Earth's magnetotail during the magnetospheric substorms. We use the fully three-dimensional Imaging Electron Spectrometer (IES) sensors to examine both streaming (unidirectional) and trapped (pancake or cigar) anisotropies during the course of substorm expansion phase onsets and during substorm recovery phases. Our visualization software allows us to identify and track boundary regions and current sheet structures using the unique CLUSTER constellation. We present several detailed analyses of substorm events in August 2001 and in July 2002.

SM31E-05 1120h

New Behavior of X lines Inside a Thick Near-Earth Plasma Sheet and Evolution of the Reconnection into Lobe Merging

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It is proposed that short-lived reconnection can occur in the center of a thick near-earth nightside plasma sheet and evolve into lobe merging. For reconnection to occur there must be outflow on both the earthward and tailward sides of an X line. The outflow on the earthward side is provided by the well-known azimuthal convection around the earth. The inner bondary of azimuthal convection is at the Alfven shielding layer, and the outer boundary is at the transition to flux tubes which are too tail-like to convect to the dayside due to the geometry of the magnetosphere. The X line is located at the outer boundary of this azimuthal convection channel; hence reconnection creates azimuthally convecting flux tubes from tail-like flux tubes by removing plasma and energy. The outflow from the tailward side of the X line occurs by earthward motion of the X line (that is there is tailward flow in a reference frame moving with the X line) and the reconnected flux forms a magnetic island on the tailward side. It is argued that the above type of reconnection is suppressed during the growth phase of substorms because the azimuthal outflow on the earthward side is blocked due to the changing topology. Both the shrinking of the dayside magnetopause and the increasing tail-likeness of nightside field lines support the idea that the outer boundary of the azimuthal convection channel moves earthward away from any newly-forming X line. When the rate of change of the topology becomes small, due to either a northward turning of the IMF or an approach to a steady-state, the above nightside reconnection is no-longer suppressed. The expansion phase commences with reconnection of the above type (earthward propagation of the X line and formation of a magnetic island). Two possible options for the further development of the expansion phase are considered. In the first, the above reconnection at the X line eats through the plasma sheet and the configuration evolves into the usual lobe-merging picture. In the second, the earthward-moving X line reaches the Alfven layer. The magnetic island coalesces with nearer-earth field lines creating a rapid inflow into the nightside and producing the outflow conditions for a second X line to form near the tailward end of the island. Reconnection at this second X line eats through the plasma sheet and the configuration evolves into the usual lobe-merging picture.

SM31E-06 1135h

Wind Observations of Asymmetric Magnetic Reconnection in the Distant Magnetotail

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Unlike dayside magnetopause reconnection, reconnection in the magnetotail is usually considered to be symmetric, involving the southern and northern lobes with similar plasma and field properties. The reconnection layer with such symmetric boundary conditions consists of a pair of slow shocks that compress, heat and accelerate the incoming (lobe) plasmas. The resulting outflow plasma jets are typically sub-Alfvenic. Here we report observations of asymmetric reconnection in the distant tail (at $X_{GSE} \sim -90$ R_E) between a nearly empty lobe and one that is loaded with plasma (the mantle). Such conditions occur when the IMF B_y component is large. This asymmetric reconnection configuration is somewhat similar to the dayside magnetopause. The observed reconnection jet is Alfvenic and the plasma density in the outflow region (the plasma sheet) is intermediate between those of the lobe and the mantle.

SM31E-07 1150h

Near-Earth Reconnection Confined in the Plasmasheet during the Substorm Growth Phase: A Study of the November 24, 1996, Event

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The present study examines a substorm event of November 24, 1996, with an emphasis on magnetic field and plasma flow measurements in the magnetotail during the growth phase. The unique and most intriguing feature of this event is a systematic change of the flow direction from earthward to tailward observed by the Geotail satellite at X = -21 Re. Good correlation between Vx and Bx suggests that observed variations of the flow velocity were spatial rather than temporal and that the earthward and tailward flows lasted at least 9 and 5 min, respectively. The signs of Bz and By variations also changed systematically along with the sign of Vx, which suggests that the observed flow reversal was caused by the earthward movement of a neutral line. This neutral line might be formed in association with a preceding pseudobreakup, and it is inferred that the associated reconnection did not reach the lobe magnetic field. Interestingly, during the interval of the flow reversal, other satellites observed typical growth-phase features. Geosynchronous magnetic field continued to be stretched in the midnight sector. The Interball and IMP-8 satellites observed continuous increase of the lobe field strength at X = -20 and -34 Re, respectively, in the premidnight sector. It is therefore concluded that the tail current intensification during the growth phase is a global process, whereas the near-Earth reconnection is a local process and at its early stage, it can proceed independently from the overall storage of the tail magnetic energy.

