

SM32B MC: 300 Wednesday 1330h

Modes of Transport in Geospace:
Plasma Sheet and Ionosphere (joint
with NG, SA, SH)

Presiding: S Sharma, University of
Maryland; J Valdivia, Univ. Chile

SM32B-01 1330h

Upstream Magnetospheric Ion Leakage: A Tool to Characterize Magnetic Reconnection

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Following our study characterizing Low Charge State Heavy Ion (LCSHI) events in the upstream region far upstream the Earth's bow shock to the LI point, we present now a case study of a remarkable O⁺ and N⁺ ion outflow event. We present observational evidence for highly ordered outflow along a small reconnected field line region that takes place in the framework of a magnetic cloud of an ICME. From the particles' 3D distribution function we conclude that interaction of the outflow with the bow shock is minimal. Original gyrophases of outflowing ions at the reconnection point are randomly distributed. This leads to a flux tube with a clover-like geometry. The outflow reveals spatial dispersion and non-gyrotropy. The observations were performed by the Suprathermal Ion Composition Spectrometer (STICS) of the Wind spacecraft. In a 3D MHD simulation we point out the location of the reconnection region of the interplanetary magnetic field with the Earth's magnetosphere via field line mapping.

SM32B-02 1345h

Global Measurements of Reconnection and its Relationship to Magnetotail Transport

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Magnetic field reconnection rates and magnetotail magnetic flux and plasma transport rates have been calculated for different states of solar wind-magnetosphere coupling. The algorithm that quantifies the reconnection rates combines the location, orientation and rate of displacement of the polar cap boundary, identified from POLAR images, with a model of high latitude plasma convection determined with SuperDARN and Sondrestrom radars. The magnitude and rate of change of the reconnection potential determined with this algorithm is compared with the convection potential to establish a threshold that separates the substorm transport rate in the magnetotail from convection bay and storm transport rates. Simultaneous ionospheric convection and Geotail plasma, magnetic field and electric field measurements near the tail axis suggest a positive correlation among the magnitude and rate of occurrence of bursty bulk flows, the magnitude of nightside reconnection rate, and the local time extent of the reconnection region.

SM32B-03 1400h INVITED

Reconnection in the Earth's Plasma Sheet

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Magnetic reconnection plays an important role in the dynamics of the magnetotail by releasing large amounts of stored magnetic energy in the lobes and releasing plasmoids and flux ropes down the tail. It has recently been shown that the decoupling of the electron and ion motion due to the much larger mass of the ions allows fast reconnection to occur in collisionless systems. This decoupling of the ions and electrons due to the Hall term in Ohm's law is manifested either as whistler physics or as kinetic Alfvén physics, depending on the angle between the reconnecting field lines. The nature of this fast collisionless reconnection will be reviewed. In addition, the role of non-ideal physics in the shocks associated with reconnection, and instabilities and turbulence in three dimensional reconnection will also be discussed. Results from 2D and 3D simulations of reconnection using two-fluid, hybrid, and full particle simulations will be presented.

SM32B-04 1420h INVITED

The Self-Organized Critical Plasma Sheet and Substorm Onset

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Our recent analyses of electrojet index and Polar UVI image data have added to the evidence for self-organized criticality (SOC) in the magnetospheric dynamics. These analyses will be reviewed. The results support our earlier suggestion that this SOC component of the dynamics is centered in the plasma sheet and that it is related to the flow bursts and associated localized reconnections that have been observed there. It is necessary now to develop an interpretation of SOC in a plasma physical context. A plasma sheet model that may evolve into SOC will be discussed. The model contains a two-dimensional resistive MHD component coupled to a current driven instability that generates anomalous resistivity when and wherever the current density exceeds a critical threshold. In general terms, the model strongly couples fluid phenomena at MHD scales with kinetic phenomena at ion scales in an idealized manner. This strong coupling between such divergent scales introduces the possibility of multi-scale behavior in the intervening range of scales, and thus to the possibility of scale-free self-organized criticality. Numerical simulations of the plasma sheet model will be presented. The model exhibits quiet loading intervals interspersed with extremely dynamic unloading intervals during which magnetic flux is both annihilated and lost through plasmoid ejection. Based on the simulation results, a possible mechanism for the transition in the plasma sheet from sporadic localized reconnection to global organized reconnection at or near substorm onset will be discussed.

