much of the initial wave energy is dissipated through electron acceleration. Observations from Cluster also allow us to identify a possible source for these waves.

SM22C-04 1425h

Electron Dispersion Below Inverted-V Energies: Resonant Deceleration and Acceleration by Alfvén Waves

Li-Jen Chen[1] (319-335-1221; li-jen-chen@uiowa.edu)

Craig A. Kletzing[1]

Shuanghui Hu[2]

[1]Department of Physics and Astronomy, University of Iowa, Iowa City, IA 52242, United States

[2]Department of Physics and Astronomy, University of California, Irvine, Irvine, CA 92697, United States

We report on studies of resonant interactions of inertial Alfvén waves with electrons along auroral field lines. The electrons in resonance can be accelerated or decelerated by the parallel electric field of the wave depending on whether the velocity of the electrons is less or greater than the Alfvén wave velocity. In this paper, we emphasize the resonant deceleration process and its effects on electrons that have gone through a parallel potential drop (the inverted-V electrons). When the backscattered population is included, a combination of resonant acceleration and deceleration effects accounts well for rocket observations of electron energy dispersion extending from the inverted-V energies to lower energy. Characteristics of the dispersion tail such as the dispersion time scale and the intensity distribution along the tail may be used to deduce the Alfvén wave properties and the parent electron spectra. Examples of the model wave signatures and their dependence on the electron population will be shown.

URL: http://alpha.physics.uiowa.edu/~lijen/KAWe.html

SM22C-05 1440h

Separating spatial and temporal variations in auroral electric and magnetic fields by Cluster multipoint measurements

Tomas Karlsson[1] (+46-8-7907701; tkarlsson@plasma.kth.se)

G T Marklund[1] (marklund@plasma.kth.se)

Sonía Figueiredo[1] (figueiredo@plasma.kth.se)

Tommy Johansson[1] (tjohansson@plasma.kth.se)

Stephan Buchert[2] (scb@irfu.se)

[1]Alfvén Laboratory, Department of Plasma Physics, KTH, Stockholm SE-10044, Sweden

[2]Swedish Institute of Space Physics, Box 537, Uppsala SE-75121, Sweden

Cluster multipoint measurements of the electric and magnetic field on auroral field lines at an altitude of 4 RE are used to show that it is possible to resolve the ambiguity of temporal versus spatial variations in the fields. We show that the largest electric fields (of the order of several hundreds of mV/m when mapped down to the ionosphere) are of a quasi-static nature, associated with upward electron beams, stable on a time scale of at least half a minute, and located in regions of downward current, and we conclude that they are the high-altitude analogues of the intense return current/black auroral electric field structures observed at lower altitudes by Freja and FAST. Outside of these structures there are temporal fluctuations, which are shown to likely be downward traveling Alfvén waves. The periods of these waves are 20 - 40 s, which is not consistent with periods associated with either the Alfvénic ionospheric resonator or field line resonances. The multipoint measurements enable us to estimate a lower limit to the perpendicular wavelength of the Alfvén waves.

SM22C-06 1455h

Temporal and Spatial Characteristics of Acceleration Structures in the Auroral Return Current Region

Goran T Marklund[1] (+46-8-7907695; marklund@plasma.kth.se)

Tomas Karlsson[1] (tkarlsson@plasma.kth.se)

Sonia Figueiredo[1] (figueiredo@plasma.kth.se)

Tommy Johansson[1] (tjohansson@plasma.kth.se)

Stephan Buchert[2] (scb@irfu.se)

[1]Alfven Laboratory, Royal Institute of Technology, Stockholm SE10044, Sweden

[2]Swedish Institute of Space Physics, Box 537, Uppsala SE-75121, Sweden

Temporal and spatial characteristics of high-altitude auroral electric fields, and, in particular, those which are related to quasi-static auroral electric potential structures, are discussed using Cluster multi-point observations from auroral field line crossings at geocentric distances of about 5 RE. Intense and narrow-structured diverging electric fields, associated with upward accelerated electrons, being fingerprints of quasi-static acceleration structures in the auroral return current region, appear more frequently at these altitudes than their counterpart, converging electric fields, on auroral field lines, for reasons not yet understood. The time needed for evacuating ionospheric electrons at the ionospheric end of the return current flux tube, which depend on the field-aligned current density, represent one characteristic time scale for the accelerating electric fields. We present results from four Cluster encounters with such acceleration structures and how these and their associated field-aligned current and electron distributions, evolve on the different time scales given by different inter-spacecraft separation distances.