SM31E-08 1205h

The Electron Diffusion Region in Component Magnetic Reconnection

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The reconnection of anti-parallel magnetic field is facilitated by the demagnetization of electrons in the inner diffusion region. Inertial effects due to electron bounce motions in the field reversal region have as their macroscopic manifestations nongyrotropies in the electron pressure tensor. The electric field maintained by the intermittent electron acceleration in the inner diffusion region, or, equivalently, by the divergence of the electron pressure tensor, provides the reconnection electric field. In the case of a significant guide magnetic field, however, electron may be magnetized and thus not able to execute bounce motions in the inner diffusion region. As a result, the structure of the diffusion region is quite different from that of anti-parallel reconnection. We will present a detailed investigation of the reconnection layer for component reconnection, based primarily on analytical arguments and supported by particle-in-cell simulations. We will demonstrate that mixing of electron distributions from within and from adjacent to the thin, central electron current layer can provide electron nongyrotropies, with similar macroscopic consequences as in the anti-parallel case.

SM32A MCC: Level 2 Wednesday 1330h

Substorms II Posters

Presiding: **T Hsu,** Institute of Geophysics and Planetary Physics, University of California, Los Angeles**; E L Kepko,** Boston University Center for Space Physics

SM32A-1132 1330h POSTER

Constellation Strategies of the THEMIS Mission From 2006 Through 2008 and Beyond

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The Constellation class mission dedicated to the Time History of Events and Macroscale Interactions during Substorms (THEMIS) is a new NASA Medium Class Explorer (MIDEX) mission to be launched in 2006. Primarily, THEMIS will monitor the onset and evolution of the macroscale substorm instability. Additionally, the production of energetic electrons during storm time in the radiation belts, and the control of the solar wind - magnetosphere coupling by upstream processes at the dayside magnetopause will be investigated. Thus, THEMIS will significantly contribute to our understanding of the solar wind - magnetosphere energy coupling and mass transport. THEMIS combines a fleet of 5 small probes equipped to measure particles and fields together with a set of about 20 ground observatories capable to monitor auroral breakups aligned over Northern America. In order to time and localize substorm onsets THEMIS utilizes conjunctions between the probes on multiple period, near-equatorial orbits with apogees between 10 and 30 Re. These nightside conjunctions will occur near the substorm meridian at times of local midnight of the ground observatories. Three inner probes (∼1day period) monitor current disruption and two outer probes (∼2day and ∼4day periods) monitor lobe flux dissipation. To maintain high recurrence of conjunctions the outer orbits are actively adjusted. Active orbit maintenance will also be used to rearrange the inner probes for dayside observations. In our presentation, we will give a detailed overview of the orbit strategy, which is primarily driven by the scientific goals of the mission but also follows a concept of cost efficiency. We will also evaluate the potential scientific return from the orbit strategy using high-fidelity orbit prediction and common magnetospheric models.

SM32A-1133 1330h POSTER

Survey of Ion Beams Observed Near Substorm Onset by Polar/TIDE in the Nightside Magnetosphere

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We investigate characteristics of ionospheric ion beams before, during, and after substorm onsets in the near-Earth (∼6-9.6 Re) nightside magnetosphere using Polar spacecraft observations and minute resolution AE and Dst indices. The ionosphere continually supplies low energy ions to the plasma sheet. Ionospheric ion outflow increases strongly with increasing geomagnetic

activity and ion transport from the ionosphere is predominantly as beams closely-aligned to the magnetic field. Polar's orbital apogee precession through low latitudes in 2001-2003 permits long-term insitu near-equatorial measurements by the Polar/TIDE ∼0.4-420 eV core plasma ion spectrometer. In a search for spatial and temporal patterns near substorm onset, detailed changes in ion flux anisotropy, average energy, and intensity level will be subject to qualitative and quantitative analysis. Historically, studies have provided average measurements and velocity moment analyses at low ion energies. This study will characterize the range of detailed low energy ionospheric ion flux variations at and around the time of substorm onset.

