SM62B-11 1645h

Post-Midnight Enhancements in the Storm Time Ring Current

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In the traditional picture of development of the storm-time ring current, most of the ions that are injected on the night side gradient-curvature drift westward around the Earth, causing the main-phase ring current to peak near local dusk. In contrast, previous simulations carried out with the Rice Convection Model (RCM), typically showed a ring current with a maximum near midnight. Recent neutral atom images of the ring current from IMAGE/HENA reveal strong enhancements in the post-midnight sector during storm main phases, even further from the traditional picture. The local times of the maximum flux seem to vary with IMF By and solar wind velocity. Simulations carried out with the Comprehensive Ring Current Model, which couples the RCM and Fok's ring current model, showed remarkably good agreement with the IMAGE/HENA data. Preliminary analysis shows that magnetosphere-ionosphere coupling plays an important role in the formation of these post-midnight enhancements. This paper will explore the physical processes that control this local-time asymmetry. We seek to understand how these mechanisms control the effects of solar wind, convection, and ionospheric conductances on observed ring current local-time distribution.

SM71A MCC: Hall D Sunday 0830h

Substorms and Storms II Posters

Presiding: **T Hsu,** University of California, Los Angeles**; J W Gjerloev,** NASA Goddard Space Flight Center

SM71A-0561 0830h POSTER

Average characteristics of triggered and non-triggered substorm-like events: Can a substorm occur without triggering?

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An outstanding question in magnetospheric physics is whether substorms are always triggered externally by changes in the interplanetary magnetic field (IMF) or solar wind plasma, or whether they sometimes occur spontaneously as a result of internal processes. Over the past decade, arguments have been made on both sides of this issue. Horwitz [1985] and McPherron [1986] suggested that substorms usually appear to be initiated by an internal instability. However, Lyons [1995; 1996] argued that substorms must be triggered by external changes in the IMF and/or the solar wind. Specifically, Lyons [1996] argued that events without apparent triggers were likely to be a non-substorm disturbance such as a convection bay [Pytte et al., 1978].

To examine this issue, Henderson et al. [1996] have presented several examples to demonstrate that non-triggered events do have substorm like signatures on the ground and at geosynchronous orbit. It seems evident from their study that substorms can occur without apparent IMF triggers.

However, a stasitical analysis to examine the average characteristics of triggered and non-triggered substorm has never been performed. In this study, we use the substorm onset list established by Hsu and McPherron [2002], which covers the spring and fall onset list of 1978 and 1979 to investigate the tail and geosynchronous response for both triggered and non-triggered substorms. It was found that the average respone in the tail suggest no difference. However, the magnitude response seems different for both classes.

SM71A-0562 0830h POSTER

Diamagnetic Processes of Substorms: Fundamental Results and a New Perspective

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By virtue of the Geotail magnetic field and low-energy-particle data, we have investigated the characteristics of substorms that observed in the near-tomid magnetotail plasma sheet. We focused on the changes of three kinds of energy density considering their primary importance, their relationship and their flux transport. We divided the substorms into the Pi2 oscillatory variation (with a period of 40-150 s) and the background disturbances. Characteristics of the expansion phase determined here include the following: (1) Plasma thermal pressure and the magnetic pressure change exactly out-of-phase. The intensity of the energy flux is stronger in the direction parallel to the magnetic field than in the direction transverse to it. The plasma fluid clearly exhibits the diamagnetic properties; (2) Characteristics are seen on almost all time scales relevant to substorms (both in the Pi2s and background disturbances), and in almost all of the 139 examples. The substance of magnetotail Pi2 is the slow MHD wave, and the nature of background disturbances indicates slow MHD disturbances.

SM71A-0563 0830h POSTER

Forecasting the Global and Multi-scale Features of Magnetospheric Dynamics During Substorms

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The magnetospheric dynamics during substorms reveals both globally coherent and multi-scale features. The coherent nature of magnetospheric dynamic is evident in a variety of large-scale processes such as plasmoid formation and ejection, large-scale convection, global current systems. However, a number of small-scale substorm phenomena such as MHD turbulence, pseudo breakups, BBFs, etc. have multi-scale nature, viz. they have broad band power spectra in a wide range of perturbation scales. To model such a complex dynamics a combined model STADY is proposed. The model is derived directly from solar wind (VBs) and geomagnetic indices (AL) data using techniques of nonlinear dynamics and statistical physics. The coherent component of magnetospheric dynamics is modeled with the use of local-linear filters (LLF) and yield accurate iterative predictions of the main trend of AL data. However, due to the high dimensional nature of the small-scale component of magnetospheric dynamics LLF fail to predict the abrupt variations and sharp peaks in the data. To model the high dimensional remainder of the time series the probabilistic approach is used. In STADY the probability distribution function of AL-VBs data is calculated in the reconstructed input-output embedding space which yields the range for a predicted AL as well as the likelihood for each value in the range.

