹; K. E. J. Huttunen²; T. Mukai³; T. Nagai⁴

¹Nasa, Goddard Space Flight Center, Greenbelt, MD 20771, United States

²Department of Physical Sciences, University of Helsinki, Finland

³Institute of Space and Astronautical Sciences, Sagami-hara, Japan

⁴Tokyo Institute of Technology, Earth and Planetary Sciences, Japan

The response of the Earth's magnetotail to long (longer than 8 hours) intervals of southward interplanetary magnetic field (IMF) has been examined. Geotail magnetic field and plasma observations together with ACE upstream observations were analyzed during years from 1999 to 2002. Magnetotail was observed to respond to prolonged southward IMF Bz intervals in three ways: (1) by loading the magnetic flux to the tail lobes, (2) by unloading the flux, or (3) by continuously dissipating the flux through the tail lobes. The last convection mode is termed here as continuous magnetospheric dissipation (CMD). Intervals of continuous dissipation are candidate of steady magnetospheric convection (SMC). Examples of each three basic responses have been found and will be described in detail. In particular, we will present statistical analyses of the frequency of the occurrence of each type of tail convection, show examples of several type of mode transitions, and determine their relationship to the upstream solar wind and IMF conditions.

SM12B-03 1100h
Magnetotail dynamics under northward IMF

Simon Wing¹ (240-228-8075; simon.wing@jhuapl.edu)

Masaki Fujimoto²

Patrick T. Newell¹

Ching-I. Meng¹

¹The Johns Hopkins University Applied Physics Lab, 11100 Johns Hopkins Road, Laurel, MD 20723, United States

²Tokyo Institute of Technology, Tokyo, Japan

Although it is well known that the plasma sheet is very dynamic during magnetically active times, it is not devoid of changes during periods of northward IMF. The plasma sheet density (n), temperature (T), and pressure (p) continue to exhibit changes for several hours after IMF northward turning, before eventually reaching cold-dense quasi-steady state. We have recently developed a technique that integrates low-altitude ionospheric observations to create 2-D/3-D global images of the plasma sheet ion p, T, and n. This method relies on the plasma sheet plasma isotropy, which has a strong theoretical foundation as well as overwhelming observational support. Plasma sheet n and T obtained from applying this method to DMSP data along with in situ observations are used to study the formation of cold-dense ion and its evolutions during periods of northward IMF. The 2-D plasma sheet n and T profiles exhibit dawn-dusk asymmetry of the cold-dense ion distribution, which is consistent with (1) the mixing of the magnetosheath and plasma sheet ions and (2) ion transport dominated by gradient and curvature and ExB drifts.

SM12B-04 1115h
Long-Duration Cold Dense Plasma Sheet During Extended Periods of Strongly Northward IMF

Marit Oieroset¹ (510-642-2290;

oieroset@ssl.berkeley.edu); Masaki Fujimoto²

(fujimoto@geo.titech.ac.jp); Tai D. Phan¹

(phan@ssl.berkeley.edu); Simon Wing³

(simon.wing@jhuapl.edu); Joachim Raeder⁴

(J.Raeder@UNH.EDU); Henri Rème⁵

(reme@cesr.fr); André Balogh⁶

(a.balogh@imperial.ac.uk)

¹Space Sciences Laboratory, University of California, Berkeley, CA 94720, United States

²Tokyo Institute of Technology, Department of Earth and Planetary Sciences, Tokyo 152-8551, Japan

³Johns Hopkins University, Applied Physics Laboratory, Laurel, MD 20723, United States

⁴Space Science Center, University of New Hampshire, Durham, NH 03824, United States

⁵CESR, 31028 Toulouse Cedex 4, Toulouse 31028, France

⁶Imperial College, Prince Consort Road, London SW7 2BW, United Kingdom

During two extended intervals of strongly northward interplanetary magnetic field (IMF) on October 22-24, 2003 (event 1) and on October 24-25, 2003 (event 2) the Cluster spacecraft detected the continuous presence of cold and dense plasma sheet over a period of 30 and 11 hours, respectively. During event 1 the Cluster spacecraft traversed both hemispheres in the tail and detected cold dense plasma sheet at all latitudes all the way down to the neutral sheet, in contrast to previous findings indicating that the cold dense plasma sheet is confined to high latitudes only. As for event 2 both Geotail and Cluster were located in the dusk side plasma sheet about 5 R_E apart, simultaneously observing the extended presence of cold and dense plasma sheet. Both spacecraft observed the transition from cold and dense to hot and tenuous plasma sheet in association with a southward turning of the IMF. Low-altitude DMSP satellite observations mapped to the equatorial plasma sheet reveal that the entire plasma sheet became cold and dense during both events. The observations are compared with global MHD simulations to examine possible cusp or flank entry of magnetosheath plasma.