SM22C-07 1510h

Polar Study of Ion Outflow Versus its Energy Input

Yihua Zheng[1] (301-286-4647; yihua.zheng@gsfc.nasa.gov)

Thomas E. Moore[2] (thomas.e.moore@nasa.gov)

Forrest Mozer[3] (fmozer@ssl.berkeley.edu)

Christopher T. Russell[4] (ctrussell@igpp.ucla.edu)

Robert J. Strangeway[4] (strange@igpp.ucla.edu)

[1]National Research Council, NASA Goddard Space Flight Center, Mailcode 696,Bldg 21, rm 232, Greenbelt, MD 20771, United States

[2]NASA Goddard Space Flight Center, Mailcode 692, Bldg.21, Rm 257A, Greenbelt, MD 20771

[3]Space Science Laboratory, University of California at Berkeley, Berkeley, CA 94720, United States

[4]Institute of Geophysics and Planetary Physics, University of California at Los Angeles, Los Angeles, CA 90024-1567, United States

A statistical study of the ion outflow versus its energy input is performed by using multi-instrument data (TIDE, EFI, MFI, HYDRA) of Polar during its perigee auroral passes in the year 2000. Several important physical quantities connected to the ion outflow have been investigated, among which are the Poynting flux from the perturbation fields (below 1./6 Hz), the electron density, temperature and the electron energy density. The perturbation fields here to calculate the Poynting flux may be associated with the small-scale quasi-static electric field structures of the field-aligned currents or/and time-varying Alfven wave structures, which are both proven to be important energy sources to power the aurora. Our preliminary results show that the field-aligned ion outflow flux correlates best with the Earth-directed Poynting flux and the precipitating electron density, and also with a much weaker correlation with the electron energy density and temperature. The findings from this Polar study are similar to those from FAST. The general corroboration between the independent data sets of the two spacecraft suggests that the empirical ion outflow scaling laws can be established, which will be beneficial to global simulation efforts.

SM22C-08 1525h

A statistical study of the orientation, motion, and thicknesses of density and electric field structures observed by Cluster II above the auroral accleration region

Arthur J. Hull[1] (510-643-0502; ahull@ssl.berkeley.edu); John W. Bonnell[1] (jbonnell@ssl.berkeley.edu); Forrest S. Mozer[1] (fmozer@ssl.berkeley.edu); M. Andre[2] (Mats.Andre@irfu.se); A. Eriksson[2] (aie@irfu.se); A. Vaivads[2] (andris.vaivads@irfu.se); A. Pedersen[3] (arne.pedersen@fys.uio.no); P.-A. Lindqvist[4] (lindqvist@plasma.kth.se); H. Laakso[5] (harri.laakso@esa.int)

[1]Space Sciences Laboratory, University of California at Berkeley, 7 Gauss Way, Berkeley, CA 94720

[2]Swedish Institute of Space Physiscs, Uppsala Division, Box 537, Uppsala , Sweden

[3]Dept. of Physics, University of Oslo, P.O. Box 1048, Oslo , Norway

[4]Royal Institute of Technology, Teknikringen 31, Stockholm , Sweden

[5]Space Science Dept., ESTEC, Noordwijk , Netherlands

We present the results of a statistical study of the properties of electric field and density structures observed by the Cluster II spacecraft above the auroral acceleration region. Of particular emphasis is the orientation, motion, and thicknesses of time stationary structures. The multi-point electric field and density measurements from the Cluster II constellation are used to estimate the direction and propagation speed of structures in the electric fields and plasma density (as inferred from spacecraft floating potential measurements), as well as to quantify the thicknesses of those structures. These spatial structures propagate transverse to the magnetic field at speeds of $\sim$10 km/s and are characterized by thicknesses that range from a few hundred kilometers to a few thousand kilometers in extent. Thus with these observations we are probing the high-altitude potential and density structures that are associated with relatively fast (1 km/s) proper motions of fairly large scale (10-100 km) features in the auroral zone. The variation in the properties of these spatial structures with other parameters that characterize the auroral zone, such as altitude, local time, invariant latitude, and geomagnetic activity will also be discussed.