SM71A-0564 0830h POSTER

Multi-scale Properties of Solar Wind - Magnetosphere Coupling During Substorms

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The global features of the magnetosphere during substorms is well known from many studies based on observations, modeling and simulations. These arise from processes such as plasmoid formation and ejection, global convection, etc. The analysis of the time series data using nonlinear dynamical techniques has characterized the global dynamics in terms of low dimensional behavior. On the other hand the multi-scale features evident in the power law distribution of many physical variables are not well understood. This property arises from physical processes such as MHD turbulence, bursty bulk flows, current disruption, etc. and are characteristic of open systems in general. These two aspects of the coupled solar wind - magnetosphere are studied by reconstructing a phase space from the time series data such that the trajectories in this space adequately describe the dynamics. The global features, obtained by an averaging of the dynamical trajectories, are described in the mean field manner and are represented by a first order phase transition. The multiscale substorm activity has features of second-order phase transitions and is characterized by a critical exponent. The power law nature of the the multi-scale behavior then arises from the critical behavior associated with the sudden transitions in the magnetosphere during substorms. The probability distribution functions computed for differnet states show the existence of a two-state system, with the transition between these states exhibiting multi-scale properties.

SM71A-0565 0830h POSTER

Using Branch Prediction and Speculative Execution to Forecast Space Weather with a Cluster of Standard PCs

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Branch prediction and speculative execution consist of making probabilistic predictions about the likely near-term evolution of the near-Earth space, and distributing among the cluster machines simulations that assume each of the probabilistically predicted outcomes as initial conditions. As the near-Earth space evolves and real-time satellite data get assimilated into the algorithm, some of the speculatively executed simulations will be proved wrong. At that point the machines that were executing them will be reassigned either to new lines of speculative simulation, or to increase the processing power devoted to more promising simulations already executing. Branch prediction and speculative execution have been very successful in the design of microprocessors, allowing CPUs to attain average processing speeds much higher than linear code execution would permit.

SM71A-0566 0830h POSTER

A cumulant-based statistical analysis of the magnetospheric response to the solar wind input

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It is well known that the magnetospheric response to the solar wind is nonlinear. In this work, we characterize the nonlinear dynamics underlying the evolution of the Kp index, given solar wind magnetic field and plasma input, using a nonparametric cumulant-based statistical approach. We examine the underlying dynamics of the system, the temporal statistical dependencies, the degree of nonlinearity, and the rate of information loss. A practical example of the usefulness of this approach is that it is possible to determine time intervals where the system is most predictable i.e. the information is most significant. By determining which periods are most predictable it would be possible to avoid training a neural network on irrelevant noise that would normally spoil the network. This approach also has the advantage that it is reliable even in the case of small data sets and therefore it is possible to avoid the assumption of stationarity, which allows for a measure of predictability even when the underlying system dynamics may change character. Evaluations of several leading Kp prediction models indicate that their performances are sub-optimal during active times. Possible improvements of these models using our results are discussed.

SM71A-0567 0830h POSTER

Revisiting the Alfven-Parker Debate

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In this talk, we will discuss the debate over the use of E = -VxB (MHD paradigm) to describe space plasmas. Alfven (Rev. Geophys. Space Phys., 15, 271, 1977) cautioned against applying this ideal equation to collisionless plasmas on the grounds that fluid description is then not valid. However, Parker (J. Geophys. Res., 101, 10,587, 1996) has incorporated this ideal equation in the MHD fluid theory and argues that his formulation effectively describes space plasma dynamics. To resolve this debate, we turn to first principles. Electric fields in moving plasma and stationary spacecraft frames are related by Epl = Esc + VxB. With Epl = 0, the total magnetic flux is conserved (df/dt = 0) and the electromotive force (EMF) is not induced. Hence, currents and magnetic fields cannot be generated by the plasma and Joule heating vanishes (J* E = 0). Our conclusion is that these conditions imposed by the MHD paradigm restrict Parkers theory to describing only the dynamics of non-dissipative space plasmas that have preexisting currents and magnetic fields. However, inductive and EMF effects are integral to plasma processes that require formation of new currents and magnetic fields (flares, auroras, reconnection, shocks, magnetic storms and substorms). For the physics to be self-consistent, these dynamical problems must be examined with non-vanishing Epl, no matter how small Epl is.

SM71A-0568 0830h POSTER

Global, Three-Dimensional Hybrid Code Simulation of the Earth's Magnetosphere: Field and Particle

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This paper describes the development of three dimensional global scale hybrid code on a massively parallel computer to simulate the Earth's Magnetosphere. The code calculates the interaction of fully kinetic ions and a massless electron fluid with the magnetic fluid. The code uses generalized curvilinear coordinates. This makes it possible to achieve high spatial resolution in regions near the Earth, in the plasma sheet and near the magnetopause, while using a much lower density of grid points in the magnetotail lobes where the resolution is not needed. The code also includes a fluid ion component to approximate the cold ionospheric plasma that spatially overlaps with the discrete particle component. A unique feature of the code is the use of multiple, discontinuously connected coordinate patches to span the magnetosphere in a way that includes the ionospheric shell as a boundary surface. The present paper describes the particle pushing and field algorithms used in the code in this context. The code will be used to study substorm growth and expansive phases.

