## SM52B CC: 516 B Friday 1030h

### Magnetopause, Mantle, and Low-Latitude Boundary Layer *(joint with SH)*

*Presiding:* **M M Kuznetsova,** NASA Goddard Space Flight Center; **J D Scudder,** University of Iowa

**SM52B-01 1030h**

### Orientation and Motion of a Discontinuity from Multi-spacecraft Measurements: Minimum Variance of Current Density

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A technique to derive magnetopause key parameters such as orientation, velocity and thickness from multi spacecraft observations is presented. The method is based on four-spacecraft determination of the current density, variance analysis to estimate the orientation and thereafter integration of the current density across the magnetopause boundary layer to find the magnetopause velocity. We show an application to Cluster data and compare the results with those from other multi-spacecraft methods as well as single-spacecraft methods such as minimum variance of the magnetic field combined with deHoffmann-Teller analysis and the minimum Faraday residue method. The results provide important quantitative validation of the curlometer application.

**SM52B-02 1045h**

### Reconstruction of two-dimensional magnetopause structures using multi-spacecraft information from Cluster

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The Grad-Shafranov reconstruction technique, a single-spacecraft based data analysis method for recovering approximately two-dimensional, time-stationary magnetic field structures in space, has been successfully applied to magnetopause crossings by the Cluster spacecraft [Hasegawa et al., 2004]. In this study, this technique is extended such that a single magnetic field map, which is optimal under the condition that the structures are two-dimensional and time-independent, can be produced, utilizing data from more than one spacecraft as input. The plasma pressure, information about which is required for the technique, is measured directly for only two of the spacecraft (C1 and C3), but, with the help of spacecraft potential measurements available at all four spacecraft, the pressure can be estimated also at the other spacecraft, based on a relationship between plasma pressure and estimated electron density at C1 and C3. As a result, four independent field maps are reconstructed and are merged into a single map. The resulting map appears more accurate than the single-spacecraft based ones, in the sense that agreement between magnetic field variations predicted from the map to occur along each of the four spacecraft and those actually measured is significantly better. However, such a composite map does not satisfy the Grad-Shafranov equation any more. We show, based on the reconstruction results, that the magnetopause surface is not planar, but has a significant curvature, even on a scale of a few thousand km, and that the thickness of both the current sheet and the boundary layer attached inside can occasionally be larger than 3000 km. Reference: Hasegawa, H., B. U. O. Sonnerup, M. W. Dunlop, A. Balogh, S. E. Haaland, B. Klecker, G. Paschmann, B. Lavraud, I. Dandouras, and H. Reme, Reconstruction of two-dimensional magnetopause structures from Cluster observations: Verification of method, Ann. Geophys., in press, 2004.

**SM52B-03 1100h**

### Cluster and Geotail Observations of Kelvin-Helmholtz Waves on the Dusk Flank Boundary Layer Under Northward IMF Conditions

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The four Cluster spacecraft observed three-minute-period waves near the dusk flank boundary layer during an equatorial passage of almost 20 hours at a location near 1900 LT on November 20-21, 2001. For most of this interval the IMF remained quite steady and northward while a slowly decreasing solar wind kinetic pressure moved the magnetopause outward causing it to remain near Cluster. During this interval the inbound Geotail spacecraft also observed waves as it moved through the boundary layer near 1500 hours. Cluster continually moved back and forth between a higher-density tailward-flowing magnetosheath plasma with cool isotropic ∼30 eV electrons and a lower density, lower-tailward-velocity boundary layer plasma with anisotropic field aligned electrons nearer 80 eV. Outbound transitions from the boundary layer to the magnetosheath were characterized by rapid, ∼10-20 second rotations to a more northward external magnetic field. Motion of the waves across the spacecraft suggests boundary thicknesses of about 600 km or 10 ion gyroradii and wavelengths on the order of 6 Re. Returns to the boundary layer were much more gradual creating the sawtooth appearance often seen in previous measurements. These transitions were seen successively at the four spacecraft with 5-30 s delays at spacecraft separation distances that ranged up to ∼2000 km. Boundary normals determined from a minimum variance analysis on the magnetic field usually agreed within ∼5 degrees at the 4 spacecraft and were consistent with normals determined from the interspacecraft delays. Outbound normals exhibited tilting toward the sunward direction as is typical for boundary waves. The recurrence periodicity of a few minutes is that often seen for Kelvin-Helmholtz waves in this boundary region. Compressible MHD theory carried out using the measured conditions at Cluster indicate local KH instability with maximum growth rates for wavelengths comparable with observations.

