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Electrostatic waves near harmonics of the ion cyclotron frequency are often seen in the auroral ionosphere.[1] These waves propagate almost perpendicular to the geomagnetic field but are sometimes observed in conjunction with parallel bipolar field structures. This presentation is based on some unpublished FAST satellite data in a downward current region showing electron and ion distribution functions measured over intervals during which waves are observed (over shorter times) near ion cyclotron harmonics. Model particle distributions closely related to the measured ones are used in a linear stability analysis to study instabilities that are capable of saturating into the observed wave spectra and particle distributions. Typically, the measured distributions are highly anisotropic and have drifts. Two kinds of instabilities are found: *current-driven* instabilities, which represent a generalization of Kindel-Kennel[2] instabilities, and *loss-cone-driven* instabilities. (It is also known that *shear* in the velocity distribution can drive cyclotron harmonic waves in the *upward* current region.[3]) An interesting new method for studying stability of quasilongitudinal wave in a magnetoplasma is also presented.

Research supported by NSF, NASA, and DOE.

[1] R. E. Ergun, et al., *Geophys. Res. Lett.*, **25**, 2025 (1998); F. J. Crary, et al., *Geophys. Res. Lett.*, **28**, 3059 (2001).

[2] J. M. Kindel and C. F. Kennel, *J. Geophys. Res.*, **76**, 3055 (1971).

[3] V. V. Gavrishchaka et al., *Phys. Rev. Lett.*, **85**, 4285 (2000).

SM21B-0556 0830h POSTER

Ion Cyclotron Waves and Ion Heating in the Auroral Ionosphere

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Upwelling ions are commonly observed along auroral field lines in association with electromagnetic ion cyclotron waves. The waves may be caused by any of a number of mechanisms: electron current or beams, ion beams, velocity shear, temperature anisotropy, and/or loss cone. Usually these waves are observed with a downward Poynting flux, and it is expected that they propagate into the ionosphere where they can heat ionospheric oxygen and helium. We have solved the electromagnetic wave equations for ion cyclotron waves as they propagate along the magnetic field lines into the ionosphere. Based on the wave solutions, it is possible to understand how much wave energy is deposited in the heavy ions through ion cyclotron and Joule dissipation as well as the location where the energy is deposited. The dissipation has a sensitive dependence on the density of the minority species and on the spectrum of the ion cyclotron waves. We provide ion heating rates as a function of altitude below the satellite for commonly observed wave spectra and discuss the resulting ion distributions.

SM21C MCC: 131 Tuesday 0830h

Magnetic Reconnection: Magnetopause *(joint with NG, SH)*

Presiding: **J Raeder,** University of California, Los Angeles**; J D Scudder,** University of Iowa Department of Physics and Astronomy

SM21C-01 0830h

Magnetopause reconnection tailward of the cusp during northward interplanetary magnetic field and its relation to magnetosheath properties

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This study examines the location of the reconnection site on the magnetopause for conditions of northward IMF. Ion distribution functions are obtained from the Toroidal Imaging Mass, Angle Spectrometer (TIMAS) instrument during passes through the dayside cusp region by the NASA/GGS Polar spacecraft when the interplanetary magnetic field (IMF) was steady and northward. Ion cutoff velocities are used in conjunction with the Onsager et al. (GRL, 1990) formula to estimate the distance from the Polar spacecraft to the site of reconnection. The Tsyganenko 1996 magnetospheric magnetic field model is used to map these determined distances along the magnetospheric magnetic field to the magnetopause. It is found that nearly all of these reconnection sites lie tailward of the cusp, in places for which the magnetosheath flow is considered to be super-Alfvenic (using hydrodynamic theory and a magnetosheath magnetic field model). Different scenarios are discussed, including the possibility of the existence of a non-stationary reconnection site, and the existence of a plasma depletion layer which acts to significantly reduce the magnetosheath Alfven speed close to the magnetopause. From the observations and mapped reconnection locations, we also estimate by how much the ion density must decrease (and the magnetic field increases) in the plasma depletion layer in order that the reconnection locations lie in sub-Alfvenic magnetosheath flow.

SM21C-02 0845h

Observation of lower hybrid drift instability in the diffusion region at a reconnecting magnetopause

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Intense lower hybrid waves are observed in the Hall current region of a reconnecting current sheet at the earth's magnetopause. Large measured cross-field drifts and density gradients are the likely sources of free energy through a lower hybrid drift instability (LHDI), which is stabilized near the neutral point where the plasma β is large. Harris neutral sheet and linear models are fitted to the data and inferred current density profiles are compared to the observed current density from particle measurements. We estimate the contribution of LHDI anomalous resistivity to the parallel electric field and show that it is more than 100 times smaller than the measured parallel field at the separator boundaries and essentially zero near the neutral point, leaving gradient electron pressure tensor and inertial terms or anomalous resistivity from higher frequency instabilities to support any parallel fields there and, hence, control the reconnection process.