SM71A-0569 0830h POSTER

Three-Dimensional Simulation of Current Sheet Thinning During the Substorm Growth Phase

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We have studied the formation of thin current sheets during the growth phase of magnetospheric substorms. Our approach is based on the conservation of entropy on magnetic flux tubes during the slow quasi-static evolution of the magnetosphere. The growth phase is initiated by the erosion of closed dayside magnetic flux. This flux is replenished by convection of closed magnetic flux from the near-Earth tail region to the dayside. However, the entropy constraint implies that this reservoir of magnetic flux is finite [since no flux can be convected from the mid- and far-tail region (*Erickson and Wolf*, 1980)]. We argue that the depletion of flux in the near-Earth tail region leads to the observed current sheet thinning. We use three-dimensional MHD simulations to model the formation of the thin current sheet in the near-Earth region during the late growth phase of substorms.

SM71A-0570 0830h POSTER

Hall MHD Ballooning Instability in the Magnetotail: A Possible Mechanism for Substorm Onset

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The ballooning instability of the magnetotail is considered within the framework of the Hall MHD model. In particular, the extent to which Hall MHD effects modify the ideal MHD ballooning instability is explored extensively. It is shown that Hall MHD effects primarily enter the stability analysis through changes in the plasma compressibility. In addition to modifying the growth rate of the compressible ideal MHD mode, Hall effects also introduce a new instability, called the entropy interchange instability which is a variant of the well-known ion temperature gradient instability. The theory is applied to two types of magnetotail configurations—analytic equilibria [Voigt 1986], and more realistic magnetotail configurations containing thin current sheets obtained from Hall MHD simulations of substorm dynamics [Ma and Bhattacharjee 1998]. It is shown that Hall effects introduce an oscillatory component to the purely growing MHD instability, consistent with the westward traveling surge seen in current disruption events at near-Earth distances. Even in the presence of line-tying constraints imposed by the ionosphere, the ballooning instability of collisionless thin current sheets continues to be robust, and a viable candidate for substorm onset.

SM71A-0571 0830h POSTER

Ballooning Modes and Sustorm Onset

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Based on the AMPTE/CCE observations [Cheng and Lui, GRL, 1998], a low frequency instability with period on the order of 1 min is observed about 2-3 minutes before the substorm onset and is identified as a kinetic ballooning instability. Kinetic effects such as ion gyroradii, magnetic drift, and trapped electrons can strongly enhance the beta threshold over that of ideal MHD ballooning mode theory prediction. However, the ballooning instability threshold based on the ideal MHD model in realistic magnetospheres is still unresolved. Here, we present the stability property of ideal MHD ballooning modes in numerical 3D magnetospheric equilibria with thin current sheet. The coupling effects between perpendicular and parallel (compressional) perturbed magnetic fields are included. The calculations make use of numerical 3D magnetospheric equilibria including thin current sheet by assuming pressure to be constant along a field line. We then, estimate the stability threshold including kinetic effects and compare with observations.

SM71A-0572 0830h POSTER

Tail Vortex Flows During Substorms

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We have used a global magnetohydrodynamic simulation coupled with in situ observations in the magnetotail and auroral images to investigate magnetosphere-ionosphere coupling during a magnetospheric substorm on December 22, 1996. The first intensification of this large multiple onset substorm occurred at 1251 UT with a second intensification at 1316 UT. The substorm sequence started when an interplanetary magnetic field with southward and dawnward components reached the dayside magnetosphere. About an hour later the reconnection rate increased at an existing neutral line located near midnight at about 25 R_E from Earth. A narrow channel of high-speed earthward flow from the neutral line caused a series of vortices to form near the Earth. The first vortex formed on the dawnside; its tailward flow created a flux rope that was pinched-off into a plasmoid by internal reconnection and that was observed on Geotail. Shortly afterward, the midnight reconnection flow formed a second vortex on the duskside. This vortex was associated with the onset of auroral emissions observed on Polar, and its tailward flow created a thin post-break-up current sheet. During the 1316 UT intensification flow vortices again formed in the near-Earth tail at onset. On the duskside, the vortex's tailward flow blew open the plasma sheet and allowed the tail neutral line to develop near 10 Earth radii. In this talk we will investigate the relationship between the convection in the magnetotail and phenomena in the polar ionosphere. We will compare the energy flux deposited in the ionosphere from the simulation with that inferred from measurements by the Polar spacecraft. We will also examine the relationship between the flow vortices and ionospheric convection, and evaluate the suggestion that ionospheric line tying may have caused the flow reversal that formed the vortices.