**SM52B-04 1115h**

### Investigating the Structure of the Low-Latitude Boundary Layer at Multiple Altitudes in a Cluster-FAST Magnetic Conjunction

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We examine the structure of the duskside low-latitude boundary layer (LLBL) during an event on 7 December 2000. This crossing is particularly suitable for such a study because Cluster remained in the LLBL for several hours. While the IMF $B_y$ was mostly negative, $B_z$ changed polarity several times, allowing us to examine the concomitant changes in LLBL structure. We compare the Cluster measurements with data from FAST at ∼ 3500 km altitude and with ground-based data. We remove the effect of magnetopause oscillations via a numerical technique. We investigate oscillations of the magnetopause, layering of the LLBL, and the relationship between LLBL structures and field-aligned currents in the auroral region. We will compare these observations with theories about structure of the LLBL.

**SM52B-05 1130h**

### Maps of Precipitation by Source Region, Binned by IMF, with Convection Streamlines

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We present maps of ionospheric precipitation regions (cusp, mantle, polar rain, etc.) binned by the interplanetary magnetic field (IMF), with SuperDARN convection patterns gathered under the same conditions, and with the same magnetic coordinates, superposed. The SuperDARN patterns have been transformed into an inertial coordinate system for better comparison with the particle satellite data (which is not co-rotating). The maps, which include the both the nightside and dayside, are created in a fully automated fashion, with, for example, the cusp centered at its centroid latitude for each half hour bin of MLT, with a width equal to the statistical difference between the poleward and equatorward edges. The mantle asymmetry about noon does not fit the pattern expected from simple theoretical considerations (namely that the mantle should be thicker postnoon for By<0 in the northern hemisphere). The mantle is appreciably thicker prenoon than postnoon, especially for By>0, but also even for By<0. This asymmetry matches the SuperDARN convection flows, in which, irrespective of the sign of By, most of the conversion of closed field lines to open occurs prenoon. Quantitatively expressed, for southward IMF, the potential encompassed by flux crossing the open-closed boundary prenoon (0600-1200 MLT) exceeds that for postnoon (1200-1800 MLT) by 30 kV to 15 kV for By>0, and by 30 kV to 20 kV for By<0. Details of the mantle shape match variations in the convection patterns. Only about 25-35% of the dayside open-closed field line conversion occurs near

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the cusp. Matching the convection patterns with the particle data shows that most field lines are converted from closed regions to open away from noon. Merging is thus active throughout the frontside magnetosphere. Field lines which merge well away from noon do not experience enough particle inflow against the solar wind velocity to produce anything more than a weak, deenergerized (mantle) precipitation in the ionosphere. The sign of IMF By also controls where most of the nightside conversion of flux from open to closed occurs. For example, Bz<0 and By>0, 31 kV reconnects from 1800-2400 MLT, and 14 kV reconnects from 0000-06000 MLT.

