SM11B MCC: Hall D Monday 0930h

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

Presiding: **R A Wolf,** Rice University; **J E Borovsky,** Los Alamos National Laboratory

SM11B-0425 0930h POSTER

Magnetosheath and plasma sheet observations by GEOTAIL during the low-density solar wind event on 24-25 May 2002

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During the low-density solar wind interval in May 2002, when the density in the solar wind was extremely low (0.1-0.3/cc), GEOTAIL was mostly in the dusk magnetosheath but went into the plasma sheet several times. Of particular interest are the plasma/field conditions in these regions when the solar wind seemed to become sub-Alfvénic intermittently (12 UT on 24 May - 12 UT on 25 May). We will report that (1) the magnitude of the magnetosheath magnetic field at GEOTAIL was lower than that in the upstream solar wind, that (2) the magnetosheath plasma density at GEOTAIL was comparable or even lower than that in the solar wind, and that (3) the plasma density in the plasma sheet became comparable to that of the magnetosheath solar wind. While the observations (1) and (2) give important information on the flow structure around the magnetosphere during such intervals, (3) extends our knowledge on the magnetosheath-plasma sheet density relationship.

SM11B-0426 0930h POSTER

Magnetospheric Oxygen in the Magnetosheath as Observed by CIS Cluster

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The Cluster Ion Spectrometry experiment (CIS) on board CLUSTER mission permits high time resolutions measurements of the three dimensional distribution functions for the four major ion species H+, He++, He+, O+. Here we present Cluster observations made on the dusk flank of the magnetopause in which, for a long time interval, magnetospheric oxygen was observed outside the magnetosphere. The oxygen distribution functions are characterized by noteworthy variability along the period of observations. We investigate on the most probable cause for the oxygen escaping process and discuss possible explanations for the peculiarities observed in the distribution functions.

SM11B-0427 0930h POSTER

Analytical Streamline Model of the Magnetosheath

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This work, based loosely on the draping of magnetic field lines around a conducting sphere or cylinder, provides an analytical construction of the magnetosheath's **B** field for arbitrary IMF direction. The basic procedure is to create a generic expression for the equation of a solar-wind streamline. This procedure is easily visualized for the case of a hemispherically capped cylindrical magnetopause, except that "cap" (which extends $\sim$ 11 R_E upstream and $\sim$ 65 R_E downstream from Earth) is better represented as half of a prolate ellipsoid [e.g., Sibeck et al., JGR, 96, 5489-5495, 1991], matched to a cylinder of radius $\sim$ 28.4 R_E. The corresponding equation of a magnetosheath streamline, most conveniently expressed in ellipsoidal coordinates, is replaced upstream from the bow shock by the equation of a straight line parallel to the solar-wind velocity, which is regarded as locally uniform until it reaches the bow shock. Since the easily constructed Euler potentials (essentially a flux variable α and an azimuth β) that label streamlines must be continuous across the bow shock, they serve also to label streamlines in the magnetosheath, whereupon the magnetosheath plasma's momentum-flux field is given by grad $\alpha \times$ grad β. This is most easily visualized for IMF parallel to the solar-wind velocity, in which case magnetic field lines are also streamlines of the plasma flow-velocity field. Results for **B** perpendicular to the solar-wind velocity can be obtained [Spreiter et al., Planet. Space Sci., 14, 223-253, 1966] by threading field lines through points of equal accrued travel time from corresponding straight field lines upstream of the prescribed (here paraboloidal) bow shock. Results for arbitrary IMF direction can be obtained through weighted superposition of results for **B** in the two limiting cases. This model for **B** is not current-free, but neither is the real magnetosheath. This model for **B** is also not unique, being dependent on a physics-based but ultimately "cooked-up" expression for the equation of a generic streamline. However, the model seems flexible enough to provide a realistic representation of the magnetosheath's **B** field upon suitable adjustment of the model's parameters. In particular, adjustment of the global "shape" parameter Q (incorporated into the analytical model for this presentation) improves the similarity of overall streamline shapes to past findings [e.g., Spreiter et al., 1966] from fluid simulations.