SM32A-1134 1330h POSTER

Timing of Substorm Signals in the Plasma Sheet and the Auroral Region

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Both the Medium Energy Neutral Atom (MENA) and High Energy Neutral Atom (HENA) imagers onboard the IMAGE spacecraft have been able to observe ENA emissions from the plasma sheet. The MENA observations showed enhanced emissions associated with high solar wind densities during magnetospheric storm intervals. The HENA observations showed decreases of emissions from the plasma sheet following dipolarization associated with substorms. We present forward modeling of ENA emission from the plasma sheet using the Tsyganenko plasma sheet model. In the model it is found that assuming a flow velocity toward the Earth of the plasma sheet plasma has a strong effect on the strength of the modeled ENA flux. Thus the ENA observations are used to infer the timing of the plasma sheet flow relative to the substorm signal seen in the FUV imager onboard IMAGE.

SM32A-1135 1330h POSTER

Investigation of IMF Trigger Structure of Substorms by Using Multi-Satellites Observations

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To understand the magnetospheric substorm, it is necessary to determine whether substorm onset is always externally triggered by the interplanetary magnetic field (IMF) or whether substorm onset sometimes occurs spontaneously as a result of internal processes. 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]. The hypothesis that most or perhaps all substorms are triggered has initiated considerable interest in substorm triggering studies. Over the past decade, several studies have demonstrated that a majority of substorms (60%) appear to be triggered by the IMF. However, 40% of all substorms appear to begin without obvious IMF perturbations. A stasitical analysis determining the average characteristics of triggered and non-triggered substorm in the magnetotail and geosynchronous orbit was performed by Hsu and McPherron [2003]. It was found that the average response in the tail field and plasma suggests no qualitative difference between the two classes of events. However, the magnitude of the response is different. Triggered substorms exhibit a larger response than non-triggered ones. This surprising result has been suggested to be a manifestation of undetected small scale structures in the IMF. Small structures are suggested to have weak driving fields of short duration and hence transfer less energy to the magnetosphere. To investigate this hypothesis, multi-satellite observations are required to eliminate the possibility of missing IMF trigger structures. In this study the authors will use multi-satellite observations to examine how frequently different IMF structure are observed at different locations in the solar wind. Specifically, data from 1977 to 1984 when at least two of the ISEE1, ISEE2, ISEE 3 and IMP8 spacecraft were in the solar wind will be used to examine the size and scale of the structures that trigger substorm onsets.

SM32A-1136 1330h POSTER

Braking of Reconnection-Generated Plasma Flows

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The NENL model of substorms accommodates the observed mapping of the auroral breakup arc to the near-Earth plasma sheet by positing that the disruption in this inner region is triggered by the braking of earthward flows that originate at the NENL in association with plasmoid formation and injection. The substorm current wedge is then associated with the eastward-directed inertial current. This braking of the reconnection generated flow hypothesis is tested via large-scale 3-D particle-in-cell simulations. The simulations are initialized with a dipole field plus distant neutral line configuration in which the neutral line is located at the down-tail boundary of the simulation. This configuration is unstable and leads to the earthward propagation of a high-speed plasma jet. The simulations are used to study the propagation of the jet, its tendency to develop structure in the east-west direction, its interaction with the near-Earth dipolar region, and the subsequent tailward ejection of localized structures on a scale of the order of 0.5 R_E.

