can be interpreted in terms of the pressure disturbance propagation through the magnetosphere at a velocity of the order of 200 km/s that is essentially slower than a magnetosonic (fast Alfvén) wave, and generation of a potential (curl-free) electric field in the wake of the disturbance. We suggest that the interchange instability is a possible reason for the development of discrete dayside auroral forms after the SI. We discuss the reasons for the slow propagation speed of the disturbance and for a vortex-like convection pattern associated with the auroral motions.

SM43A CC: 220 C-E Thursday 1330h

Reconnection? Posters

Presiding: **J E Borovsky,** Los Alamos National Laboratory**; P W Daly,** Max-Planck-Institut fr Aeronomie

SM43A-01 1330h POSTER

Magnetotail Bubbles and Current Sheet Stability

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Using three-dimensional MHD simulations, we further investigate stability and dynamical properties of the magnetotail current sheet. We compare the effects of localized entropy depletions in 2-D and 3-D models and investigate the role of the entropy distribution in ideal MHD stability. We also investigate the mechanisms that may couple the dynamically evolving flux tubes with near-Earth effects.

SM43A-02 1330h POSTER

Magnetic reconnection in the flow of an MHD-scale Kelvin-Helmholtz vortex triggered by electron inertial effects

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In order to understand the structure of an MHD-scale Kelvin-Helmholtz (K-H) vortex universally, magnetic reconnection triggered by the vortex flow must not be neglected. To study the nature of magnetic reconnection within the MHD-scale K-H vortex, we have performed two-dimensional two-fluid simulations considering finite electron inertial effects. In the two-fluid system, magnetic reconnection occurs spontaneously by electron inertial effects. An MHD-scale velocity shear between the two regions is set up and evolution of MHD-scale K-H mode is followed. The K-H vortex can grow up to a highly rolling-up stage when the shaer is strong enough to overcome the stability effect of in-the-plane magnetic field component. In the non-linear state, the magnetic field lines are stretched into an anti-parallel geometry, and then magnetic reconnection occurs within the vortex. First, we have simulated basic cases where the magnetic field has only in-the-plane component with the uniform density. Particularly, we focus on two cases in which in-the-plane component is parallel between two regions and in-the-plane component is anti-parallel. We observe that magnetic reconnection in the flow of the highly rolled-up vortex occurs in both cases. Then, numerous magnetic islands are formed within the vortex by reconnection and the flow pattern of the vortex is destroyed. Only in the anti-parallel case, magnetic reconnection occurs even when the vortex does not highly roll-up. Furthermore, when in-the-plane magnetic intensity is extremely different between two regions, we observe the magnetic islands to be injected into the side with the weaker field. On the basis of these results, we have simulated cases with the LLBL like geometry in a two-dimensional two-fluid system. The density gradient between two sides of the shear layer and the out-of-the-plane magnetic field component are set up. In the LLBL like situation, magnetic reconnection in the flow of the MHD-scale K-H vortex occurs and essential features stay the same as the basic cases.

SM43A-03 1330h POSTER

Formation of Slow Shocks in Anisotropic Plasmas

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The Petschek's reconnection model involves two pairs of slow shocks that play the role of accelerating plasma by reducing the magnetic field. There have been some observational evidences for the existence of slow shocks in the Earth's magnetotail where the plasma beta is usually low. For plasmas in strong magnetic field, the thermal pressure is found to display the gyrotropic form with two distinct pressure components parallel and perpendicular to the local magnetic field. In this study, the structure of slow shocks is examined based on the anisotropic MHD model for which the energy closure is of the double-polytropic laws (Hau and Sonnerup, 1993). In particular, slow shocks are formed through the evolution of a tangential discontinuity current sheet initiated by the presence of magnetic normal field. The results are compared with those obtained from the isotropic MHD model.