SM71A-0573 0830h POSTER

Properties of the Plasma Sheet Turbulence During Substroms Observed by Interball/Tail Satellite.

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Fluctuations of the plasma bulk velocity across the plasma sheet are studied using single-point measurements form the Corall instrument onboard the Interball-Tail satellite. Several hour-long intervals of continuous data corresponding to the different phases of isolated substorms are analyzed. The plasma sheet flow appears to be strongly turbulent, i. e. is dominated by fluctuations that are unpredictable. However it was found that the level of turbulence increases significantly after the substorm expansion phase onset and descreases slowly to the initial level during the recovery phase. Corresponding Eddy diffusion coefficients were obtained as a function of the autocorrelation time and rms velocity.

SM71A-0574 0830h POSTER

A Comparison of Cluster Observations of the Tail Current during Substorms and Quiet Times

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On August 15, 2001 the Cluster spacecraft passed through the plasma sheet at 0100 LT at a distance of 18 Re. During the passage, three substorms were observed. Each substorm was characterized by an increase in Bz or dipolarization. The first and last substorms were also accompanied by strong earthward flows. We utilize observations from the four fluxgate magnetometers to calculate the gradient of each component of the magnetic field. From the gradient matrix we determine the divergence and curl of the magnetic field, and convert the curl to current density. We find that the integral of the observed current density is too small by at least a factor of two to account for the measured lobe field. We then use a static Harris model of the magnetic field and again show that the measured current density is less than expected. Finally we use a nonlinear fitting procedure to calculate the thickness (h), and location (z0) of a Harris sheet. The time series for these parameters show systematic variations with the phase of a substorm. The location of the neutral sheet moves away from its statistical location during the growth phase and recovers in the expansion/recovery phase. The thickness of the current sheet systematically decreases prior to the onset of major expansions and increases afterwards. These temporal changes in the current sheet can be taken into account by plotting the current density scaled by the current sheet thickness (0hJy) against the normalized spacecraft location ((z-z0)/h). The resulting plot shows that Ampere's law is correct, and there is sufficient current to account for the observed lobe field. We have also carried out the same analysis for a quiet crossing on September 22, 2001. The current sheet was quite thin (h 0.5 Re) during this rapid crossing and only the growth phase of one substorm occurred during the passage. Again the measured current apparently does not account for the lobe field. However, a time varying fit of a Harris sheet again demonstrates that Ampere's law is satisfied.

SM71A-0575 0830h POSTER

How are storm-time injections different from nonstorm-time injections?

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One of the key elements of storms and substorms is the injection of energetic particles into the region of near geosynchronous orbit, that is, the sudden flux enhancement in the energy range of tens to hundreds of keV. This paper reports the observational results on how such injection features are different during storm times compared to nonstorm times. We particularly focus on the difference between proton injections and electron injections during storm times. Based on a number of storm time injection events that meet our strict selection criteria, a notable difference is found between proton injections and electron injections in the spectral dependence of the flux enhancement averaged over the first 30 min after the injection onset: The average flux enhancement of protons tends to be bigger at higher energy channels than at lower energy channels, but electron injections exhibit opposite behavior for the energy-spectral dependence of flux enhancement, i.e., flux enhancement decreasing with energy. We show that this feature is almost unique only for the injection events during the storm main and early recovery phase. It is suggested that any successful acceleration mechanism intended to model storm time injections should be able to explain this difference between proton injections and electron injections.

SM71A-0576 0830h POSTER

IMF Control of Auroral Dynamics during a Magnetic Storm

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The Far Ultraviolet Imager system on the IMAGE satellite obtains separate images of the proton and electron auroras. Previous experiments have shown that following the passage of interplanetary shocks, auroral activity typically progresses from near noon to near midnight in a period of a few minutes. As shown by IMAGE-FUV, the proton auroras are more intense in the dusk sector following the shock while the electron auroras are more intense near midnight. However, once substorm activity begins, the two types of aurora generally show the same morphology. In a particular case, on September 25, 2001, a shock was followed by several large substorms. Throughout this time period, IMF By remained strongly negative. As a result, a super-rotation of all auroral forms, oval as well as polar cap, was observed. This continuous counterclockwise motion maintained an angular velocity of 1-2 degrees per minute throughout the event. Co-incident with the arrival of a second shock, By rotated to near 0, and the auroral rotation stopped. During the event, localized bright aurora indicative of a reconnection region was observed in the cusp, while a second bright auroral spot moved from the nightside across the polar cap and back to the cusp region. Its motion in local time corresponded with cusp motions that were correlated with changes in By such that both spots moved simultaneously either westward or eastward. This second spot is possibly associated with a neutral line that is located far down the tail and moves along the boundary of a magnetospheric lobe cell as the event progresses.