SM11B-0428 0930h POSTER

Size, Shape and Orientation of Magnetosheath Mirror Mode Structures

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Using magnetic field data from the four Cluster spacecraft, we present estimates of the size, shape and orientation of mirror mode structures in the terrestrial magnetosheath. Timing analysis of individual magnetic depressions can be used to estimate their orientation, and we show, using CIS measurements, that they are not moving at a significant speed relative to the local plasma. By considering differences between structures at the four spacecraft, on both a single event and statistical basis, it is possible to estimate their size and shape. We show that the direction in which the structures are of largest extent is often significantly different from the local magnetic field vector, and that the structures vary widely in total size, from a few hundred to a few thousand km. We also discuss the variation in size of the mirror modes in different directions, demonstrating that they are often significantly shorter parallel to the local magnetopause normal, consistent with their being compressed against the magnetopause.

SM11B-0429 0930h POSTER

Low Frequency Electric Field Turbulence in the Magnetosheath Observed by Cluster

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Low frequency magnetosheath turbulence is studied using electric field measurements obtained by Cluster satellites. The use of four point measurements enables the identification of the direction of wave propagation and phase velocity. The wave phase velocity is used to identify plasma wave modes. The results are then compared with linear kinetic models of magnetosheath waves.

SM11B-0430 0930h POSTER

Polarization and Dispersion Analysis of ULF Waves in the Magnetosheath Using Cluster Data

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We analyzed ULF wave events in which the Cluster spacecrafts crossed the magnetosheath region. Using single spacecraft data, we investigated polarization properties such as degree of polarization, ellipticity, ratio of perpendicular to parallel component in the magnetic field fluctuation, and wave propagation angle at each frequency by means of minimum variance analysis, and coherency between plasma data (e.g.., velocity and density) and magnetic field data as well. Then we investigated wave number vector at each frequency by means of a wave telescope technique using multi-spacecraft data. We found that the wave propagation angles obtained from the wave telescope technique were fairly comparable with the angles that were obtained from the minimum variance analysis. The results from these methods can be compensated with one another and synthesized by associating polarization properties and coherency with the wave number vectors. This opens a new way to decompose dispersion relations that can be obtained from multi-spacecraft data analysis into different branches of wave modes.

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SM11B-0431 0930h POSTER

Modeling the Structure of Magnetic Mirrors Using Cluster Data

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Magnetic mirror structures are common in space plasma where the temperature is anisotropic, in particular they can be often found in the terrestrial magnetosheath.

Because of their ability to provide simultaneous measurements from points separated by distances of the order of the magnetic mirror dimensions the four Cluster spacecrafts constitute an adequate tool for the study of the geometrical structure of magnetic mirrors .

In this work we present a method for the identification of magnetic mirrorstructures using Cluster magnetometer observations and a recently developed analytical model for magnetic mirrors.

The model used here allows for very complex geometry of magnetic mirrors to be described. The structure is made up of many coaxial layers and only near the axis it has the well-known bottle shape. Because of this feature, multi-spacecraft measurements are necessary in the search of the magnetic mirrors. Once a mirror structure is identified, we can specify its location, orientation, shape and dimensions.

The method we have used consists of two distinct steps. First we do a simultaneous fitting of the magnetic field data from two or more spacecrafts. Making use of the parameters obtained from the first step we compute the magnetic field predicted by the model at the locations of the remaining spacecrafts. The comparison between these results and the measured data decides if a mirror structure has been identified successfully or not.

Several magnetic mirrors have been found and their characteristics have been determined.

SM11B-0432 0930h POSTER

Can the Magnetopause, Viewed as Thin Layer, be Kelvin-Helmholtz Stable, and yet be Unstable When Examined as a Continuous Transition of Finite Width?