SM32B-05 1440h

Kinetic Simulations of thion current sheets: prediction and comparison with CLUSTER observations

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We have carried out two- and three-dimensional kinetic plasma simulation of the stability and decay of thin current sheets. We demonstrate the consequences of their instability in both the current- and the reconnection direction. We found a number of cases when CLUSTER was well positioned for a multi-point investigation of current sheets. The constellation of four spacecraft allowed us to determine the sheet thickness and - dynamics independently. It appeared that thin current sheets can be found at substorm onsets as well as without substorms. The observed dynamics of the sheet evolution compares well with the simulation results. The observations allowed us to verify main theoretical predictions.

URL: <http://www.linmpi.mpg.de/~buechner>

SM32B-06 1525h

Phase Transition-like Behavior of Magnetospheric Substorms: Global MHD Simulation Results

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Because of their relevance to massive global energy loading and unloading, lots of observations and studies have been made for magnetic substorm events. Using nonlinear dynamical techniques, we investigate whether the simulated substorms from global MHD models have the non-equilibrium phase transition-like features revealed by Sitnov et al. [2000]. We simulated 6 intervals of total duration of 240 hours from the same data set used in Sitnov et al. [2000]. We analyzed the input-output (vB_s -pseudo-AL index) system obtained from the global MHD model and compared the results to those in Sitnov et al. [2000, 2001].

The analysis of the coupled vB_s -pseudo-AL index system shows the first-order phase transition map, which is consistent with the map obtained for the vB_s -observed-AL index system from Sitnov et al. [2000]. The explanation lies in the cusp catastrophe model proposed by Lewis [1991]. Although, the comparison between observation and individual global MHD simulations may vary, the overall global transition pattern during the substorm cycle revealed by Singular Spectrum Analysis (SSA) is consistent between simulations and observations. This is an important validation of the global MHD simulations of the magnetosphere. The coupled vB_s -pseudo-AL index system shows multi-scale behavior (scale-invariant power-law dependence) in singular power spectrum. We found critical exponents of the non-equilibrium transitions in the magnetosphere, which reflect the multi-scale aspect of the substorm activity, different from power-law frequency of autonomous systems. The exponents relate input and output parameters of the magnetosphere and distinguish the second order phase transition model from the self-organized criticality model. We also discuss the limitations of the global MHD model in reproducing the multi-scale behavior when compared to the real system.

SM32B-07 1540h

Spatially Resolved WINDMI Substorm Model

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A new high-dimensional Solar Wind Driven Magnetosphere-Ionosphere model called WINDMI.SR has been constructed to address the issue of the propagation of compressional Alfvén pulses and mini-shocks up and down the magnetotail. The Tsyganenko-96 model is used to calculate a large inductance matrix that describes, along with the local central plasma sheet polarization capacitance vector, the solar wind driven interactions in the geotail and their coupling through field aligned nightside current loops to the auroral and polar cap ionosphere. The diagonalization of the large, symmetric inductance matrix gives the eigen modes of the system ranging from the global one hour mode of the Global WINDMI model to one minute modes. For large substorm energy releases the compressional pulse fronts steepen forming mini-shocks. For a midtail unloading event an N-shaped pulse travels both Earthward and tailward. The Earthward traveling pulse is partially reflected and partially transmitted to the dissipative ionosphere. The communication between the two substorm onset regions – auroral field lines and the midtail NENL region – are studied in some detail in the new model. When supplemented with an external northward turning trigger, this substorm model can successfully compete with neural networks in reproducing the essential features of the standard substorm databases. The model is based on plasma physics equations and has properties such as charge and energy conservation and causality intrinsic to the physical laws.

This work was supported in part by the National Science Foundation Grant ATM-9907637.

SM32B-08 1555h

Double Layers, Electron Scattering and Anomalous Resistivity in 3-D Magnetic Reconnection

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In the case of a simple reversed magnetic field, simulations in three dimensions have revealed that collisionless magnetic reconnection remains nearly two-dimensional. The strong current layers which form near the x-line in 2-D simulations remain completely stable in 3-D while the slow shocks which bound the outflow region downstream of the x-line exhibit weak lower-hybrid-drift turbulence which does not significantly impact the rates of reconnection. Reconnection in the presence of a guide field is much more dynamic. The guide field slows the convection of electrons away from the x-line, which enables the reconnection electric field to accelerate electrons in this region to very high velocity. The resulting magnetic-field-aligned electron beams are two-stream unstable. The instability nonlinearly develops into distinct double layers, in which regions of locally intense electric fields form on spatial scales of 10's of Debye lengths. These intense electric fields scatter the electron beams, causing strong electron heating and a large effective resistivity. The nonlinear development of the system is being explored with full particle simulations using up to one billion particles to understand the conditions under which these structures develop and their impact on electron energization and the rates of reconnection in magnetospheric and astrophysical systems.