SM71A-0577 0830h POSTER

A Small Postmidnight Substorm During IMF Bz+ and By+ Conditions – Joint Optical, Radar, Magnetic and Satellite Observations

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Multi-instrument observations of a small postmidnight substorm event during a period of IMF dominated by Bz+ and By+ conditions on October 9, 2000, showed the substorm structure with high time resolution. Three optical intensifications and Pi2 bursts occurred. The last and strongest Pi2 burst was associated with an expansive phase (EP) onset, characterized by a 100 nT magnetic bay at Fort Churchill and an auroral breakup in which the 630 nm emissions moved poleward about 2.5 degrees. About 11 minutes after the first EP onset, a second stage of auroral brightening occurred. For each of the three initial optical intensifications, there was an eastward-moving discrete azimuthal structure. SuperDARN HF radar line-of-sight velocity measurements revealed eastward electric fields within each Pi2 wave train. The observations are interpreted as resulting from the drift-Alfven-ballooning (DAB) mode instability at near-geosynchronous orbit (NGO) locations. Within the NGO drift waves, regions of charge separation led to electric fields and field-aligned currents (FACs) of alternating direction. The ionospheric reflection of Alfven wave energy likely generated the Pi2 pulsations observed on the ground. The multi-instrument ground observations agree quite well with the substorm onset scenario based upon CRRES satellite observations by Erickson et al. [2000]. There was a single, relatively confined (4 hour in MLT) counterclockwise convection cell during the growth phase and EP onset. A clearly defined vortex at its center defined the center of the downward FAC. This vortex, initially northward of the optical aurora, moved eastward and then suddenly southward just prior to the EP onset. At that time, the FAC structure was typical of the substorm current wedge (SCW). Reasons for the convection cell motion and SCW development are discussed.

Erickson, G. M., N. C. Maynard, W. J. Burke, G. R. Wilson, and M. A. Heinemann, Electromagnetics of substorm onsets in the near-geosynchronous plasma sheet, J. Geophys. Res., 105, 25265, 2000.

SM71A-0578 0830h POSTER

Correlation of plasma and field behaviors in the near-Earth magnetotail with substorm injections

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We have investigated statistically correlation of plasma flows, energization, and field variations observed by the Geotail spacecraft with particle injections observed at geosynchronous orbit. For this study, we visually inspected both Geotail and the Los Alamos National Laboratory (LANL) geosynchronous satellites data during Apr., 1995 Mar., 2001 and have identified 50 conjunction events in which Geotail observed the near-Earth plasma sheet (-5 Re $>$ X $>$ -17 Re) when LANL observed dispersionless injection of energetic particles at geosynchronous distance on the nightside. We have made a superposed epoch analysis of plasma and field variations in the near-Earth plasma sheet by referring to the time of the associated dispersionless injections. The result is that, in all of the cases where Geotail and LANL are located closely in the dawn-dusk direction ($|dY| < 3$ Re), Geotail observed a gradual |Bx| increase prior to the injection time and then observed a sharp decrease in |Bx| as well as a rapid Bz increase around the injection time. These field signatures are consistent with the field stretching during the growth phase and subsequent dipolarization associated with a substorm onset. In addition to the field signatures, flux enhancements of energetic ($>$30 keV) ions and electrons are also observed in most of the cases when Geotail reenters the plasma sheet as expected from the thickening of the plasma sheet after onset. On the other hand, in the cases in which Geotail and LANL are separated azimuthally from each other ($|dY| > 3$ Re), the |Bx| increase prior to the injection time is not seen clearly and the Bz increase tends to be less sharp and smaller than those in the former cases. This result suggests that the thinning and subsequent thickening of the plasma sheet occurs more markedly at the injection sector and such a change in the field configuration becomes weaker away from there. We have also examined the spatial evolution in the X-Y plane of the region of dipolarization and their relative timings in detail. It is found that a substantial part of dipolarization events occur first around the injection sector about one minute before the corresponding injections, and subsequently they propagate azimuthally fairly fast ($\sim$ 1 min) toward the other local time sectors.

SM71A-0579 0830h POSTER

Four spacecraft study of dipolarization-like signatures at the lobe/plasma sheet interface

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Observations from the four Cluster spacecraft are utilized for a study of magnetic dipolarization-like events. The focus is on measurements obtained at the lobe/plasma sheet interface in the midnight sector at a distance of about 15 Re downtail. From this position we observe the dynamics of the reconfiguration of the tail magnetosphere associated with the substorm expansion phase.

Empirical observations at Cluster related to these events include bursty bulk flows, dipolarization-like magnetic field changes, a sudden reappearance of the plasma sheet with a significant increase in particle energy relative to the prior situation as well as strong E-field fluctuations. These events are transient in nature and often appear in multiple trains. The time periods in between the events, typically a few hours, are characterized by a gradual decrease of plasma energy and stretching of the magnetic field at the Cluster location.