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According to incompressible MHD theory, when the magnetopause is approximated by a tangential discontinuity, the perturbations are Kelvin-Helmholtz (KH) stable when the following relation is satisfied:

$$\rho_{0,1}(V_{\kappa,1})^2+\rho_{0,2}(V_{\kappa,2})^2 < (4\pi)^{-1})[(B_{\kappa,1})^2+(B_{\kappa,2})^2]. \quad (5)$$

Here the indices 1,2 refer to quantities on either side of the magnetopause, ρ_0 is the plasma density, and V_κ, B_κ are the projections of plasma velocity $\mathbf{V}$ and magnetic field $\mathbf{B}$ on the direction of the wave vector $\mathbf{k}$, respectively. An example of a continuous velocity profile with finite thickness Δ that can be solved analytically and for which condition (1) is satisfied is presented. Yet the configuration is KH unstable and it becomes stable only in the limit $\Delta \rightarrow 0$. Using hyperbolic tangent profiles for ρ_0, $\mathbf{V}$, and $\mathbf{B}$, and solving the stability problem numerically with parameters typical of the dayside magnetopause, we show cases of unstable configurations, all of them stable according to (1). This possibility, as far as we know, has passed unnoticed in the literature. The theory applies to subsonic regions of the dayside magnetopause. In this region the neglect of compressibility effects on the equations of the main branch of the KH instability is justified.

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SM11B-0433 0930h POSTER

The Achilles Heel of Normal Determinations via Minimum Variance Techniques: Worldline Dependencies

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Time series of data collected across current layers are usually organized by divining coordinate transformations (as from minimum variance) that permits a geometrical interpretation for the data collected. Almost without exception the current layer geometry is inferred by supposing that the current carrying layer is locally planar. Only after this geometry is "determined" can the various quantities predicted by theory calculated. The precision of reconnection rated "measured" and the quantitative support for or against component reconnection be evaluated.

This paper defines worldline traversals across fully resolved Hall two fluid models of reconnecting current sheets (with varying sizes of guide fields) and across a 2-D hybrid solution of a super critical shock layer. Along each worldline various variance techniques are used to infer current sheet normals based on the data observed along this worldline alone. We then contrast these inferred normals with those known from the overview of the fully resolved spatial pictures of the layer. Absolute errors of 20 degrees in the normal are quite commonplace, but errors of 40-90 deg are also implied, especially for worldlines that make more and more oblique angles to the true current sheet normal. These mistaken "inferences" are traceable to the degree that the data collected sample 2-D variations within these layers or not. While it is not surprising that these variance techniques give incorrect errors in the presence of layers that possess 2-D variations, it is illuminating that such large errors need not be signalled by the traditional error formulae for the error cones on normals that have been previously used to estimate the errors of normal choices. Frequently the absolute errors that depend on worldline path can be 10 times the random error that formulae would predict based on eigenvalues of the covariance matrix.

A given time series cannot be associated in any a priori way with a specific worldline. Accordingly, the errors possible considering a variety of possible world lines is the only sure way to understand the imprecision of the normal from a given passage across a current sheet layer. Of course multiple spacecraft penetrating the same layer during an elapsed interval short to the evolution of the layer may help with this ambiguity. For a given crossing the remaining conservation laws beyond those exploited in minimum variance and Faraday Residue techniques may more constructively limit the error cone on the normal.