SM43A-04 1330h POSTER

Time Scales for Energy Release in Hall Magnetic Reconnection

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We present a study of the time scales for energy release in 2D Hall magnetic reconnection. We use the NRL Hall MHD code VooDoo for this study. We consider a 2D reversed field current layer with a magnetic perturbation that initiates the reconnection process. We use boundary conditions that allow inflow and outflow (i.e., not periodic) and let the system reach a steady state. We find that the system goes through three stages: a relatively long current layer thinning process, a fast reconnection phase, and a final steady state phase. We define the time scale for energy release as the fast reconnection period: from onset to steady state. Preliminary results indicate that the time for energy release scales as the initial thickness of the current layer. We apply these results to the magnetotail and magnetopause.

Research supported by NASA and ONR.

SM43A-05 1330h POSTER

The scaling of reconnection in magnetospheric relevant systems

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Reconnection is a process ubiquitous to plasmas which plays a very important role in the dynamics of the Earth's magnetosphere, allowing solar wind and magnetospheric plasma to mix, and releasing large amounts of magnetic energy in the tail during a substorm. Recently, much progress has been made on understanding how fast reconnection rates consistent with those inferred from observations can occur. However, these previous studies were limited to highly idealized systems lacking many properties ever-present in the magnetosphere: asymmetries acrosss the current sheet, equilibrium normal magnetic fields, equilibrium shear flows, and multiple charged species in the plasma. In this paper, we will present initial results on the scaling of the reconnection rate in these complicated systems and discuss which aspects most strongly affect the reconnection rate.

SM43A-06 1330h POSTER

Plasma Transport Across the Magnetopause

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Particles enter the magnetosphere through transport processes which occur near the magnetopause. It has been estimated that the transport coefficient must be $D \sim 10^9 m^2/s$ in order to maintain a quasi-steady plasma density gradient at the magnetopause. There are two main candidate mechanisms for producing this transport: direct entry along reconnected field lines and particle transport via wave-particle interactions. Most of the observed wave energy is at frequencies below the ion cyclotron frequency and the low frequency transverse wave are almost always observed during magnetopause crossings. When there is large magnetic shear (southward IMF) across the magnetopause, the magnetic reconnection rate is expected to be faster and the transverse wave amplitude is observed to be larger. A larger reconnection rate would imply a faster particle entry into the magnetosphere from the magnetosheath. It has also been shown that larger amplitude kinetic Alfveń waves with wavelength the order of ion gyroradii can cause stochastic particle transport leading to magnetosheath ion entry across the magnetopause with $D \sim 10^9 m^2/s$. We will discuss the relative importance of these two mechanisms for producing plasma transport arcoss the magnetopause.

SM43A-07 1330h POSTER

Motion of the Flank LLBL During Changes of Upstream Parameters

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The magnetopause is a principal boundary dividing the magnetospheric and solar wind plasmas and magnetic fields. At low latitudes, one can identify the low-latitude boundary layer (LLBL) on the magnetospheric side and rather often a depletion layer on the magnetosheath side of the magnetopause. A thickness of these layers varies from 0.2 to 1 Earth's radius but several examples of a very thick LLBL have been reported in flank parts of the magnetopause. Plasma parameters inside the LLBL are variable, the spacecraft usually observes a mixture of magnetosheath and plasma sheet plasmas. Several mechanisms including intermittent reconnection, impulsive penetration, and Kelvin-Helmholtz instability have been proposed to explain this phenomenon. We are using the INTERBALL-1/MAGION-4 satellite pair separated by several thousands of kilometers in order to distinguish between spatial and temporal changes. The observation of LLBL crossings invoked by sudden changes of upstream conditions during strongly northward IMF, shows that (1) even very complicated temporal profile measured by one satellite can be explained in terms of surface waves, (2) the LLBL thickness is a rising function of the solar wind dynamic pressure, and (3) the most probable source of a magnetosheath-like plasma in the flank LLBL is reconnection in the cusp region.