SM22D MCC: 2008 Tuesday 1600h

Substorms I

Presiding: **J D Perez,** Auburn University**; W J Hughes,** Center for Integrated Space Weather Modeling

SM22D-01 1600h

Substorm Onset by Plasma Sheet Divergence

Larry R Lyons[1] (larry@atmos.ucla.edu)

Chih-Ping Wang[1] (cat@atmos.ucla.edu)

Tsugunobu Nagai[2] (nagai@geo.titech.ac.jp)

[1]Department of Atmospheric Sciences, UCLA, Los Angeles, CA 90095-1565, United States

[2]Tokyo Institute of Technology, Ookayama 2-12-1, Meguro, Tokyo 152-8551, Japan

It is necessary to understand current wedge formation in order to understand the cause of the substorm expansion phase. Geotail spacecraft observations have shown that the inner-plasma-sheet cross-tail current reduction within the current wedge results from a process that leads to a reduction in equatorial plasma pressure and a substantial reduction in flux tube ion content. We use the single-species continuity equation for plasma sheet particles to identify a plausible cause of these plasma reductions. We find that a convection reduction, which follows a growth phase period of enhanced convection, should cause a divergence of plasma sheet particles driven by diamagnetic drift that leads to flux tube content reduction. Such reduction in flux tube content is longitudinally localized to the premidnight to midnight region where the current wedge has been observed to initially form and must initiate within the region of the equatorial mapping of the Harang discontinuity, consistent with ionospheric observations of substorm onset. We also find that the reduction in flux tube content should initially develop slowly, and then develop more rapidly as the current wedge forms. This is consistent with observations which show that expansion phase aurora, and thus also the current wedge, develops slowly for a few minutes before brightening rapidly, and it is as required if plasma sheet divergence driven by diamagnetic drift leads to current wedge formation and initiation of the substorm expansion phase.

URL: http://www.atmos.ucla.edu/~larry

SM22D-02 1615h

A macroscopic / microscopic view of a substorm

Richard Elphic[1] (relphic@lanl.gov); Matthew C Taylor[1] (mggtt@lanl.gov); Reiner H Friedel[1] (friedel@lanl.gov); Geoff D Reeves[1] (reeves@lanl.gov); Michael G Henderson[1] (mhenderson@lanl.gov); Michelle F Thomsen[1] (mthomsen@lanl.gov); Joachim Birn[1] (jbirn@lanl.gov); Jonathan Rae[2] (jrae@Space.UAlberta.CA); James A Slavin[3] (James.A.Slavin@nasa.gov); Benoit Lavraud[4] (Benoit.Lavraud@cesr.fr); Arne Aasnes[1,5] (aasnes@lanl.gov); Andre Balogh[6] (a.balogh@ic.ac.uk); Patrick W Daly[7] (Daly@linmpi.mpg.de); Malcolm W Dunlop[8] (M.W.Dunlop@rl.ac.uk); Andrew N Fazakerley[9] (anf@mssl.ucl.ac.uk); Theodore A Fritz[10] (fritz@bu.edu); Henri Reme[4] (Henri.Reme@cesr.fr); Jack Scudder[11] (jds@space-theory.physics.uiowa.edu)

[1]Space and Atmospheric Sciences, Los Alamos National Lab, Los Alamos 87545, United States

[2]Space Physics Group, University of Alberta, Alberta T6G 2J1, Canada

[3]NASA, Goddard Space Flight Center, Greenbelt 20771, United States

[4]CESR, 9 avenue du colonel Roche, Toulouse 31028, France

[5]Institute of Physics, University of Bergen, Bergen 5007, Norway

[6]Space and Atmospheric Physics group, Imperial College, London SW7, United Kingdom

[7]Max-Planck-Institut für Aeronomie, Max-Planck-Str. 2, Katlenburg-Lindau D-37191, Germany

[8]Rutherford Appleton Laboratory, Space Sciences Division, Didcot OX11 OQX, United Kingdom

[9]Mullard Space Science Lab, University College London, Holmbury St. Mary RH5 6nt, United Kingdom