SM11B-0434 0930h POSTER

A Statistical Study of IMF Bz Formation

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Although interplanetary magnetic field (IMF) vectors near the Earth are on average lying near the ecliptic plane, there is often a significant Bz component, which is important for the development of geomagnetic activity. Two main causes are thought to be responsible for the generation of IMF Bz: an inherent magnetic field existing inside plasma clouds in the solar wind, and 3-D disturbances of the ambient magnetic field by moving plasma inhomogeneities (due to draping of the ambient magnetic field around plasma inhomogeneities). The former mechanism links the IMF Bz to new plasma with a frozen-in magnetic field while the latter one assumes the formation of IMF Bz to take place in ambient plasma as an effect of, for instance, approaching high-speed plasma flows. In the first case the plasma density per unit magnetic flux (the n/B parameter) may vary in an arbitrary way while in the second case the n/B parameter should be approximately constant. This allows us to try to estimate relative contributions to IMF Bz generation from these two mechanisms. For this purpose we carried out a statistical study of hourly IMF variations for three years 1998-2000. We provided a cross-correlation analysis for variations IMF Bz with Bx, By, and the value of horizontal magnetic field vector Bxy for different values of n/B (which is a freezing-in parameter). We found high correlation for IMF Bz and By and lower correlation for Bz and Bx, but the best correlation was observed for variations of Bz and Bxy. For all cases the correlation was out of phase: increasing Bz was associated with decreasing other IMF components that is consistent with predictions from the draping mechanism. Correlation coefficients increased strongly with decreasing n/B factor. For Bz versus Bxy and n/B = 0.1, the correlation coefficient was higher than 0.6 that says in favor of high effectiveness for the formation of Bz field by moving plasma inhomogeneities from horizontal magnetic field components. This effect increases with increasing solar wind speed and for small angles of IMF vector to Sun-Earth line. We also compared the obtained results with expected 3-D variations in the magnetic field appearing because of draping magnetic field lines about a moving plasma ball and inclined cylinder (the last case is related to high-speed stream in the solar wind). The experimental results are well consistent with predictions from these simple models but the better agreement takes place for inclined plasma cylinder.

SM11B-0435 0930h POSTER

Electron Inertia Effects in an MHD Scale Kelvin-Helmholtz Vortex

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We study the effects of the electron inertia in an MHD scale Kelvin-Helmholtz (KH) vortex by two-dimensional two-fluid simulations including electron inertia. An LLBL like situation, that is, an MHD/ion scale velocity shear with density gradient, is set up and the evolution of a MHD-scale KH-mode followed. The magnetic field is assumed to be perpendicular to the flow and the simulation plane.

When the electron dynamics is not considered (MHD), the highly rolled up MHD-scale vortex is generated and remains rather stable. The vortex behaves just as in MHD studies even when the ion inertia is included (Hall MHD). However, when the electoron dynamics is taken into account, that is, when the effects of electron inertia is considered, we observe the decay of the MHD-scale vortex for the duskside-like situation.

In the duskside case, small vortices appear inside the MHD-scale vortex. As the small vortices grow quickly in time and expand outward, the parent MHD-scale vortex is destroyed.

The nature of the small vortices is as follows: First, an ion-electron hybrid-scale instability is driven by the electron inertia at the hyperbolic point. Then the fluctuations produced by this instability are convected by the electron flow along the outer region of the parent vortex. A velocity gradient exists at this part of the vortex and the fluctuations become the seed for the secondary KH instability within the parent KH vortex, which produces the small vortices. That is, the coupling between the hybrid-scale phenomenon and the MHD-scale phenomoenon within the parent vortex makes it to decay. This naturally explains the self-similarity observed in the decay process when the thickness of the initial velocity shear layer is varied.

In the dawnside-like case, since the fluctuations produced by the hybrid-scale instability do not propagate to the velocity shear region, the small vortices don't grow within the parent vortex and its decay does not proceed.

We will present results of detailed analyses that support the above story for the newly found vortex decay process. We will also discuss the implications of the decay process in the context of magnetospheric physics.