SM12B-05 1130h
Energetic electron morphology in the central mid-tail plasmashet

Reiner H. W. Friedel¹ (1 505 665 1936;

friedel@lanl.gov); Steven P. Monk²

(monk@aerobee.colorado.edu); Matthew G.G.

Taylor¹ (1 505 665 5395; mggtt@nis-mail.lanl.gov);

Geoff D. Reeves¹ (1 505 665 3877;

gdreeves@lanl.gov); Daniel Baker²

((303)492-4509; daniel.baker@lasp.colorado.edu);

Patrick W. Daly⁴ (49-5556-979-279;

daly@linmpi.mpg.de); Malcolm W. Dunlop³

(44-1235445427; m.dunlop@rl.ac.uk); Jackie A.

Davies³ (J.A.Davies@rl.ac.uk)

¹Los Alamos National Laboratory, ISR-2 MS D436, Los Alamos, NM 87544, United States

²Univ Colorado Boulder Lab Atmospheric Space Physics, 1234 Innovation Dr, Boulder, CO 80309-7814, United States

³Rutherford Appleton Lab SSTD, Chilton, DIDCOT Oxf OX11 0, United Kingdom

⁴Max-Planck Inst Aeronomie, Max-Planck-Str 2, Katlenburg-Lindau, DEU 37191

Cluster RAPID observations of the electron high energy tail (40-200keV) near 18 Re have revealed a highly dynamic and structured high energy electron plasmashet. Detailed observations of the 3-D distribution show a rich variety of trapped, field aligned or beaming distributions, including some highly non-gyrotropic distributions. The origin of these particles is of central importance both as a possible source population for higher energy electrons in the inner magnetosphere, and as a possible "smoking gun" for reconnection-related acceleration processes. Understanding the nature of the energetic electron plasmashet is very dependent on the observation locality with respect to the central plasmashet (CPS). As energetic electrons are high-speed tracers of the magnetic field topology, being just above or below the CPS can map the observed particles a unknown distance down tail and may thus not be representative of the local CPS. Using single spacecraft measurement of Bx reversals has traditionally been used as an indicator of the CPS - but RAPID data has shown that the observations of energetic electrons has no 1-to-1 relation to such reversals. This study focuses on 4-spacecraft determination of the magnetic field line curvature and defines the center of the energetic plasmashet to be the region of minimum field line curvature. We will attempt to order the energetic electron observations with respect to this CPS definition in order to sort the data into trapped, streaming or locally accelerated categories.

SM12B-06 1145h
BATSRUS/CCMC Simulations of the Magnetosphere for the Solar-Wind Conditions that Drive Global Sawtooth Oscillations

Joseph E Borovsky¹ ((505)667-8368; jborovsky@lanl.gov)

Joachim Birn¹ (jbirn@lanl.gov)

Aaron J Ridley² (ridley@umich.edu)

¹Los Alamos National Laboratory, Mail Stop D466, Los Alamos, NM 87545, United States

²University of Michigan, Center for Space and Environment Modeling, Ann Arbor, MI 48109, United States

Global sawtooth oscillations of the Earth's magnetosphere are characterized by a periodic stretching and collapse of the magnetic-field orientation at all local times at geosynchronous orbit. Statistically, the solar wind that drives global sawtooth oscillations has low density, high magnetic-field strength, normal to high speed, southward IMF, and low-levels of upstream MHD turbulence. This "sawtooth solar wind" is a low-Mach-number wind that produces a magnetosheath with extremely low beta values. Through the Community Coordinated Modeling Center (CCMC), the BATSRUS 3D MHD code is used to run simulations of the solar wind driving the magnetosphere. A fiducial "sawtooth-solar-wind" run utilizes solar-wind conditions that should produce sawtooth oscillations; other runs deviate from these conditions by varying one parameter at a time. The variations include (a) solar-wind density, (b) solar-wind magnetic-field strength, (c) solar-wind speed, (d) the orientation of the IMF, (e) the steadiness of the IMF, (f) ionospheric conductivity, and (g) dipole tilt. For "sawtooth solar wind", the simulations reveal the following. (1) The low-beta magnetosheath is asymmetric about the Earth, with the orientation of the IMF affecting the shape of the bow shock and the flow pattern of the magnetosheath. (2) The magnetotail is short and unflared. (3) A sunward flow of plasma in the magnetotail bifurcates around the Earth to produce a flattened sunward-flowing plasma sheet in the once-dipolar