SM32A-1137 1330h POSTER

MHD aspects of fire-hose type instabilities

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In a homogeneous anisotropic plasma the magnetohydrodynamic (MHD) Alfvén wave may become unstable for $p_\| > p_\perp + B^2/\mu_0$. Recently a new type of fire-hose instability is found by Hellinger and Matsumoto [2000] that has maximum growth rate occurring for oblique propagation and may grow faster than the Alfvén mode. This new mode is compressional and may be more efficient at destroying pressure anisotropy than the standard fire hose. In this study we examines the fire-hose type ($p_\| > p_\perp$) instabilities based on the linear and nonlinear double-polytropic MHD theory. It is shown that there exist two types of MHD fire-hose instabilities associated with the intermediate and slow modes, respectively, and with suitable choice of polytropic exponents the linear instability criteria become the same as those based on the Vlasov theory in the hydromagnetic limit. Moreover, the properties of the nonlinear MHD fire-hose instabilities are found to have great similarities with those obtained from the kinetic theory and hybrid simulation. In particular, the classical fire-hose instability evolves toward the linear fire-hose stability threshold while the nonlinear marginal stability associated with the new fire hose is well below the condition of $\beta_\| - \beta_\perp = 2$ but complies with less stringent linear stability threshold for MHD slow-mode wave.

SM32A-1138 1330h POSTER

Dynamics of the Firehose Instability in the Central Plasma Sheet

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There is renewed interest in the nonlinear dynamics of the firehose instability in the high beta central plasma sheet. This strong instability produces order unity magnetic fluctuations that propagate up and down the magnetic field line as Alfvenic fluctuations. A new nonlinear model of this instability is presented where the anisotropy parameter $A = \mu_0(p_\| - p_\perp)/B^2$, the dispersion parameter of the ion gyradius over the thickness of the central plasma sheet and the sub-grid scale damping are the three key parameters. When the anisotropy parameter A is a few percent above the critical value of unity, the magnetic turbulence strongly increases. The $\mathbf{E} \times \mathbf{B}$ kinetic energy remains subdominant, so this process gives a direct conversion of plasma energy to magnetic energy. We focus here on mapping out the state space for the different nonlinear states. Depending on the values of A, ρ_i/L_z and the sub-grid scale damping rates, we give examples of weak bursty soliton like states, weakly turbulent wave states, strong turbulence states, and nonsaturating secularly growing states The magnetic turbulence is a good candidate to explain the Pi-2 oscillations seen in association with bursty bulk flows and substorms (Sigsbee et al. 2002). A continual driving up of the parallel pressure anisotropy occurs through the inward convection of the flux tubes with their continuously shortening field line length or the discontinuous shortening with the onset of magnetic reconnection in the geotail. The Lagrangian codes of the Rice group show the firehose instability arising from the magnetic buoyancy effects which is used to explain the bursty bulk flows in Chen and Wolf (1999) and Ji and Wolf (2002). This work was supported by National Science Foundation Grant ATM-0229863. [1] Sigsbee et al., *JGR, 2002.* [2] Ji, S., and R. A. Wolf, *JGR, 108(A5), 2003.*

SM32A-1139 1330h POSTER

Three-Dimensional MHD Simulation of Current Sheet Thinning During the Growth Phase of Magnetospheric Substorms

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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 of magnetic flux tubes during the slow quasi-static evolution of the magnetosphere seen during the growth phase. 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, this process of magnetic flux replenishment is subject to the entropy constraints imposed on the slow quasi-static convection of magnetic flux tubes from the mid- and far-tail regions, first identified by *Erickson and Wolf* (1980). We argue that the depletion of flux from a finite reservoir 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.

SM32A-1140 1330h POSTER

The Significance of Dipole Tilt for Substorm Onsets

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One important factor that decides the location of substorm onset is the dipole tilt angle, defined as the angle between the earth's north dipole axis and the GSM z-axis. Naturally, the solar wind also plays an important role in the determination of the location and ionospheric footprint of the magnetospheric onset. A combination of ground-based signatures have been used to time substorm onsets from magnetometer and photometer data, viz. Pi2 onset, poleward motion and simultaneous brightening of 486.1 nm proton emissions and 557.7 nm electron emissions. The rapid poleward motion of brightening auroral arcs indicates acceleration of magnetotail electrons, likely from a reconnection event. When the onset locations are mapped to the magnetotail with Tsyganenko's T87, T89, T96, and T01 models, all the models indicate significant differences are found to depend strongly on dipole tilt. Near-earth onsets consistently feature large negative dipole tilts, with onsets moving progressively further down-tail as tilt increases. These results are consistent with previous observations of the effect of dipole tilt on magnetotail boundaries.