SM11B-0436 0930h POSTER

Solar-Wind/Magnetosphere Coupling: The Turbulence Effect

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The correlation between the amplitude of the MHD turbulence in the upstream solar wind and the amplitude of the Earths geomagnetic-activity indices AE, AU, AL, Kp, ap, Dst, and PCI is explored. Increased amplitudes of the turbulence results in elevated geomagnetic indices. It is found that this turbulence effect accounts for about 100 nT of the variability of the AE index. The magnitude of the effect is the same for northward and for southward IMF. Tests are performed that conclude (1) that the turbulence effect is not caused by the turbulence amplitude acting as a proxy for —B— in the solar wind and (2) that reversals of the IMF from northward to southward in the turbulent fluctuations is not the cause of the correlations. An expression is derived for the total viscous-shear force on the surface of the magnetosphere; improved solar-wind/magnetosphere correlations result when this expression is used. The turbulence effect is interpreted as an enhanced viscous coupling of the solar-wind flow to the Earths magnetosphere caused by an eddy viscosity that is controlled by the amplitude of MHD turbulence in the upstream solar wind: more upstream turbulence means more momentum transfer from the magnetosheath into the magnetosphere, resulting in more stirring of the magnetosphere, which produces enhanced geomagnetic-activity indices. The total energy input to the magnetosphere by this eddy-viscous coupling is theoretically estimated and compared with the data.

SM11B-0437 0930h POSTER

The Effects of Solar Wind Structure on Magnetosphere Parameters

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During the ISTP program we demonstrated that in order to understand the magnetospheric response to solar wind and interplanetary magnetic field changes we had to simulate the magnetosphere using actual spacecraft observations as input to our global MHD models [Frank et al., 1995]. In these studies, we assumed that plasmas and fields observed by the spacecraft monitoring the solar wind were homogeneous and that all of the variations seen at the monitor reached the Earth. Although this approach allowed us to obtain qualitative agreement between the simulations and observations made within the magnetosphere, it has often limited our ability to quantitatively assess the validity of the model. In this study we have tested the assumptions made on the solar wind properties and propagation by modeling a magnetic storm on May 24, 2000 using data from five solar wind monitors (ACE, Wind, Imp-8, Geotail and Interball-1). We compare quantitatively the results of the five simulations assuming that each spacecraft was the only solar wind monitor and discuss the topological changes in the magnetospheric configuration caused by the different solar wind inputs. We use these results to assess quantitatively the errors encountered using a single spacecraft and homogeneous solar wind.

SM11B-0438 0930h POSTER

Multi-Spacecraft Observations of Whistler Waves Close to the Magnetopause

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We study emissions of whistler waves observed on the magnetospheric side of the magnetopause. Electric and magnetic field observations from the four Cluster spacecraft are used to determine the wave vectors. The results show that the semi-continuous emissions actually are composed of several individual bursts. Some of the bursts can be seen by two or more satellites while other are just observed by one. The direction of propagation is consistent with waves being generated close to the magnetopause. The wavelength is about 35 km. We compare emission events with spacecraft separations of about hundred or about thousand kilometres to investigate the scalelengths of the wave generation region. The possible association of these waves with reconnection processes is also considered.

SM11B-0439 0930h POSTER

Localized Diamagnetism and Phase Transition in High-Temperature Space Plasma

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We present two- and three-dimensional strictly collisionless homogeneous full particle numerical simulations with periodic boundary conditions of the formation of localized diamagnetic structures in high temperature plasmas of the kind observed in the magnetosheath and the geomagnetic tail. Such plasmas are in general anisotropic. It is shown that such plasmas spontaneously evolve into a series of localized electron scale magnetic depressions with anticorrelation between the magnetic and plasma pressures while the correlation lengths in both cases are different. The magnetic depression reaches values of 80%. The effect is purely electronic with the ion remaining strictly inert. The depressions are practically two-dimensional having very long extension along the magnetic field lacking any effect of particle trapping by mirror forces. Closer investigation shows that the effect is due to the spontaneous formation of nearly circular electron drift (Hall) currents and is thus purely diamagnetic which is a typical microscopic effect. Such currents form when diamagnetic drift sets on in density fluctuations. Only a small percentage of electrons contributes to these currents. Moreover, the depressed flux tubes arrange in a quasi-crystalline array which is caused by the repulsing forces between neighbouring diamagnetic current rings. This resembles second order phase transitions in the Landau-Ginzburg model at very low temperatures which here is working at high plasma temperature.