magnetosphere. In this plasma sheet the magnetic-field strength is weakened and the magnetospheric field lines are distorted into a "stretched" configuration that extends from the nightside well sunward of the dawn and dusk terminators. (4) An equatorial current system associated with this stretching forms a horseshoe around the nightside of the dipole. (5) The field lines poleward of the flattened plasma sheet are open to the magnetosheath; dipole tilt and the twisting of this plasma sheet by the IMF can bring lobe field lines to the equator in the middle magnetosphere. (6) If the IMF is not steadily southward, the field lines in the dipole are not stretched. (7) If the strength of the solar-wind magnetic field is not high, the field lines in the dipole are not stretched. (8) If the solar-wind density is too high, the field lines in the dipole are not stretched. (9) Dipole tilt does not prevent the stretching of field lines in the dipole. None of the simulations make known sawtooth oscillations in the magnetosphere. Reasons are suggested as to why the magnetosphere does not undergo sawtooth oscillations in the MHD simulations.

SM13A CC: 518 A Monday 1330h
Magnetosphere-Ionosphere Coupling at Subauroral Latitudes (*joint with P, SA*)

Presiding: P L Rothwell, Air Force Research Laboratory; M Wiltberger, National Center for Atmospheric Research High Altitude Observatory

SM13A-01 1330h

Electrical currents from global ENA images

Pontus C. Brandt¹ (240-228-3837; pontus.brandt@jhuapl.edu); Edmond C. Roelof¹ (ed.roelof@jhuapl.edu); Robert DeMajistre¹ (robert.demajistre@jhuapl.edu); Donald G. Mitchell¹ (don.mitchell@jhuapl.edu); Brian J. Anderson¹ (brian.anderson@jhuapl.edu); Yusuke Ebihara² (ebihara@lepvox.gsfc.nasa.gov); Mei-Ching Fok² (Mei-Ching.Fok@gsfc.nasa.gov)

¹The Johns Hopkins University Applied Physics Laboratory, 11100 Johns Hopkins Rd., Laurel, MD 20723, United States

²NASA Goddard Space Flight Center, MC 692, Greenbelt, MD 20771, United States

Plasma pressure gradients in the plasmasheet and ring current are in force balance with electrical currents. Energetic Neutral Atom (ENA) images obtained by the HENA imager on board IMAGE can be inverted to retrieve the proton pressure, and to some extent the O⁺ pressure, in the ring current region. Assuming a magnetic field model and isotropic pitch-angle distributions (PADs), or assimilating PADs from in-situ measurements, the electrical currents can be computed by using the force balance equation $\mathbf{J} \times \mathbf{B} = \nabla P$, where the inertial term has been neglected for the inner magnetosphere. We present results from several geomagnetic storms and compare the ionospheric end of the currents with the field-aligned current (FAC) patterns obtained from Iridium magnetometer data. At present the HENA-derived currents are about a factor of 5 below the current densities derived from Iridium, and the Iridium FAC pattern is often at lower latitudes than that derived from HENA. While a slight underestimation of the intensities are expected due to HENA's energy and mass range, we investigate some possible reasons for these discrepancies: (1) HENA only obtains a part of the total pressure; (2) The choice of magnetic field model; (3) The choice of constraints in the inversion algorithm; (4) Unwanted effects at the edges of the field-of-view of HENA. We also compare the results to runs of the Comprehensive Ring Current Model (CRCM) in order to investigate how the most intense ionospheric FACs relate to the morphology of the plasma pressure in the plasma sheet and ring current.