SM43B CC: 220 C-E Thursday 1330h

Bow Shock, Foreshock, and Magnetosheath Posters *(joint with SH)*

Presiding: **H Kucharek,** University of New Hampshire**; L L Kepko,** Center for Space Physics, Boston University

SM43B-01 1330h POSTER

Statistical analysis of periodic solar wind number density variations

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Several recent studies have suggested that the solar wind sometimes contains number density variations at periodic, repeatable intervals. As these number density variations interact with the Earth, they alternately compress and expand the magnetosphere, leading to

global, discrete ULF magnetic pulsations. It is not yet known how often or under what conditions the solar wind periodicities occur. We present the initial results from a statistical study examining the occurrence rate of such number density periodicities. We also examine the the question of whether these number density periodicities occur at the same discrete intervals, or whether the observed frequencies are variable.

SM43B-02 1330h POSTER

The three dimensional foreshock and the response of the terrestrial foreshock to rapid changes in interplanetary magnetic field orientation: Cluster observations

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Cluster observations of ULF wave activity in the terrestrial foreshock are presented, focusing on intervals when the orientation of the upstream magnetic field was not stable. The location of the foreshock in front of the bow shock depends on the orientation of the upstream magnetic field, since this defines the region of space accessible to backstreaming plasma distributions. Whilst the structure of the foreshock for a particular magnetic field orientation may be calculated, the way in which the foreshock morphology responds experimentally to changes in magnetic field orientation, and the timescale on which it responds, remains of interest. Measurements of ULF wave activity made by Cluster FGM at large (1Re) spacecraft separations are used to examine how the foreshock responds to different changes in upstream magnetic field orientation. Also considered is fact that in general, the shock normal, the magnetic field vector and the solar wind vector are not coplanar. The polar orbit of Cluster allows measurements to be made at a series of latitudes, thus allowing an image of the three dimensional foreshock to be constructed.

SM43B-03 1330h POSTER

Gyrophase-bunched Ions and Low Frequency Waves in the Earth's Foreshock: Production Mechanisms

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Gyrating Backstreaming ions displaying gyrophase-bunching around the local magnetic field are frequently observed by the CLUSTER CIS experiment upstream of the Earth's bow shock in association with quasi-monochromatic low-frequency waves. The analysis of the 3D angular distributions indicates that field-aligned beam ions are observed at the onset of each event. Later on, the angular distribution is gyrophase-bunched and peaked at a nearly constant pitch-angle value during the interval of wave occurrence. The waves are left-handed (in the spacecraft frame) and propagate nearly along the ambient magnetic field; we have found that they are fast mode waves in cyclotron resonance with (and likely generated by) the field-aligned beam observed just upstream. By solving the linear Maxwell-Vlasov dispersion relation with the observed parameters as input we confirm that the field-aligned beam drives an ion-ion instability at the observed frequency and wavenumber. Two types of gyrophase-bunched ion events can be observed. For the first type, the pitch-angle distribution is peaked at $\alpha_0 \sim \theta_{BN}$. This is consistent with specular reflection at the shock and the observed particle flux-modulation is interpreted in term of θ_{BN} changes at the shock due to the low frequency waves. For the second type, the gyrophase bunching is due to the nonlinear coherent disruption of the field-aligned beam by the low frequency waves through cyclotron resonant wave-particle interaction: the pitch-angle α_0 of the ion distribution is explained by a wave-trapping process and is directly dependent on the amplitude of the waves. From a statistical study of their occurrence, we discuss the relative importance of these two mechanisms in the foreshock.