SM32B-09 1610h INVITED

Direct Observation of Parallel Electric Fields of the Aurora

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We report direct measurements of parallel electric fields, electron distributions, and ion distributions related to particle acceleration in the downward current region of the aurora. The observations suggest three distinct, narrowly-confined regions along the magnetic field (*B*) that are related to a strong double layer. In the "ramp" region, the parallel electric fields are hundreds of millivolts per meter and indicate a monotonic potential ramp localized to ~10 Debye lengths along *B*. On the high-potential side of the ramp, an unstable electron beam is seen for roughly another ~10 Debye lengths along *B*. In this "beam" region, the characteristic energy of the electrons matches the potential of the ramp. The electron beam is rapidly stabilized in a region with intense electrostatic waves and nonlinear structures interpreted as electron phase-space holes. The region of electrostatic turbulence is spatially separated from the ramp by the beam region. The parallel electric field structures are observed to move along *B* in the same direction as the accelerated electrons at roughly the ion-acoustic speed. Numerical simulations reproduce similar spatial makeups, electrostatic structure, and plasma characteristics of the observations. These results suggest that large double layers can account for the parallel electric field in the downward current region and that intense electrostatic turbulence rapidly stabilizes the accelerated electron distributions. These results also demonstrate that parallel electric fields are associated with the generation of large-amplitude electron phase-space holes and plasma waves.

SM32B-10 1630h

Simulation of Current-Driven Double Layers in the Auroral Ionosphere

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Recent FAST satellite observation [Ergun et al., *PRL*, **87**, 045003 (2001)] provide detailed measurements of a strong localized parallel electric field in the downward-current region of the auroral ionosphere. The results of new 1-D Vlasov simulations show that a strong electrostatic double layer, possessing a DC electric field with a spatial structure that is in good agreement with the FAST observations, develops from a weak density depression in a current-carrying plasma. The double layer produces a beam of accelerated electrons that interact with background electron on the high-altitude side resulting in a near-continuous series of electron holes via the electron two-stream instability. The electric-field signature of these holes is also in agreement with the FAST observations, including a characteristic gap between the location of DC field and the hole turbulence. Stages in the formation and eventual disruption of the double layer will be illustrated using phase-space and field diagnostics.

Research supported by grants from NSF and NASA.

SM32B-11 1645h

The role of electron-ion instabilities in the development of phase space holes from localized self-consistent electric fields (double layers)

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One-dimensional Vlasov simulations have shown that a localized self-consistent electric field (double layer) can develop in a current-carrying plasma when an initial density depression is imposed (Newman, contributed paper, this conference; Newman, et al. 2001). The localized field accelerates electrons in one direction and ions (much more slowly) in the opposite direction. The accelerated electrons interact with a slower electron component to create growing waves via a two-electron-stream instability. These waves then trap the electron beams and create fast-moving electron holes. On a slower time scale, after the ions have been accelerated in the opposite direction an electron-ion instability occurs. The growing waves move slowly in the direction of the ions and trap both ions and electrons leading to an alternating train of ion and electron phase space holes (Goldman, et al. 2001). We interpret the simulations in terms of these electron-ion instabilities and further describe how yet another electron-ion instability, (a cold Buneman instability) may play a role in the destruction of the double layer.

D.L. Newman, M.V. Goldman, R.E. Ergun and A. Mangeney, "Formation of Double Layers and Electron Holes in a Current Driven Space Plasma, submitted to Phys. Rev. Lett., 2001

M.V. Goldman D.L. Newman and R.E. Ergun, "Phase space holes due to electron and ion beams accelerated by a current-driven potential ramp," submitted to Nonlinear Processes in Geophysics, 2001

This work was supported by NASA and NSF.

SM41A MC: 135 Thursday 0830h

Van Allen Lecture - Magnetospheric Imaging: Promise to Reality

Presiding: J T Gosling, Los Alamos National Laboratory

SM41A-01 0835h INVITED

Magnetospheric Imaging: Promise to Reality

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There is no abstract available for this presentation.

SM41B MC: Hall D Thursday 0920h

Magnetosheath, Magnetopause, and Dayside Magnetosphere

Presiding: S Wing, The Johns Hopkins University Applied Physics Lab; D G Sibeck, JHU/APL

SM41B-0781 0920h POSTER

INTERBALL-1 Observations of Turbulent Plasma Upstream to the Earth's Bow Shock

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