SM13A-02 1345h

Influence of Ionosphere Conductivity on Ring Current

Yusuke Ebihara¹ (301-286-6674; ebihara@lepvox.gsfc.nasa.gov)
 Mei-Ching Fok² (mei-ching.h.fok@nasa.gov)
 Richard A Wolf³ (rawolf@rice.edu)
 Thomas J Immel⁴ (immel@ssl.berkeley.edu)
 Thomas E Moore² (thomas.e.moore@nasa.gov)

¹USRA/NASA GSFC, Code 692, Greenbelt, MD 20771, United States

²NASA GSFC, Code 692, Greenbelt, MD 20771, United States

³Physics and Astronomy Dept., Rice University, MS108, P.O.Box 1892, Houston, TX 77251-1892, United States

⁴Space Sciences Laboratory, University of California Berkeley, Berkeley, CA 94720-7450, United States

Using the Comprehensive Ring Current Model (CRCM), which self-consistently solves the kinetic equation of ring current protons and the closure of the electric current between the magnetosphere and ionosphere, we have studied how ionospheric conductivity controls injection of the storm-time ring current. By changing ionospheric conductivity artificially, we found the corresponding effects of the ionospheric conductivity on the ring current. The conductivity for F10.7=250 (solar maximum condition) produces about 29% stronger ring current than for F10.7=70 (solar minimum condition), and the conductivity at equinox produces about 5% stronger ring current than at solstice. That is because the two-hemisphere conductivities at equinox are higher than at solstice. This would be a new mechanism for probably explaining the semi-annual variation of Dst. Simulation with a realistic auroral conductivity estimated from the IMAGE/FUV auroral imager data reveals the fact that the auroral brightening does not significantly change the intensity of the ring current. The overshielding condition is found to be produced when the auroral conductivity decreases abruptly near the Dst minimum, triggering a rapid decay of the ring current. The ring current is shown to be influenced by not only IMF and the solar wind, but by solar radiation and morphological feature of the auroral electron precipitation as well.

SM13A-03 1400h

Dynamical coupling of ionosphere, plasmasphere and ring current.

Jerry Goldstein¹ (jgoldstein@swri.edu); Bill R. Sandel² (sandel@arizona.edu); Anthony J. Mannucci³ (tony.mannucci@jpl.nasa.gov); John C. Foster⁴ (jcf@haystack.mit.edu); Pontus C. Brandt⁵ (pontus.brandt@jhuapl.edu); Marc R. Hairston⁶ (hairston@utdallas.edu)

¹Southwest Research Institute, Space Science Department, 6220 Culebra Road, San Antonio, TX 78238, United States

²University of Arizona, Lunar and Planetary Laboratory 1040 East 4th St Rm 901, Tucson, AZ 85721, United States

³Jet Propulsion Laboratory, California Institute of Technology MS 138-308, 4800 Oak Grove Dr, Pasadena, CA 91109, United States

⁴M.I.T. Haystack Observatory/ASB, Route 40, Westford, MA 01886, United States

⁵Johns Hopkins University Applied Physics Lab, 11100 Johns Hopkins Road, Laurel, MD 20723, United States

⁶University of Texas at Dallas, Center for Space Science, P.O. 830688 F022, Richardson, TX 75083, United States

The first unambiguous observations of drainage plumes by IMAGE EUV have verified the qualitative predictions of early convection-based MHD models, but quantitative agreement demands treatment of the physical processes that couple the plasmasphere, ring-current/plasmasheet, and ionosphere. The sub-auroral polarization stream (SAPS), a ring-current/ionospheric feedback process, forms a narrow flow channel that focuses the effects of convection in the pre-midnight and dusk MLT sectors, modifying plasmapause locations and contributing to the formation of narrow duskside plumes. There is a connection between drainage plumes and 'storm-enhanced density' (SED) or 'tongues of ionization' in the ionosphere that implies strong coupling between plasmasphere and ionosphere, perhaps especially during intervals of SAPS. We investigate the nature of the coupling between plasmaspheric plumes and ionospheric SED tongues using a variety of techniques. First IMAGE EUV data are used to provide the equatorial global shape and motion of plumes. From the motion of the plume boundary we can infer the component of the electric field tangent to this boundary; this allows study of some of the details of the erosion process, and also opens the door to investigation of the disturbance-time inner magnetospheric electric field. Second, we use GPS total electron content (TEC) measurements and DMSP in situ observations to gain insight into the structure and dynamics of the low-altitude ionospheric portion of the flux tubes occupied by the plumes. Third, we use IMAGE HENA measurements to examine the role of the ring current in the dynamical formation and development of plumes during times of plasmaspheric erosion. Finally, to help deconvolve the TEC and EUV 2D spatial maps, we employ a three-dimensional model of plasmasphere and ionosphere density. With these tools we examine the highly coupled inner magnetosphere system during geomagnetically active periods.