SM43B-04 1330h POSTER

Backstreaming ion beams formed at the oblique Earth's bow shock

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Recent observations at the Earth's bow shock with Cluster spacecraft provide new insights into time evolution of particle distributions and the reflection properties of the oblique Earth's bow shock. Field-aligned ion beams appear to emerge from the gyrating ions in the shock ramp created by the same reflection process. In fact, effective scattering in pitch angle within the shock ramp during the reflection seems to be the basic production mechanism of field-aligned ion beams. The efficiency of reflection, transmission and scattering depends on shock parameters, such as Mach number, plasma beta and shock angle. Therefore, these parameters appear to control the relative intensity of these ion beams. Meanwhile the Cluster spacecraft have crossed the Earth's bow shock many times under different interplanetary conditions. A database of shock crossings for a wide range of plasma conditions such as shock normal angle, Mach number, and plasma beta has been compiled. In a statistical study this data set is used to investigate the ion reflection and the ion beam properties at the oblique Earth bow shock in detail. The results will be compared on an event-by-event basis with results of numerical simulations and predictions from theoretical models.

SM43B-05 1330h POSTER

Simultaneous observations of energetic ions upstream and downstream of the bow shock

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We present observations of 1-40 keV ion events observed nearly simultaneous by two Cluster spacecrafts straddling the bow shock. During such events, Cluster SC-1 is located in the magnetosheath while SC-3 is upstream of the bow shock; the 2 spacecrafts are separated by 1 R_E. Typically, energetic ions appear in the magnetosheath only when upstream distribution functions are intermediate-like, with the former resulting from the convection of the latter through the shock. A systematic short time delay is observed between the flux enhancement in the sheath and the change in the upstream distribution function, corresponding to the 1 R_E travel time along the field line. Other events, that are not typical, upstream and downstream energetic particle flux increases occur simultaneously. In this case, the energetic particles present in the sheath are propagating towards the shock, and therefore cannot result in such a direct manner from the upstream distributions. Initial examination of these events indicates strong evidence for leakage. We will present results from a detailed examination of how these distributions fit within a framework of shock reflection, leakage and downstream transmission, in order to determine their source and establish a likely production mechanism.

SM43B-06 1330h POSTER

A Quasilinear Theory of Ion

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A quasilinear theory is presented for the relaxation of the proton and Helium distribution functions and the associated excitation of ion cyclotron waves, downstream of the quasi-perpendicular Earths bow shock. The theory predicts the wave polarization (left), power and peak frequency, and the proton bulk velocity and temperature anisotropy ($T_\perp/T_\parallel$, where $\parallel$ and $\perp$ refer to the orientation of the ambient magnetic field), sufficiently far downstream of the shock that the ions and waves have relaxed to a quasi-equilibrium. The results are compared with the AMPTE/IRM crossings of the marginally supercritical bow shock documented by Sckopke et al. (1990), for which the number of reflected protons is small (~3%-5%) and the quasilinear approximation is expected to be valid. The theory starts with the trajectories of the specularly reflected protons and transmitted Helium in the laminar electromagnetic fields of the shock transition. In a simplified treatment of the downstream relaxation process neglecting wave dispersion and assuming that the downstream ion speed v_0 is larger compared with the Alfven speed V_A, the wave and proton quasi-equilibrium predictions are qualitatively in agreement with the observations. In a more precise treatment limited to a perpendicular configuration, in which dispersion is included and v_0 is comparable with V_A, the agreement with the observations is quantitatively very good with the allowance that the spacecraft did not in some cases quite reach the quasi-equilibrium. One interesting feature is that the minor ion Helium may contribute to the wave power, and in return change the proton and Helium distribution functions. The Helium contribution is estimated but requires further investigation.

SM43B-07 1330h POSTER

Interplanetary Influence on the Occurrence of Magnetic Depressions in the Magnetosheath

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Earlier investigations showed that ISEE-1 most frequently observed mirror type magnetic field depressions close to the average location of the magnetopause in the magnetosheath. In this analysis interplanetary magnetic field reference data are also included in order to study how the IMF direction influences the occurrence of mirror type fluctuations. According to our statistical investigation, mirror type depressions occur closer to the Earth at lower Solar Zenith Angles when the IMF is of southern direction causing an erosion of the magnetopause at the nose. In case of northern IMF when a depletion layer may develop upstream of the nose of the magnetopause, the peak of the frequency of the magnetic depressions is farther away from the Earth. When the IMF is of northern direction, magnetic field depressions are observed more frequently than in the case of southern IMF. Based on the geometry of the bow shock and on the interplanetary magnetic field direction, observations in the magnetosheath downstream of quasi-perpendicular shocks are separated from those downstream of quasi-parallel shocks. Mirror type magnetic field depressions are more frequently found in magnetosheath regions connected to quasi-perpendicular shocks.