URL: http://faculty.erau.edu/wanlib01

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SM32A-1141 1330h POSTER

Substorm Growth Phase, Onset and Dipolarization

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Our 3D quasi-static solutions of magnetosphere show that as the plasma pressure gradient increases in the near-Earth plasma sheet region during the substorm growth phase, a current sheet with enhanced cross-tail current density is formed around the local midnight in a finite radial (7 - 10 R_E) and azimuthal domain. In the ionosphere the Birkeland current moves equatorward, the current density is enhanced, and its latitudinal width shrinks. This is consistent with the observed ionospheric growth phase signatures that the polar cap region expands equatorward, both the electron and proton aurora emissions move equatorward and brighten, and the auroral oval shrinks in width. In the current sheet the plasma beta becomes about 50 or larger and the magnetic field curvature is enhanced, and we find that the kinetic ballooning instability (KBI) can be excited with amplitude localized at the maximum plasma beta region. The KBI explains the low frequency (in Pi 2 frequency range and about 1 min period) instability observed by AMPTE/CCE excited at about 2-3 minutes before the substorm onset. The KBI is responsible for substorm onset because as it grows to a large amplitude with $\delta B/B \geq 0.2-0.5$, it causes enhanced ion drift in the westward or eastward direction. During the explosive growth phase that lasts about 30 sec before onset, the enhanced ion drift is in the westward direction. The eastward-westward oscillating ion drift caused by KBI then excites higher frequency instabilities in Pi 1 frequency range during the expansion phase, and the plasma and magnetic field become strongly turbulent. The plasma transport in both radial and azimuthal direction caused by the turbulence relaxes the steep plasma pressure profile during the expansion phase. As the plasma pressure profile relaxes in the plasma sheet, the magnetic field configuration dipolarizes and eventually returns to the pre-substorm more dipole-like geometry. Theories of growth phase magnetospheric configuration, KBI mechanism and dipolarization will be presented.

SM32A-1142 1330h POSTER

Energy Storage and Release at the Inner Edge of the Plasma Sheet.

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The inner edge of the plasma sheet, as a region of transition from the dipolar to stretched magnetic field topology, may stay in the equilibrium for long lasting periods. At the same time, relatively slow energy storage, and its release at pseudo-breakups and substorm onsets, occur in this region. We use three complimentary MHD models, full nonlinear MHD, Lagrangian approach, and the Grad-Shafranov equation based model, to study the balance between the pressure gradient, stretched magnetic field, and convection velocity gradients. We show that the main energy is stored in the stretched magnetic field. Convection may play both stabilizing and destabilizing parts. The latter can trigger fast release of energy via the interchange (or low-beta ballooning) magnetic curvature instabilities. In this case, the modeling reveals the initial linear stage lasting for several minutes followed by the fast (tens of seconds) nonlinear instability. We suggest that at breakups, the linear stage is responsible for the equatorward arc intensification and auroral vortex formation whereas the nonlinear part brings about an explosive burst of pulsations, vortex expansion, and dipolarization in the region. We present samples of CANOPUS, Geotail, and geosynchronous data supporting the model constraint.

SM32A-1143 1330h POSTER

Substorm Injection Electron Flux

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One of the main questions concerning radiation belt research is the origin of radiation belt particles. Under the hypothesis that the plasma sheet electron population is the source of radiation belt electrons which are convected to the outer radiation belt region during substorms, we estimate the flux of particles generated at geosynchronous orbit. These electrons then serve as a source population for other energization mechanisms which accelerate the electrons to Mev and greater energies (i.e. killer electrons). The model fields are based on the *Li et al.* substorm particle injection model [1]. The flux is computed using the Hamiltonian guiding center equations in which the phase space density is conserved.

[1] Li, X., D. N. Baker, M. Temerin, G. Reeves, R. Belian, Simulation of Dispersionless Injections and Drift Echoes of Energetic Electrons Associated with Substorms? Geophys. Res. Lett., 25, 3763, 1998.