SM21C-03 0900h

Cluster Observations of the Magnetopause at Ion and Electron Scales

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Observations of the magnetopause by the four Cluster satellites are presented. We investigate electric and magnetic field, and wave, data together with particle observations obtained at satellite separations from around hundred to thousands of kilometres. Observations include examples of strong (10 mV/m) varying electric fields in narrow (much less than an ion gyroradius) boundaries, extending along the magnetopause for at least several ion gyroradii. The emissions in these "turbulent boundaries are broadband in frequency. The potential drop across this narrow region can be a few hundred Volts, which may be important for energization of particles close to the magnetopause. We investigate the nature of this decoupling of ion and electron motion, and its relation to various transport processes across the magnetopause. We also compare waves and particle energization at the magnetopause with similar phenomena in the auroral region.

SM21C-04 0915h

Ambipolar Electric Fields Parallel and Perpendicular to the Local Magnetic Field: Magnetopause and Depletion Layers

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The electric fields that occur in a plasma in the presence of pressure gradients have long been inventoried in laboratory plasmas, but only recently have these same effects been taken seriously in the experimental space science community. When these effects are present, the electric field can no longer be inferred from fluid velocities and the magnetic field, but there are substantial (and detectable mV/m class) corrections to the unipolar electric field associated with the pressure gradients of the electron part of the plasma. A pressure ridge is theoretically anticipated astride the separator which implies that there are pressure gradients there and, in general, parallel electric fields of this type. Pressure gradient electric fields, whether parallel or not to B, occur in other places as well; accordingly the detection of pressure gradients and parallel E are not, by themselves, sufficient to indicate reconnection.

In this paper we illustrate the power of cross strapping the plasma, electric and magnetic field measurements to elucidate a new picture of the electrodynamics of the magnetopause and its associated boundary layers. Even depletion layers, long held to be the hallmark of a magnetopause that is locally "closed", will be illustrated with well developed pressure gradient and parallel electric fields. A particularly well resolved layer yields the following picture of the scale lengths involved in this layer. As pressure variations are perceived in the time domain, the comparisons of the electron flow and the electromagnetic field suggest waxing and waning gradients that may be inverted to determine the time sequence of spatial scales encountered. As the depletion layer is traversed, the spatial scales do on average decrease, but they do not collapse to the electron inertial scale before the magnetopause is traversed. This type of crossing will be contrasted with a magnetopause layer where the observer penetrates the separator and all the classically expected signatures of reconnection are observed, and the spatial scales of such a reconnecting layer has collapsed to and asymptoted to the limiting electron inertial length, thereby demagnetizing the electrons. Such comparisons give the impression that the sights of reconnection depend on the precised collapse of scales that the local boundary conditions require: if they are not short enough to demagnetize the thermal electrons reconnection does not occur; if it does it has been observed to occur.

SM21C-05 0930h

What is Behind the Plasma Depletion Layer?

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The plasma depletion layer (PDL) is a layer on the sunward side of the magnetopause with lower plasma density and higher magnetic field compared to the corresponding upstream magnetosheath values. It predominantly occurs during northward IMF conditions. In this presentation, we investigate the basic physics of the formation of the PDL, which is fundamental for the understanding of the magnetosheath and magnetopause boundary layer. In a previous study, we have validated our global model by comparing model results with PDL observations. We now extend this work by studying the more detailed physics of the PDL with global MHD simulations. Detailed force analysis shows that different forces are playing different roles at different locations. A new technique is presented to test the location of the possible slow mode front in the magnetosheath. The results show that, when we assume a magnetopause wave source, slow mode fronts do not exist for typical IMF and solar conditions that otherwise lead to PDL formation. A more detailed flux tube depletion process in the magnetosheath is described. The results are compared with the former results by Zwan and Wolf [1976]

and major differences are found. Finally, we show that plasma expansion, more likely than a slow mode front, is responsible for the plasma depletion layer.

SM21C-06 0945h

Observational search for magnetosheath merging

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Magnetosheath merging has been predicted using the Integrated Space Weather Model (ISM). Directional discontinuities are distorted as they are slowed inside the bow shock, but continue to propagate downstream in the unshocked solar wind. Merging is predicted to occur as the discontinuity is compressed and the current intensifies. Polar, with its apogee now near the equator, slowly traverses the magnetosheath in front of the nose. Several directional discontinuities have been observed outside of the magnetopause where accelerated particles and wave Poynting flux indicates the possibility of merging (on April 7, 2000, March 31, 2001, and March 12, 2001). For one case in particular where the IMF rotated from south to north and the observation was clearly away from the magnetopause, the ion acceleration and Poynting flux was particularly strong. We will test these observations for other commonly accepted signatures of merging.