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M

SM43B-08 1330h POSTER

Contrasting Magnetosheaths Observed by Geotail on May 10-12, 1999

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The expanded bow shock on and around "the day the solar wind almost disappeared" allowed Geotail to make a magnetosheath pass near dusk (16-20 magnetic local time) lasting 54 hours. During this time, interplanetary parameters varied adiabatically in such a way that they included two extremes of magnetosheath structures, one dominated by magnetohydrodynamic effects and the other by gas dynamic effects. Magnetic fluctuations in the high-β_p magnetosheath were dominated by compressional mirror mode waves, and left and right-handed tranverse waves. In contrast, the low-β_p magnetosheath, lasting for over 1 day, was devoid of mirror oscillations and permeated instead by transverse waves of weak intensity. We relate the weak intensity of these transverse waves to the low dynamic pressure. Left-handed ion cyclotron waves were replaced by bursts of right-handed waves when the solar wind proton temperature anisotropy became negative ($T_{\parallel} > T_{\perp}$). Unlike the normal case, these right-hand waves were not daughter waves but derived their energy source from the magnetosheath anisotropy. The weak transverse activity is examined and modeled. The study extends our knowledge of magnetosheath properties made possible by the extreme range of external parameters during the period studied.

SM43C CC: 220 C-E Thursday 1330h

Cluster Posters *(joint with SH)*

Presiding: **J E Borovsky,** Los Alamos National Laboratory**; P W Daly,** Max-Planck-Institut fr Aeronomie

SM43C-01 1330h POSTER

A Survey of Energetic Plasma Observations by the RAPID Experiment on Cluster

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In the near Earth environment, plasma with particle energies of tens to hundreds of keV provides a powerful diagnostic of the acceleration processed associated with magnetospheric boundaries and phenomena. Such energetic plasma can be detected by the RAPID (Research with Adaptive Particle Imaging Detectors) experiment on Cluster, which comprises an imaging ion mass spectrometer (IIMS) and an imaging electron spectrometer (IES). A survey of the RAPID electron and ion observations taken since June 2002, the start of near-continuous coverage, is presented and interpreted in the context of corresponding magnetic field observations from both Cluster and ACE. The Bryant plot representation, used to provide an overview of the data, reveals populations of energetic ions and electrons within the magnetosphere associated with the radiation belt, when Cluster is at perigee, and the plasma sheet. The latter population is observed from the dawn to dusk flank on both the dayside, on the inner edge of the magnetopause, and in the magnetotail. Asymmetries in the fluxes of ions and electrons observed on the flanks are related to the oppositely directed effect of gradient and curvature drift on electrons and ions from the tail. Energetic ions are also observed outside the magnetopause, in the bowshock and solar wind, where their observation appears to be governed to some degree by the solar wind conditions.

SM43C-02 1330h POSTER

A multifractal analysis of magnetic field fluctuations inferred from Cluster measurements: Evidence for intermittent turbulence in the plasma sheet.

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Cluster fluxgate magnetometer data and ion spectroscopic data are employed to construct and interpret scaling exponential functions and intermittency coefficients for magnetic field fluctuations. This technique, often used in analysis of space and laboratory plasmas, is used to look for intermittent plasma turbulence. Our results show non-self similar scaling in the plasma sheet MHD inertial range, which suggests that intermittent turbulence is common in the plasma sheet. The degree of non-self similar scaling varies with both the distance from the plasma sheet and the geomagnetic activity. The strength of the intermittent turbulence is quantified with the intermittency coefficient, which varies from about 0 to 0.27 for regions in the lobe and plasma sheet.