We plan to discuss the relationship between these transient observations and substorm onset timing. The timing among the signatures observed at Cluster varies between events. This fact will be utilized in the discussion of the physics of these events. In addition, multi-spacecraft techniques will be used to determine the direction of boundary motions associated with the events.

SM71A-0580 0830h POSTER

The Substorm at 05:45 on October 13, 2001 Observed From the Ground, and the LANL, GOES, Polar, and Cluster Satellites

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The substorm at 05:45 was not the first, last, or most intense of those observed during the first half of October 13, 2001. However the configuration of platforms noted in the title was excellent for obtaining a comprehensive view of the initiation and evolution of a substorm. The combination of Canopus ground magnetograms and Polar VIS images identified onset at 05:45:02 +/- 00:00:22 west and south of Ft. Churchill, Canada. The closest satellite, Polar, was located near geosynchronous altitude at 23:00 MLT. Polar was sampling magnetic fields and plasmas characteristic of the outer plasma sheet before 05:45 UT and characteristic of the central plasma sheet after 05:45 UT. Polar magnetometer data from below the magnetic equator and GOES 12 magnetometer data from above the magnetic equator suggest that the main currents were flowing tailward of near-geosynchronous altitude. The Cluster satellites were located at 19 Re and 21:00 MLT on the dusk side of the magnetotail. A coherent dispersion feature in the plasma at several of the Cluster spacecraft was observed at 05:36 UT, when the Bz (GSM) component on all four spacecraft began decreasing. The Bz component was negative on all four Cluster spacecraft from 05:42 to 05:55 UT.

We will present these observations and a time line of events derived from them. We will discuss how these observations agree and disagree with current ideas of the initiation and global evolution of substorms.

SM71A-0581 0830h POSTER

Convection Transients in the Polar Cap During Substorms

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We report transient convection signatures during substorms, seen by the Cluster satellites at about 7 RE on field lines mapping to the central polar cap, using data from EDI and FGM on Cluster, and WIC on IMAGE. In these events, typically lasting 1-3 minutes, the Ygse component of electric field (corresponding to anti-sunward polar cap convection) drops from a quasi-steady value of a few mV/m, to zero or slightly negative values, and then returns to the quasi-steady level. At the same time the magnetic field shifts to a less "tailward" direction. We interpret these events as part of the global reconfiguration associated with substorms.

SM71A-0582 0830h POSTER

Correlation Between Ground-Based Observations of Substorm Signatures and Magnetotail Dynamics.

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We present a substorm event study combining Cluster and ground-based instrumentation. For this event ground-based magnetograms show a substorm onset and two separate substorm intensifications over Scandinavia, at the time located in the pre-midnight sector. During the substorm Cluster is located in the southern plasma sheet at a downtail distance of 18.5 Re. For all the substorm signatures seen on ground, corresponding plasma sheet drop-outs and re-entries of all or individual spacecraft of the Cluster constellation are observed. In general, plasma sheet drop-outs are assumed to be due to plasma sheet thinning/thickening and/or to magnetotail flapping. However, in the literature there has been some disagreement on both spatial and temporal characteristics of plasma sheet thinning and thickening during substorms. We therefore investigate the causes for the plasma sheet drop-outs for this event, which at first glance appears to show plasma sheet thinning at substorm onset, contradictory to the present standpoint in the literature.

SM71A-0583 0830h POSTER

Quantitative relationship between substorm auroral intensity and magnetotail Stretching

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Magnetic field line stretching is a key feature in the near-Earth magnetotail during the growth phase of a substorm. The stretched field line ceases abruptly at the onset of substorm and returns to its original dipole-like configuration. The degree of field line stretching is controlled by the solar wind-magnetosphere coupling and may be used as an indicator of the amount of energy available for substorms to occur later. The purpose of this study is to investigate relationship between substorm auroral intensity and magnetic field stretching and to find a practical way of predicting energy dissipation during substorms. We parameterize the intensity of substorms by the total energy deposition from particle precipitation inferred from auroral luminosity in the long wavelength bands of N2 Lyman-Birge-Hopfield auroral emissions (160 - 180 nm) from the Polar ultraviolet imager. The stress of the magnetic field line in the tail is inferred from the magnetotail stretching index, b2i, which is identified by DMSP as the ion precipitating energy flux maximum and is in good relationship with the magnetic field inclination at geosynchronous orbit. We will present quantitative relationships between the two quantities and discuss potential uses of the result in substorm intensity forecasting.

SM71A-0584 0830h POSTER

Growth–Phase Auroral Arcs and Ionospheric Currents

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Perhaps the most widely–accepted aspect of magnetospheric substorms is that onset begins with the brightening of a pre–existing auroral arc. The presence of this arc during a substorm growth phase implies that a region with enhanced coupling between the magnetosphere and ionosphere exists *before* onset. In fact, a growth–phase arc invariably marks the region where onset will occur and basically, it can act as a predictor of at least the location of an impending substorm. Stated somewhat differently, the properties and context of a growth–phase arc form an important part of the initial conditions for substorm onset, leading to the question "why do substorms preferentially release energy along field lines that map to these arcs"? Previous studies examined the nature of these arcs and have shown that they are typically stationary and that the associated electron precipitation energy flux increases gradually. In this study, we investigate the relationship of growth–phase arcs to ionospheric currents on both small and large scales and discuss the arcs in relation to region 1,2 currents as well as the substorm current wedge.