### SM52B-06 1145h

## A Comparison Of Cluster And Polar Energetic Particle Fluxes On November 13, 2003

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Unusual energetic electrons Pitch Angle Distributions (PADs) were found on the dusk side of the magnetotail of the earth's magnetosphere using data collected by the Cluster and Polar satellites on November 13, 2003. Both satellites at 0830 UT were located at approximately 20 MLT and at radial distances of about 9 and13 RE, respectively, when both Polar and Cluster observed a significant increase in the fluxes of energetic electrons and ions. The Cluster C2 (Salsa) spacecraft was being operated in a special mode known as NM3 for the RAPID investigation that permitted the detailed three-dimensional distribution of energetic electrons to be fully resolved. The period of the observations showed initially a peaked at 90-degree pitch angle distribution that first evolved into an isotropic distributions for the electrons and then the PAD distribution further evolved into a distinct butterfly distribution. The most straightforward interpretation of the Cluster measurements was that these fluxes were demonstrating pitch angle dependent drift dispersion as the electrons drifted from the location of the magnetopause. The differences and physical implications between Polar and Cluster measurements will be presented and discussed in detail.

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# SM53A CC: 220 C-E Friday 1330h

## Double Layers in Space and Astrophysical Plasmas III Posters *(joint with SA)*

***Presiding:*** **R J Strangeway,** University of California, Los Angeles**; M E Koepke,** West Virginia University

### SM53A-01 1330h POSTER

## The Local Time Propagation of Electron and Proton Shock-Induced Aurora and the Role of the Interplanetary Magnetic Field and Solar Wind

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Shock-induced aurora observed with satellite-borne ultraviolet imagers shows distinct characteristics from the more common and extensively studied aurora generated during magnetospheric substorms. It is initiated in the noon sector immediately following dynamic pressure pulses associated with the arrival of enhanced solar wind plasma at the front of the magnetosphere. The brightness enhancement rapidly propagates toward the dawn and dusk sectors and may trigger the development of an auroral substorm on the nightside. The FUV imaging system on board the IMAGE satellite has the ability to discriminate between proton and electron precipitation. This feature has been used to study the morphology and dynamics of the electron and proton precipitation following pulse-induced magnetospheric perturbations. A set of 14 cases occurring during positive and negative Bz periods has been selected and studied. A different dynamics is observed for aurora caused by electron and proton precipitation. The important role played by the Bz component of the interplanetary magnetic field is analyzed as well. A correlation between the precipitated power deduced from FUV images and solar wind (SW) and interplanetary magnetic field (IMF) measured by ACE is presented. The effect of SW and IMF conditions prevailing before and during the shock on shock aurora is studied separately in order to distinguish the role of the preconditioning of the magnetosphere and the effects induced by the shock itself. The time evolution of the injected power is also studied in the entire oval and in individual MLT sectors.

### SM53A-02 1330h POSTER

## Details on Parallel Electric Fields and Shocks in Downward Auroral-Current Regions From Theory and Satellite Data

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This poster provides the details for a companion paper by a similar title given in session SM03. In that presentation, a method for determining the parallel electric field ($E_{\parallel}$) and/or electrostatic shocks for downward auroral-current regions that includes wave-particle interactions was given. We derive the multi-moment fluid equations for a weakly inhomogeneous, magnetized plasma where the Vlasov-Maxwell hierarchy is used to treat the particle dynamics and the Fokker-Planck method is used to calculate the momentum (anomalous resistivity) and energy (anomalous heating) transfer rates between the waves (turbulence) and the particles. Two major assumptions are necessary: (1) a renormalized kinetic theory for the turbulence either exists or can be developed; and (2) both the length and frequency scales between the single-particle distributions and the fluctuations are separable. Some implications of these assumptions are briefly discussed: for example, we can show that the multimoment fluid equations for a plasma in thermal equilibrium obey the Fluctuation-Dissipation Theorem. For electrostatic turbulence, both the momentum and energy transfer rates are functionals of the renormalized spectral density of the fluctuating electric field and the renormalized dielectric function. For downward currents, we may approximate the momentum and energy transfer rates by using FAST satellite data for the renormalized spectral density, the conservation laws, and a scaling assumption for the renormalized dielectric function. Using FAST data for the particle velocity moments as a boundary condition, we may integrate the multimoment fluid equations both upward and downward from the satellite altitude in order to determine the potential and the particle velocity moments as functions of distance along the geomagnetic field line. We analyzed a winter FAST satellite pass near local midnight at ∼4130 km which shows a downward current region having a latitudinal width of about 45 km. At each subinterval (∼1.5 km) along the pass, we found a double layer (DL) below the satellite altitude; a transition (T) region just above the DL region where strong electron thermalization and intense ion heating occur; and a long range potential (LRP) region extending from the top of the T region to several earth radii and beyond. In the LRP region, ion conics are produced and further electron thermalization occurs. The average altitude of the DL/T region is in good agreement with experimental observations. Our analysis suggests that the formation of the DL, the particle dynamics, and the turbulence are intermittent in space and time. We also calculated the anomalous resistivity in the LRP region and showed that it has a very small effect on $E_{\parallel}$ (< few %) and that $E_{\parallel}$ is determined primarily by the velocity-space anisotropy and pressure gradient terms in the momentum balance equation. A similar analysis is in process for an upward auroral-current region.