[10]Centre of Space Physics, Boston University, Boston 02215, United States

[11]Department of Physics and Astronomy, University of Iowa, Iowa City 52240, United States

In this paper we study a plasma sheet thinning event which took place on 11th August 2002, while CLUSTER was located in the nightside, northern hemisphere of the magnetosphere in the plasma sheet/plasma sheet boundary layer. This event took place during a period of quite low Dst but high AE, with substorm signatures observed by ground based measurements and the Los Alamos instruments aboard geosynchronous spacecraft coincident with the plasma sheet thinning observed by both CLUSTER and POLAR. Just prior to the plasma sheet thinning and entrance into the lobe, the CLUSTER tetrahedron observed a tailward moving travelling compression region, as identified by magnetic field measurements from the FGM (Flux Gate Magnetometer) instrument. At this time the IES/RAPID (Imaging Electron Spectrometer/Research with Adaptive Particle Imaging Detectors) and PEACE (Plasma Electron and Current Experiment) instruments on CLUSTER 3 observved a highly collimated field aligned electron beam. By combining groundbased and multi-point spacebased (magnetospheric and up-stream) observations we are able to construct a detailed macroscopic picture of the evolution of this substorm as well as a more microscopic description of the local phenomena at CLUSTER. We study the possible relationship of the beam to reconnection separatrix formation and evolution.

SM22D-03 1630h

A Fresh Perspective of the Substorm Current System and Its Dynamo

Anthony T Y Lui[1] (1-240-228-5598; Tony.Lui@jhuapl.edu)

Yohsuke Kamide[2] (kamide@stelab.nagoya-u.ac.jp)

[1]The Johns Hopkins University Applied Physics Laboratory, 11100 Johns Hopkins Rd., Laurel, MD 20723-6099, United States

[2]Solar-Terrestrial Environment Laboratory, Nagoya University, Honohara 3-13, Toyokawa, Aichi 442, Japan

The common view for the substorm current system is a current wedge involving principally an azimuthal current system. We first evaluate briefly previous studies that provide strong evidence for the dominance of a meridional current system (MCS) in substorms. Based on these clues, we propose the dynamo for the MCS to be a kinetic current disruption process in the magnetotail such that dipolarization is achieved by magnetic field line slippage, thus producing the dynamo action of a tailward directed current with an earthward directed electric field. The total current strength is estimated to be about 10 MA for an average substorm size, consistent with that obtained from the KRM algorithm.

SM22D-04 1645h

Periodic magnetospheric substorms and their relationship with solar wind pressure variations

Chao-Song Huang[1] (781-981-5628; cshuang@haystack.mit.edu); J. C. Foster[1]; G. D. Reeves[2]; G. Le[3]; H. U. Frey[4]; C. J. Pollock[5]

[1]Haystack Observatory, Massachusetts Institute of Technology, Route 40, Westford, MA 01886, United States

[2]Los Alamos National Laboratory, Mail Stop D-466, Los Alamos, NM 87545, United States

[3]NASA Goddard Space Flight Center, Laboratory for Extraterrestrial Physics, Greenbelt, MD 20771, United States

[4]University of California, Space Science Laboratory, Berkeley, CA 94720, United States

[5]Southwest Research Institute, Department of Space Science, San Antonio, TX 78228, United States

Outstanding problems in magnetospheric substorms include what causes substorm onsets and whether substorms have some specific periodicity. We will present observations and interpretation that are related to the above problems. In one event, the Geotail satellite was located in the near tail between X = -20 and -30 Re and detected periodic southward turnings of the magnetospheric magnetic field. Geosynchronous satellites measured sawtooth-like injections of energetic charged fluxes from the tail. The IMAGE satellite measured enhanced emissions of energetic neutral atoms in the ring current and auroral brightenings. The CANOPUS photometers measured intensifications and latitudinal motion of auroral emissions. These magnetospheric and ionospheric phenomena have the same periodicity and indicate the occurrence of periodic substorms. Several other events show similar phenomena. The periodic substorms have periods of 2-3 hours and occur after a solar wind pressure impulse impinges on the magnetosphere. We suggest that magnetospheric substorms have an intrinsic cycle time of 2-3 hours. If solar wind pressure oscillations with periods comparable to the substorm cycle time are imposed on the magnetosphere, some magnetospheric resonant state may be excited, and periodic substorms can be triggered. Otherwise, if the solar wind oscillates too fast, no enough energy is accumulated in the magnetotail for substorms to occur; if the period of solar wind pressure oscillations is too long, magnetospheric energy may be released through other processes including internally triggered substorms.