SM71A-0585 0830h POSTER

Electrodynamics during substorm growth phase.

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We presents results from a statistical study of the auroral electrodynamics during the growth phase of classical bulge-type auroral substorms. Electric field, magnetic field perturbations, particle precipitation, and ion-drift data have been used from 27 Dynamics Explorer 2 and 10 FAST auroral oval crossings. Their magnetic local time (MLT) distribution is fairly uniform covering the interval 18-06 MLT. Global auroral images from the Dynamics Explorer 1 and the Polar satellites were used to select substorms displaying a typical bulge-type auroral emission pattern. Low altitude satellite passes were selected if these occurred prior to the optical onset and after the southward turning of the IMF Bz. Post-midnight and from 18-21 MLT

we find a simple two sheet field-aligned current configuration. In the 21-24 MLT region a more complex current configuration is seen. In this local time region an overlap of the eastward and westward auroral electrojets are found consistent with the more complex field-aligned current pattern. Height integrated Pedersen and Hall conductivities are typically in the 5-20 mho range indicating an increase from quiet time.

SM71A-0586 0830h POSTER

The Observation and Simulation of Substorm Related Chorus Events

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Substorm-Related chorus events (SCE), VLF emissions with upper and lower cutoff frequencies increasing over time scales 10 min, have been identified in data from the SANAE base in Antarctica. These emissions, occurring predominantly in the midnight-dawn local time sector, have been shown to be a signature of the magnetospheric substorm expansion phase[1], and are thought to arise from cyclotron resonance between whistler mode waves and energetic particles injected around midnight.

The guiding-center motion of the injected particles is influenced by energy-dependent azimuthal drift (due to the gradient and curvature in B) and energy-independent radial ExB drift. The results of simulations indicate that the relative importance of these two drifts in determining the temporal evolution of the SCE is local time dependent. These simulations also suggest that the model used to describe the pre-dawn SCE might be applicable to another class of VLF events observed mainly in the dawn-noon sector.

References [1] A. J. Smith, M. P. Freeman, and G. D. Reeves. Postmidnight VLF chorus events, a substorm signature observed at the ground near L = 4. Journal of Geophysical Research, lOI(All):24641-24653, November 1996.

SM71A-0587 0830h POSTER

The temporal evolution of Whistler-mode waves; the relationship between space based observations, ground based observations and energetic electrons.

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One of the defining characteristics of substorm onset is the injection of energetic electrons. The observed evolution of the energy spectra of these injected electrons has been well documented and is understood in terms of energy dispersed gradient-curvature drifts. A less defining, but often observed, characteristic is the enhancement of equatorial whistler mode wave amplitudes. Whilst studies have categorised the occurrence of these waves in terms of location and geomagnetic activity levels, to our knowledge no attempt has been made to document and explain the evolution of the whistler frequency spectrum as has been done with injected electrons. In this paper we address this problem by examining 22 case studies of CRRES observations of substorm enhanced whistler mode waves. These observations were made close to the geomagnetic equator and between 02:00 and 06:00 MLT. The frequency of the enhanced whistler waves is seen to vary strongly with magnetic field strength and for this reason we re-plot the data in terms of the equivalent parallel resonant energy of an electron in first-order cyclotron resonance with a wave of a given frequency. We can interpret our findings in terms of the injected electron population and resonant ellipses in velocity space. Furthermore, we relate the findings of our study to observations of ducted waves seen on the ground as Substorm Chorus Events (SCEs) and conclude that the frequency dispersion seen in SCEs is dominated by electric field effects.

SM71A-0588 0830h POSTER

Energetic Ion Entry into the Magnetosphere During Storm Intervals

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During magnetic storms the magnetosphere is subjected not only to strong interactions with the solar wind and the interplanetary magnetic field (IMF) but can also be bombarded by energetic particles (SEP) of solar and interplanetary origin. For this study, storm time intervals with high SEP fluxes will be studied by using magnetohydrodynamic (MHD) simulations and particle tracing calculations. We have found that SEP entry in a slowly varying magnetosphere is determined by the magnetospheric configuration, which is controlled in turn by the IMF. The questions we will address in this study are how and where energetic (100 keV 50 MeV) protons enter the highly stressed storm time magnetosphere, and if rapid time variations in the solar wind and the IMF augment the entry of the particles. We have performed MHD simulations of storm intervals by using solar wind and IMF time series measured by upstream spacecraft. The upstream boundary conditions for the MHD simulations are based on these time series. A large number of test ions are launched in the time-dependent electric and magnetic fields from the MHD simulation. The accessibility of magnetospheric regions to these ions as well as precipitation and trapping in the model is then evaluated.