SM13A-04 1415h

Electric potential pattern in the inner magnetosphere derived by Cluster EDI: Dependencies on IMF B_Z, K_p index, and Dst index

H. Matsui¹ (hiroshi.matsui@unh.edu)
 J M Quinn¹ (jack.quinn@unh.edu)
 R B Torbert¹ (Roy.Torbert@unh.edu)
 V K Jordanova¹ (vania.jordanova@unh.edu)
 G Paschmann² (goetz.paschmann@mpe.mpg.de)
¹Space Science Center, University of New Hampshire, Morse Hall, Durham, NH 03824, United States
²Max-Planck-Institut fuer extraterrestrische Physik, P.O.Box 1603, Garching D-85740, Germany

Electric potential patterns are derived in the inner magnetosphere at $4 < L < 10$ using data from the Electron Drift Instrument (EDI) on Cluster. First, we examine the relations between the electric field and the following three parameters to understand how the potential patterns are organized: B_Z component of the interplanetary magnetic field (IMF), K_p index, and Dst index. From these correlations, we can recognize the effect of the interplanetary electric field (IEF) on the inner magnetospheric electric field as measured by Cluster. Next, the electric field is related to the quantity proportional to the injection rate of the plasmasheet particles, $(dDst^*/dt + 0.13Dst^*)$, where the effect of the magnetopause current is removed in Dst^* . Then we develop a method to obtain potential patterns. An inverse problem is solved by adjusting a trade-off parameter for smoothness of the result. We discuss the following features from the potential patterns sorted by IMF B_Z, K_p index, and $(dDst^*/dt + 0.13Dst^*)$: 1. potential drop, 2. rotation of the direction of the convection electric field, 3. dawn-dusk asymmetry of the strength of the electric field, and 4. shape of the last closed equipotential (LCE) and its relation to the outflow of the plasmaspheric material. We find that the LCE for $Kp < 2$ is a typical tear-drop shape, while those for $2 \leq Kp < 4$ and $4 \leq Kp$ are distorted because of the inward shift of the LCE in the evening MLT.

SM13A-05 1430h

Do Region 2 Currents Affect the Cross Polar Potential?

John G Lyon (603-646-1242; lyon@tinman.dartmouth.edu)
 Department of Physics and Astronomy, Dartmouth College, 6127 Wilder Lab Dartmouth College, Hanover, NH 03755, United States

Global MHD simulations of the magnetosphere tend to (1) have high values of the cross-polar potential (CPP) and (2) have weak or possibly non-existent Region 2 currents. Since the Region 1 current closes both across the polar cap and through the Region 2 system, Hill has suggested that strengthening the Region 2 system causes more current to close at lower latitude which may act as an added ionospheric conductance and, thus, reduce the cross-polar potential. We present a simple model of ionospheric convection to indicate why we believe this is unlikely. The basic idea is that an increase in the Region 2 current causes a corresponding increase in the Region 1 current. Assuming an ionosphere with constant Pedersen conductance, the total resistance (in a dynamic, not electrical sense) which the ionosphere presents to the solar wind depends on Σ_P and the CPP. The effect of the Region 2 currents is to shield the inner magnetosphere from the potential generated by the solar wind. However, the total amount of flux which must return from the nightside to the dayside is unaffected by this shielding. What the shielding does is constrict the channel available for the return. We present a simple model to show the relation between the Region 1 and Region 2 currents as a function of channel width that indicates that enhanced Region 2 current leads to enhanced Region 1 current. We will present results from global simulations to indicate whether this scenario holds for these calculations.

SM13A-06 1445h

Modeling the Proton Precipitation During Detached Subauroral Arc Events

Vania K Jordanova¹ (vania.jordanova@unh.edu)
 Thomas J Immel² (immel@ssl.berkeley.edu)