SM22D-05 1700h

The Relative Timing of Substorm Onset Phenomena

Emil L. Kepko[1] (lkepko@bu.edu)

Margaret G. Kivelson[2] (mkivelson@igpp.ucla.edu)

Robert L. McPherron[2] (rmcpherron@igpp.ucla.edu)

Harlan E. Spence[1] (spence@bu.edu)

[1]Boston University, Center for Space Physics 725 Commonwealth Ave., Boston, MA 02215, United States

[2]UCLA, Dept. of Earth and Space Sciences, Los Angeles, CA 90024, United States

Current debate over the initiation of a magnetospheric substorm centers on two viable onset models. One model is that substorm onset begins with disruption of the near-Earth crosstail current. The other possibility is that onset begins with magnetic reconnection in the midtail plasmasheet, and that subsequent dynamics are driven by convective flow bursts. Each model predicts a different temporal ordering of onset phenomena. We present the results of event studies where we examine the temporal ordering of convective plasma flow in the plasmasheet, Pi2 pulsations, and auroral arc brightening. Using the causal link between midtail plasma flows and low latitude Pi2 pulsations and the relative timing of phenomena we show that the observed sequence of events disagrees with predictions of CD models. We then show that the observations lend strong support to the flow-burst model of magnetotail dynamics.

SM22D-06 1715h

Firehose instability near substorm expansion-phase onset?

Shuo Ji[1] (713-348-3358; jishuo@rice.edu)

Richard A Wolf[1] (713-348-3308; rawolf@rice.edu)

[1]Physics and Astronomy Dept., Rice University, MS108, P. O. Box 1892, Houston, TX 77251, United States

The evolution of plasma ejected earthward from a patch of reconnection at about 25 RE is studied using a double-adiabatic-MHD simulation of a thin filament. Firehose instability occurs in the simulation after a compressional shock reflects from the near-Earth region. The tailward-propagating compressional wave, which brakes the earthward flow in the filament, is thus characterized by strong magnetic fluctuations. Within the context of the Near-Earth-Neutral-Line model of substorms, we suggest that firehose instability might cause the intense magnetic-field fluctuations that are observed in the inner plasma sheet at substorm onset. To assess the accuracy of double-adiabatic MHD, we tested it for a situation that resembles the substorm-generated filament but is simple enough to allow an exact kinetic theory solution. The test confirms that double-adiabatic MHD does a reasonable job of predicting when the firehose criterion is satisfied.

SM22D-07 1730h

Magnetospheric Substorm Evolution in the Magnetotail: Challenge to Global MHD Modeling.

Masha M Kuznetsova[1] (301-286-9571; masha@elbrus.gsfc.nasa.gov)

Michael Hesse[1] (301-286-8224; hesse@gsfc.nasa.gov)

John Dorelli[1] (301 286-0166; jdorelli@kahala.ccmc.gsfc.nasa.gov)

Lutz Rastaetter[1] (301-286-1085; lr@waipio.gsfc.nasa.gov)

[1]Electrodynamics Branch, NASA Goddards Space Flight Center, Greenbelt, MD 20771, United States

Testing the ability of global MHD models to describe magnetotail evolution during substroms is one of the elements of science based validation efforts at CCMC. We perform simulations of magnetotail dynamics using global MHD models residing at CCMC. We select solar wind conditions which drive the accumulation of magnetic field in the tail lobes and subsequent magnetic reconnection and energy release. We will analyze the effects of spatial resolution in the plasma sheet on modeled expansion phase evolution, maximum energy stored in the tail, and details of magnetotail reconnection. We will pay special attention to current sheet thinning and multiple plasmoid formation.