SM71A-0589 0830h POSTER

Storm Dependence of Occurrence Probability and Spatial Distribution of Upstream Events: Its Implication for Their Origin

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Increases of high energy (> 50 keV) particle flux, called upstream events, have been reported but their origin is yet to be identified. We examined how upstream events depend on geomagnetic storms, by using ion flux data acquired by the ICS sensor of the EPIC instrument on board the Geotail spacecraft.

In an analysis using ion data from the EPIC P3 channel (77.3 keV − 107.4 keV), we identified upstream events to be flux enhancements by a factor of greater than 100 occurring in less than 10 minutes in the upstream region defined by $X_{GSE} > 0$ and $15 < \sqrt{X^2_{GSE} + Y^2_{GSE}} < 35$ Re. Observations are sorted into four radial distance bins and eight local time bins, resulting in each mesh has a radial size of 5 Re and a local time of 1.5 hours. We calculated the occurrence probability, which is the total duration of events divided by traveling time of the satellite, in each mesh. We also analyzed its dependence on the SYM-H index, which is thought to indicate a geomagnetic storm activity. The probability was about 0.05 regardless of satellite location when the SYM-H was larger than zero (no storm). By contrast, the probability reached 0.2 to 0.3 in the dawnside and about 0.1 in the duskside when the SYM-H was below −30 nT (storm time). This dawn-dusk asymmetry was stronger than that derived from all events.

We have also examined carbon-nitrogen-oxygen (CNO) ions detected by M3 channel (221.4 keV − 275.2 keV) during the upstream events. Plots of M3 channel data show that background flux of CNO ions was less than one count in the upstream region. We consider ion counts more than three as a flux enhancement of CNO ions, because the lower limit of the uncertainty for three counts (2.42) is larger than the upper limit of the uncertainty for one count (2.00). The enhancement was observed in almost all the upstream events. The rate of detecting the enhancement reached more than 80 %.

These statistical results indicate that particles of magnetospheric origin are observed more frequently in the upstream region when a storm occurs in particular. We conclude that energetic particles can leak out of the magnetosphere and travel toward the dawnside of the upstream region when a storm occurs. We propose that this leakage process is a possible decay mechanism of the storm-time ring current.

URL: http://www-step.kugi.kyoto-u.ac.jp/~keika/

SM71A-0590 0830h POSTER

Low Frequency Weak Signals Detected in Storm Sudden Commencements: Is There a Correlation With the Solar Magnetic Cycle?

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A series of storm sudden commencements (SSCs) is analyzed during the period from 11 to 22 solar cycles using a Dynamical Spectrum technique combined with the Maximum Entropy Method. Our main interest is to study the low frequencies range. Several periodicities were identified at 22y, 18.6y and 30y approximately. Not all the signals are present in the whole period. We believe that they could be associated to the magnetic solar and Gleissberg cycles and possibly with another intermittent solar phenomena. Additionally and comparing with sunspot numbers a sunspot series for the same period has been analyzed with the same methods. Results between SSCs and sunspot numbers show similarities as expected as well as some marked differences also. They will be discussed in the context of their possible origins.

SM71B MCC: 105 Sunday 0830h

Magnetosphere-Ionosphere Coupling I

(joint with SA)

Presiding: **P Song,** University of Massachusetts Lowell**; T I Pulkkinen,** Finnish Meteorological Institute

SM71B-01 0830h INVITED

The Unreasonable Success of Magnetosphere-Ionosphere Coupling Theory

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The description of plasma dynamics on the basis of self-consistent coupling between magnetosphere and ionosphere, as first systematized in the early 1970's, is arguably one of the most successful theories in magnetospheric physics. It accounts for the pattern of magnetospheric convection at auroral and low latitudes, the distribution of Birkeland currents, and the dependence on changing orientation of the interplanetary magnetic field. It can incorporate assumed effects, e.g. of particle sources or conductance variations, to almost any degree of complexity at moderate cost in additional computing effort (compare the levels of physics included in advanced versions of the Rice Convection Model and of global MHD simulations, respectively). Such success combined with relative simplicity, however, is possible only because the theory has limited itself in significant ways. It treats the system in effect as doubly two-dimensional: height-integrated ionosphere plus field-line-integrated magnetosphere, with the background magnetic field structure treated as known or derived from some empirical model. It assumes that the system is always in slowly evolving quasi-equilibrium and deals only with time scales long compared to wave propagation times. Hence the theory is not easily applied where genuine 3D aspects (e.g. height and field-line dependence), poorly known or variable magnetic fields (e.g. open field lines), or transient responses e.g. to rapid solar-wind changes are important, and it is intrinsically incapable of describing explosive non-equilibrium developments such as substorm onset. Possible extensions