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

SM43C-03 1330h POSTER

Cluster measurements in the context of global modeling and observations

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The magnetospheric research community has long sought the capability to view the Sun-Earth system in a global way and concurrently to probe the microphysical details of key physical regions. This objective has now been substantially realized with the combination of the CLUSTER constellation and global imaging missions. With the addition of SOHO, ACE, FAST, SAMPEX, POLAR, and various geostationary orbit spacecraft, there is an ability to apply both telescopic and microscopic principles. Many recent examples serve to illustrate the observational power of these new tools. Using events from 2001 and 2003, we have observed strong geomagnetic storms and have studied powerful compression of the magnetosphere and concomitant particle injection events. Using tail crossing events in 2001-2002, CLUSTER observed clear substorm sequences of events in the mid-magnetotail region (X $\sim$ -19R_E). In these cases, CLUSTER data reveal microphysical details while other spacecraft show the global, macroscopic context. We have used the Lyon-Fedder-Mobarry MHD simulation code to numerically model several of these specific events. The new observations and model comparisons are leading to new understandings of magnetospheric processes. Several of the cases to be presented show global features consistent with present-day models of substorm and storm dynamics, but the specific details reveal heretofore unappreciated aspects of processes such as magnetic reconnection and particle acceleration.

SM43C-04 1330h POSTER

High latitude boundary observed by Cluster

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We present statistical results based on the data set obtained by Cluster when these spacecraft were in the vicinity of the dayside magnetopause. Sometimes a clear boundary signature was observed, sometimes the magnetic field, plasma density, and flow changed smoothly and no clear boundary signature was observed, and at other times the boundary is partly clear (not all of the three parameters have clear boundary). Twenty-eight clear boundary crossings, 39 unclear boundary crossings and 19 partly clear boundary crossings have been selected from about 300 boundary crossings (we have data for 86 crossings) that occurred during the period from Jan. 1 to Apr.30, 2001 and Mar. 1 to Apr.30, 2002. We have studied the conditions related to the formation of these three kinds of different boundaries. Clear boundary signatures were observed during northward IMF or these boundaries were located between the magnetosheath and the high latitude trapping region. Unclear boundary signatures were observed during southward or variable IMF. We will report on the dependence of these three boundary types on the dipole tilt angle, solar wind pressure and the Interplanetary Magnetic Field (IMF) as well as determining the relationship of energetic particles to this region. Whether the boundaries are rotational or tangential discontinuity has also been studied.

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Intercalibration of the Magnetometers Onboard the CLUSTER Spacecraft from Natural Constraints

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The calculation of spatial magnetic field gradients requires the determination of orientations, zero levels and scale factors (calibration parameters) of all four CLUSTER magnetometers with very high accuracy (48 parameters, overall). This daunting task is made easier by natural constraints imposed on geophysical signals by nature. For example by observing that on a spinning spacecraft, the spin tone and its second harmonic are introduced in the magnetic field data by eight (per spacecraft) of the calibration parameters, one can determine their value by using techniques that reduce spin induced tones in the observations. Another constraint is provided by the fact that $\nabla \times B$ is zero everywhere and $\nabla \cdot B$ is zero in certain regions of the magnetosphere. Corrections to 12 additional calibration parameters can be obtained by ensuring that $\nabla \times B$ and $\nabla \cdot B$ are zero in those regions. The above techniques are however incapable of providing absolute values of the offsets of the spin axis sensors. We recover these by using the fact that rotational discontinuities in the solar wind do not change the magnitude of the magnetic field. Finally, a complete calibration can be cross-checked by comparing the data from the four magnetometers when they are relatively close together in the solar wind and should see no systematic differences in the magnetic field over a sufficient long period of time. Additionally, we describe how we handle small discontinuities that occur when a magnetometer switches from one range to another.