SM22D-08 1745h

Substorm Injection Modeling With Non-dipolar, Time-dependent Background Field

Sorin Zaharia[1] (szaharia@lanl.gov)

Joachim Birn[1] (jbirn@lanl.gov)

Geoffrey Reeves[1] (gdreeves@lanl.gov)

Michelle Thomsen[1] (mthomsen@lanl.gov)

C.Z. Cheng[2] (fcheng@pppl.gov)

[1]Los Alamos National Laboratory, NIS-1, MS D466, Los Alamos, NM 87545, United States

[2]Princeton Plasma Physics Laboratory , Princeton University, P.O. Box 451 , Princeton, NJ 08543, United States

We model substorm energetic particle injections by studying the interaction of particles with earthward-propagating electromagnetic pulses of westward electric field and consistent magnetic field with localized radial and azimuthal extents, superposed over a background magnetic field. The improvement in the current work over previous models is the consideration of a non-dipolar background magnetic field before the pulse arrives (corresponding to the stretched field during the substorm growth phase), which changes in a time-dependent manner and transforms into a dipole field in the wake of the pulse. The particle motion is still adiabatic, even in the lower stretched field, and therefore both ions and electrons are dragged earthward by the ExB drift to regions of higher magnetic field, thus undergoing betatron acceleration. As in the previous model, we obtain fully-analytical solutions for the particle motion. We present an analysis of the differences in the results with the current model vs. the previous model (with dipole background), both for the particle

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orbits and the injected particle fluxes. We also discuss the dependence of the ion and electron injections on pulse parameters, such as speed, field magnitude and spatial extent. The results with the non-dipolar, time-dependent background field show marginal increase in injection strength for energies of 10 to 400 keVs and typical pulse parameters compared to the case of dipole background, however the differences become more significant for very active events or very high particle energies.

SM31A MCC: 2002-2004 Wednesday 0800h

Multipoint Observations of Reconnection Signatures

Presiding: **R Strangeway,** Institute of Geophysics and Planetary Physics, University of California, Los Angeles**; J D Scudder,** University of Iowa

SM31A-01 0800h

A CLUSTER INVESTIGATION OF THE OCCURRENCE AND CAUSES OF RECONNECTION IN THE VERY NEAR-EARTH TAIL (X > -19Re)

J. A. Slavin[1] (james.a.slavin@nasa.gov); E. Tanskanen[1] (eija.tanskanen@nasa.gov); S. Imber[2] (suzanne.imber@nasa.gov); A. Szabo[1] (adam.szabo@nasa.gov); C. J. Owen[3] (cjo@mssl.ucl.ac.uk); M. W. Dunlop[4] (m.dunlop@ic.ac.uk); E. Lucek[2] (e.lucek@ic.ac.uk); A. Balogh[2] (a.balogh@ic.ac.uk); K. -H. Fornacon[5] (k-h.fornacon@tu-bs.de)

[1]NASA GSFC, Laboratory for Extraterrestrial Physics, Greenbelt, MD 20771, United States

[2]Imperial College, Space and Atmospheric Physics, London SW7 2BZ, United Kingdom

[3]Mullard Space Science Laboratory, Holmbury St. Mary, Dorking Surrey, United Kingdom

[4]Rutherford-Appelton Laboratory, Chilton, Didcot, Oxfordshire OX11 0QX, United Kingdom

[5]Technische Universität Braunschweig, Institut für Geophysik und Meteorologie, Braunschweig D-38106, Germany

The Cluster spacecraft cross the plasma sheet at distances of X -16 to -19 Re, significantly earthward of the mean X-line location of -25 Re determined by Geotail. Indeed, transport in the plasma sheet observed by Cluster is usually directed sunward during both quiescent and active intervals. Cluster's polar orbit is ideally suited for the detection of traveling compression regions (TCRs) in the tail lobes and, to a lesser extent, flux ropes in the plasma sheet. TCRs are caused by the rapid motion of flux ropes embedded in high-speed plasma sheet flows generated by multiple X-line reconnection. Hence, they can be used to remotely sense the movement of flux ropes and the plasma sheet flows in which they are embedded. Cluster fluxgate magnetometer measurements taken during the 2001 and 2002 tail seasons have been used to identify and analyze flux rope motion in the near-tail. Earthward moving flux ropes, detected either in situ or remotely as TCRs, are found to outnumber tailward moving flux ropes by a ratio of 3 to 1. Here we investigate the interplanetary and magnetospheric conditions associated with the production of tailward moving flux ropes at Cluster and, by implication, X-line formation in the very near-tail (i.e., X > -19 Re). The results will be discussed in terms of the processes leading to plasma sheet thinning and current sheet filamentation.