### SM53A-03 1330h POSTER

## Nature of Parallel Electric Fields in a Diverging Auroral Flux Tube with Upward Current

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Using one-dimensional (1-D) particle-in-cell (PIC) simulations of a diverging magnetic flux tube we have studied the distribution of parallel electric field in response to an applied potential drop. Hot and cold plasma populations as appropriate for the upward current region are included. When an appropriate warm secondary electron population at the ionospheric boundary is included in the simulations, we find that a rarefaction shock forms near the boundary and it accelerates the ionospheric ions upward. But this feature occurs only in the early stages of the simulation while in the late stages the rarefaction shock disappears when the ionosperic cold electrons are heated by wave particle interactions. We further find that the total potential drop in the flux tube only occasionally occurs in a single strong double layer (DL). Often it is distributed into substructures as multiple double layers (DLs), which are highly dynamic and evolve continually via plasma turbulence consisting of both electron and ion time scales. Averaging the fast fluctuations at the electron time scales, the potential distribution across the DLs yields spiky parallel fields, which evolve with ion-acoustic and ion hole turbulence. We compare our results with observations from satellites.

### SM53A-04 1330h POSTER

## Perpendicular Fine Structure Associated with Strong Auroral Double Layers

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2-D simulations of strong double layers have shown that fine structure perpendicular to B (e.g., filamentation) can form [Singh and Khazanov GRL 2003 and Newman et al., this meeting]. Here we will present observations by the FAST satellite, when it was on the high potential side of a strong double layer. For the event under consideration, the FAST satellite is moving more or less perpendicular to the normal of the large-scale double layer. However both electric-field and particle measurements indicate the presence of perpendicular fine structure, suggesting that the location (parallel to B) of the strongest parallel electric field (i.e., the potential ramp) is not uniform in the direction perpendicular to B. According to the observations, the perpendicular fine structure of the double layer appears to be less consistent with a continuously varying (e.g., sinusoidal) ramp location and more consistent with a segmented structure. The observations indicate that the perpendicular scale characterizing the transitions between the individual segments is smaller than the parallel distance between two adjacent segments. The distance (parallel to B) between the satellite and the potential ramp at any given time will influence the nature of the observed waves, with turbulent waves typically found closer to the ramp than are coherent field structures indicative of isolated electron phase-space holes. The different wave environments are also correlated with characteristics of the electron distribution. Specifically, turbulent waves are found to be associated with electron spectra that are fluctuating at multiple energies, whereas in regions dominated by electron phase space holes,modulations in the electron spectra are observed to be more mono-energetic. Ion conics are also seen on the high potential side of the double layer. Although these conics are believed to originate from the low potential side, signatures of local heating are also observed during times when the satellite is far from the ramp region. These observations will be discussed in the context of the existing simulation studies.