SM21D MCC: 131 Tuesday 1020h

Magnetotail, Plasma Sheet, and Boundary Layers II

Presiding: **J M Weygand,** University of California, Los Angeles**; N E Turner,** University of Texas at El Paso

SM21D-01 1020h

Plasma Convection in the Cross-Section of the Magnetotail: Geotail Observation

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Plasma convection pattern in the cross-section of the magnetotail is derived for the first time from the archive plasma dataset of the Geotail spacecraft. In this statistics, the measured ion velocities are divided into two independent components, i.e., components parallel and perpendicular to the magnetic filed, respectively, and only the result for the perpendicular component is discussed. Since Geotail has an equatorial orbit, only the portion of the tail close to the plasma sheet has been covered by Geotail, but still the result provides sufficient information to identify some of the interesting characteristics of the plasma convection in the y-z plane. Some characteristics are consistent with the standard view of the convection in the magnetotail, but others are not readily compatible with the standard view. Important findings are as follows:

(1) The plasma convection is directed from the lobe toward the plasma sheet near the midnight meridian plane as is consistent with the standard view.

(2) Near the flanks of the magnetotail, however, the convection direction is reversed, that is, directed from the plasma sheet to the lobe. This means that two convection vortices are formed within the y-z plane for each hemisphere, and some of the plasmas convecting from high latitudes are deflected towards flanks before they reach the neutral sheet and finally return to the high-latitude portion of the tail along the flank magnetopause.

(3) The sense of rotation for these plasma vortices is not apparently correlated with the sign of the IMF z component. That is, the plasma convection always has a component directed toward the plasma sheet near the midnight meridian even in the case of northward IMF. This probably means that the conversion process of closed field lines to open field lines is occurring at the dayside magnetopause even during periods of northward IMF. The reverse convection expected for the northward IMF seems to be spatially limited to the higher latitude portion of the tail not covered by GEOTAIL observations.

(4) The effect of the y-component of the IMF is visible as an intensification of one of the two vortices, whose dawn-dusk asymmetry is controlled by IMF-By. The effect is smaller than expected, and barely visible at the distances of x=-15 to -25 Re.

SM21D-02 1035h

Cluster Observations of Traveling Compression Regions in the Near-Tail

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Observations of traveling compression regions in the tail lobes accompanied by north-then-south Bz signatures, i.e. NS TCRs, have long been used as indicators of the tailward movement of plasmoid-type flux ropes. South-then-north compression regions, i.e. SN TCRs, are expected to occur in association with the earthward motion of BBF-type flux ropes. However, their interpretation has been problematical because similar magnetic field signatures in single spacecraft observations are also known to be caused by short duration enhancements of the external solar wind pressure. Here we present the first three-dimensional analysis of SN TCRs in the Cluster measurements. The Cluster observations clearly show that these compression regions do, indeed, move earthward. Furthermore, they provide the first direct observations of the plasma sheet "bulge" generating the TCR, and they lend new insights into the nature of the lobe - plasma sheet interface during reconnection events. The implications of these new multi-spacecraft observations for nature of the changes in the configuration of the plasma sheet in response to magnetic reconnection will be discussed.

SM21D-03 1050h

CLUSTER Observation of the Dynamics of Ionospheric O+ and H+ Ions in the Mid-Tail

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Cluster ion measurements inside the tail lobes and inside the plasma sheet clearly indicate the ionosphere is supplying a large amount of ionospheric H+, O+ (He+, O++) ions to the magnetospheric mid-tail both during quiet and disturbed periods. Hydrogen ions and beams of oxygen ions are quasi systematically detected inside the lobe and inside the PSBL, flowing tailward with velocities of the order of 30-80 km/s. These ions are later energized deeper inside the plasma sheet. We analyze in detail the dynamics of this ionospheric magnetotail component, particularly during episodes of fast field aligned flow events of magnetospheric ions inside the PSBL: they drift perpendicular to the local B field either under the influence of diamagnetic pressure effects inside the flow itself or under the action of the electric field fluctuations associated with large alfvenic waves in the vicinity of the flow. Heating processes of oxygen ions inside the plasma sheet are briefly discussed.

SM21D-04 1105h

Characteristics of the Magnetotail Current Density from Cluster Observations

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We present observations of the inferred current density in the magnetotail current sheet from Cluster magnetometer measurements during summer 2001. In particular, the average directions and magnitudes of the current density have been examined for approximately 25 current sheet encounters between July and October 2001. Considerable variation is observed in the current density magnitudes. The current sheet encounters have been organized in local time and we find that the cross-tail current density is not strictly organized along Y_{GSM} across the entire magnetotail. Large deviations from Y_{GSM} are observed at the flanks of the magnetotail. The current sheet encounters have also been organized by solar wind conditions and geomagnetic activity indices. We find that the current sheet becomes more disordered during intervals of increased geomagnetic activity and often the Y-component of the current density is not the dominant component. We will use substorm onset times determined from ground magnetometer observations to gauge changes of the tail current sheet direction and magnitude during substorms. This behavior will be explored for individual current sheet events and also in a superposed epoch analysis.