SM31A-02 0815h

Near-Earth Magnetotail Reconnection and Plasmoid Formation in Connection With a Substorm Onset on 27 August 2001

Stefan Eriksson[1] (1-303-492-8573; eriksson@lasp.colorado.edu); M. Øieroset[2] (oieroset@ssl.berkeley.edu); D. N. Baker[1] (daniel.baker@lasp.colorado.edu); R. L. McPherron[3] (rmcpherron@igpp.ucla.edu); S. Monk[1] (monk@lasp.colorado.edu); M. W. Dunlop[4] (M.W.Dunlop@rl.ac.uk); H. Rème[5] (henri.reme@cesr.fr); T. E. Sarris[1] (sarris@lasp.colorado.edu); C. Shen[6] (sc@center.cssar.ac.cn); A. Balogh[7] (a.balogh@ic.ac.uk)

[1]Laboratory for Atmospheric and Space Physics, University of Colorado, 1234 Innovation Drive, Boulder, CO 80303-7814, United States

[2]Space Sciences Laboratory, University of California, Centennial Dr at Grizzly Peak Blvd, Berkeley, CA 94720-7450, United States

[3]Institute of Geophysical and Planetary Physics, University of California, 405 Hilgard Avenue, Los Angeles, CA 90024-1567, United States

[4]Space Sciences Division, Rutherford Appleton Laboratory, DIDCOT, Chilton, Oxfordshire OX11 0QX, United Kingdom

[5]Centre d'Etude Spatiale des Rayonnements, 9 Ave Colonel Roche, Toulouse 31029, France

[6]Laboratory for Space Weather, Center for Space Science and Applied Research, No.1, Nanertiao, Zhongguancun, Haidian District, Beijing 100080, China

[7]Physics Department, The Blackett Laboratory, Imperial College, Prince Consort Road, London SW7 2BZ, United Kingdom

We have examined the magnetic field and ion velocity data from the Cluster spacecraft on 27 August 2001 when the spacecraft were located in the postmidnight magnetotail at $x_{GSM} = -19R_E$ and $y_{GSM} = -2R_E$. Fast earthward flows were recorded at both Cluster sc1 and sc3 $\sim$32 min prior to a substorm onset at $\sim$0401 UT, when enhanced tailward flows were detected at both spacecraft. Cluster sc3 also detects earthward directed flows $\sim$30 min after the onset. These plasma flows are suggestive of slow-mode shocks in a Petschek-type reconnection layer. The negative B_y component of the observed magnetic field coincident with high-speed tailward flows at substorm onset strongly suggest the formation and ejection of a plasmoid. We apply a curvature analysis technique on the magnetic field data to investigate the topology of the plasmoid during its evolution. The indication that reconnection is active prior to the downtail release of the plasmoid at substorm onset may be interpreted as a semi-continuous erosion of magnetic fields in the near-Earth magnetotail region and may provide us with information on the dynamic evolution of the near-Earth neutral line (NENL) to the point of plasmoid release.

SM31A-03 0830h

Cluster Observations of a Near-Earth Neutral Line on August 27, 2001

Robert L McPherron[1] (310-825-1882; rmcpherron@igpp.ucla.edu); Daniel N Baker[2] (Dan.Baker@lasp.colorado.edu); Margaret G Kivelson[1] (mkivelson@igpp.ucla.edu); Khrishan Khurana[1] (kkhurana@igpp.ucla.edu); Andre Balogh[3] (a.balogh@ic.ac.uk); Henri Reme[4] (Henri.Reme@cesr.fr); Iannis Dandouras[4] (Iannis.Dandouras@cesr.fr); Howard Singer[5] (Howard.Singer@noaa.gov); Eric Donovan[6] (eric@phys.ucalgary.ca)

[1]Institute of Geophysics and Planetary Physics, University of California, Los Angeles, CA 90095-1567, United States

[2]Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO 80309, United States

[3]Space and Atmospheric Physics Group, The Blackett Laboratory Imperial College Prince Consort Road, London SW7 2BW, United Kingdom