This work was supported by the National Science Foundation Grant ATM-0229863.

SM32A-1144 1330h POSTER

CLUSTER Measurements of Substorm Electric Fields at the Near-Earth Plasma Sheet Boundary

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The four-satellite CLUSTER mission offers the opportunity to look at the time sequence and spatial pattern of electric field intensification at times near substorm onset. Using data from the Electron Drift Instrument (EDI), the Flux-Gate Magnetometer(FGM), and the Composition instrument (CODIF), intense perpendicular flows (40 km/s) towards the neutral sheet can often be seen around the time of onset, followed by expansion of the plasma sheet. Comparisons of these observations with MHD simulations of substorms will be presented.

SM32A-1145 1330h POSTER

Vorticity Change in the Magnetosphere: A Study with Particle Guiding Center Motion

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The generation of field-aligned current in the magnetosphere has been ascribed to dynamic changes of vorticity for at least two cases: the quiet time aurora of region R1 (Sato and Iijima, 1979) and the substorm onset (Hasegawa and Sato, 1979). From the point of view of particle guiding center motion the temporal change of vorticity is directly related to the polarization drift. In the guiding center formalism, it consists of five terms. We examine the contribution of each term to the change of vorticity. A distorted dipole (Stern, 1976) is adopted to model the magnetic field in the magnetosphere. This field is easily made time-dependent to simulate a dipolarization of the field, and its Euler potentials have an analytic expression. For numerical calculations, typical values of electric field and plasma density are used.

SM32A-1146 1330h POSTER

Effects of the interplanetary magnetic field and substorms on nightside upward field-aligned currents during storm-time inferred from geomagnetic data at mid-latitudes

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Mid-latitude east-west geomagnetic disturbances on the nightside are attributed to field-aligned currents at high-latitudes. In order to discuss storm-time variations in field-aligned currents on the nightside, we examined east-west geomagnetic disturbance fields at mid-latitudes on the nightside for some geomagnetic storms. The results indicate that upward field-aligned currents are developed on the nightside (esp. in the post-midnight) under the condition that the interplanetary magnetic field (IMF) is directed southward. It is also suggested that substorm expansions have a secondary effect on the upward field-aligned currents on the nightside. We will discuss some possible mechanisms of substorms on the upward currents in the post-midnight.

SM32B MCC: Level 2 Wednesday 1330h

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

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

SM32B-1147 1330h POSTER

Magnetospheric response to solar wind pressure during strongly southward IMF: MHD simulations

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The solar wind energy input to the magnetosphere is generally controlled by the solar wind magnetic field, with significant energy transfer occurring during periods of southward IMF. In fact, empirical expressions of the energy coupling tend to be functions of solar wind speed, magnetic field, and the orientation of the field, but do not include the density or dynamic pressure as a factor. Recent investigations, both observational and theoretical, have suggested that the dynamic pressure can play a significant role in coupling solar wind energy to the magnetosphere during periods of strongly southward IMF. In the paper, we present results of global MHD models using idealized solar wind conditions as controlled experiments. We find that for moderate driving levels there is little influence of dynamic pressure, but during strong IMF driving the pressure is a major, or even dominant, factor in controlling the dayside merging rate and magnetospheric energy dissipation. We will discuss these results in the context of determining the geoeffectiveness of extreme solar wind conditions like magnetic clouds arising from CMEs.

SM32B-1148 1330h POSTER

Magnetospheric Response to Pulsed Variation in Solar Wind Dynamic Pressure: A Case Study

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On September 3 (day 247), 2000, ∼0408-0417 UT, a pulsed geomagnetic signature was observed at the low-latitude dayside ground stations. The magnetic field strength at geosynchronous orbit also showed this single pulse variation. Using solar wind observations, we confirmed that the pulsed geomagnetic field was due to the change in the solar wind dynamic pressure, which indicates that the external source is in the form of the single pulse signature. Unlike the dayside feature at low-latitudes, mid- and high-latitude ground stations on the nightside(local time ∼4-5 hours) recorded latitude-independent geomagnetic perturbations with a period longer than 700 s during about three cycles. These perturbations simultaneously occurred with the