SM11B-0440 0930h POSTER

Vlasov Simulations of Ion-Acoustic Instabilities in Non-Maxwellian Space Plasmas: Enhanced Anomalous Resistivity.

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Results of a one-dimensional electrostatic Vlasov simulation study of ion-acoustic waves in a collisionless plasma are presented. The waves are current-driven unstable. We model the plasma using Lorentzian distribution functions of electrons and ions for similar particle temperatures. Lorentzian (kappa) distributions are observed in planetary magnetospheres, astrophysical plasmas and the solar wind. Stability curves of the Lorentzian plasma for several values of the high energy tail parameter κ are calculated and compared with the Maxwellian stability curve. The threshold for wave growth at given absolute current density is reduced for a Lorentzian distribution and the region of resonance in velocity space is narrower. These two effects are responsible for increasing the anomalous resistivity in the Lorentzian plasma with respect to that in a Maxwellian plasma, which itself has been previously shown by us to be three orders of magnitude above some analytical estimates [Watt et al., Geophys Res. Lett, 29, 10.1029/2001GL013451, 2002]. Hence the form of the distribution function can be a significant factor in electron diffusion across the magnetic field in the reconnection site in the earth's magnetopause region and in similar space plasmas.

SM11B-0441 0930h POSTER

Bursty Mode Conversion in Inhomogeneous Plasmas

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The process of linear mode conversion of electrostatic Langmuir waves into transverse electromagnetic waves in the presence of density inhomogeneities in an unmagnetized plasma is investigated numerically. In inhomogeneous plasmas, Langmuir waves often tunnel into density wells near the mode conversion region and it is shown that these density wells can act as resonators for the mode conversion process. Specifically, changes in the size of the density cavity on scales of order the Langmuir wavelength can alter the mode conversion efficiency from zero to its maximum value (up to 100% in some instances). Thus, with density inhomogeneities evolving on MHD timescales, the production of radio emission by mode conversion of Langmuir waves should be a bursty process. The dependence of the degree of burstiness on the inhomogeneity scales is discussed, together with potential applications to mode conversion phenomena in magnetized space plasmas, including interplanetary and magnetospheric radio emissions and pulsations in auroral roar emissions.

SM11B-0442 0930h POSTER

Finite Larmor Radius Effects in Ponderomotive Force

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The Ponderomotive Force (PF) due to a high frequency electromagnetic wave in a magnetized plasma is derived using a hybrid model that involves both the fluid and the kinetic approaches. We obtain an analytical expression for the PF using the fluid model and the hot plasma dielectric tensor [1] elements where the contribution of finite Larmor radius (FLR) are appropriately incorporated into the model. The contribution of FLR effects due to the Lorentz part of the PF are studied in greater detail. The PF could play a dominant role in the selective charged particle acceleration (energization) in the magnetospere, and possibly in the heliosphere, and in particular, perpendicular heating of ions. In such space plasma environments, the effects of FLR could be significant. Finally, the analytical expression for PF obtained by the above procedure is compared with the results derived from the equation of motion of a single charged particle in a magnetic field in the presence of an arbitrarily propagating electromagnetic wave.

[1] J.R. Myra and D.A. D'Ippolito, Phys. Plasmas 7(2000)3600.

SM11C MCC: Hall D Monday 0930h

High-Latitude Ionosphere and Magnetosphere Posters *(joint with SA)*

Presiding: **D R Weimer,** Mission Research Corporation**; T Moretto,** NASA Goddard Space Flight Center

SM11C-0443 0930h POSTER

Temporal variation in the cross-polar-cap potential for periods of steady IMF as determined using SuperDARN.

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