[4]CESR BP4346 , 9 avenue du Colonel Roche, Toulouse, Cedex 04 31028, France

[5]NOAA Space Environment Center, 325 Broadway, Boulder, CO 80305, United States

[6]Department of Physics and Astronomy, University of Calgary, Calgary, ALB T2N 1N4, Canada

At 0400 UT on August 27, 2001 the Cluster spacecraft located near midnight at 19 Re began to observe a tailward flow with southward magnetic field. This flow persisted for several minutes and then both field and flow reversed to northward and Earthward. The event was associated with a rotation of the magnetic field from its usual orientation along the GSM X-axis to nearly antiparallel to the Y-axis. In a principal axis system the Bx' component changed from +12 nT to -12 nT and then back. As the spacecraft passed downward through Bx' = 0 significant current antiparallel to the magnetic field was encountered. At this time the line containing the field and current pointed roughly 45 from gsm Bx towards dawn. The plasma flow was generally tailward orthogonal to the line containing the field and current. While the spacecraft were in the region of negative Bx' the plasma flow was tailward along X. When the spacecraft returned through Bx' = 0 the current and field were again antiparallel at 45 and the flow was still tailward orthogonal to the current and field. Next the flow rotated 180 becoming Earthward with a duskward component. These observations suggest that an x-line formed Earthward of Cluster releasing a structure that was convected tailward past the spacecraft. This x-line remained Earthward of Cluster for four minutes steadily forcing plasma tailward with imbedded southward magnetic field. The x-line then moved tailward past Cluster rotating the field to northward and the flow to Earthward. These observations become particularly important when placed in the context of substorm activity on this day. A major substorm expansion followed the onset of the x-line signatures by about six minutes.

SM31B MCC: Level 2 Wednesday 0830h

Sun-to-Earth Elements and Linkages That Drive Geoeffectiveness I Posters *(joint with SA, SH, NG)*

Presiding: **J U Kozyra,** University of Michigan**; L Goncharenko,** MIT Haystack Observatory

SM31B-1105 0830h POSTER

Mass and Speed of the April 21, 2002 CME at 1.64 Solar Radii

John C Raymond (617-495-7416; jraymond@cfa.harvard.edu)

John Raymond, Center for Astrophysics 60 Gardden St., Cambridge, MA 02138

A partial halo CME was associated with an X-class flare on April 21, 2002. It accelerated to 2500 km/s and produced an SEP event. UVCS/SOHO observed the event at 1.64 solar radii, near the peak acceleration. The UV spectra establish the conditions in the pre-CME streamer where much of the mass of the CME originates. Doppler shifts show that a large part of the streamer motion is transverse rather than radial, with an Earth-directed velocity component of 850 km/s. The transverse acceleration is even larger than the radial acceleration. From the density and acceleration we derive a lower limit to the magnetic field at 1.64 solar radii. High temperature emission indicates a probable current sheet, which in some CME models is vital to the CME acceleration. Thus we obtain estimates of the mass, acceleration and magnetic field of the CME in the region of the corona where these quantities are established.

SM31B-1106 0830h POSTER

Source Regions and Storm Effectiveness of Earth-Directed Halo CMEs Between 14 and 24 April 2002

Xue Pu Zhao[1] (650-7250474; xpzhao@solar.stanford.edu)

Yang Liu[1] (650-7245605; yliu@sun.stanford.edu)

[1]Stanford University, 455 Via Palou, Stanford, CA 94305-4085, United States

All three halo CMEs occurred between 14 and 24 April 2002 are found to be associated with flares, interplanetary trasient shocks and geomagnetic storms, and thus are Earth-directed. To understand why the April 15 and 17 Earth-directed halo CMEs cause geomagnetic storms much stronger than the April 21 Earth-directed halo CME, we first determine the central position and the line-of-sight propagation velocity of the three halo CMEs using the cone model (Zhao et al., 2002), and then identify source regions of the halo CMEs and examine the magnetic configuration of those source regions. It is found that the April 15 and 17 halo CMEs originated in a bipolar closed field regions with the bipolar boundary layer being favourable for the occurence of the southward IMF event, and the April 21 halo CME originated in an unipolar region with the