

Ions are accelerated upward along the Earth's magnetic field to form ion beams. We compare the beam location normalized to the location of the auroral zone to the density, energy, number flux, and energy flux of H^+ , He^+ , and O^+ for about 290 ion beams measured with the FAST satellite during winter 1997. We see ions with energies above 2 keV only in the poleward half of the auroral zone, and larger energy fluxes are more likely to occur at higher latitudes. There may be a decrease in density of H^+ and an increase in number flux of He^+ as FAST moves poleward.

SM42A-09 1330h POSTER

Nightside Auroral Zone Outflow as a Function of Substorm Phase

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Ion outflow measurements made by the TEAMS instrument on the FAST spacecraft during the months of December 1996, and January and February 1997 are used to study the relationship of ion outflow flux to substorm phase. During this time interval there were over 220 moderate to large substorms imaged by the UVI camera on Polar. The UVI data are used to determine substorm onset times, and the duration of the expansion and recovery phases. FAST passes through the nightside auroral zone within 30 minutes before onset or during expansion and recovery were then used to characterize the suprathermal (≥ 8 eV) H^+ , He^+ , and O^+ flux from the auroral zone. Nearly all of the substorms are represented with outflow measurements because of the two-hour orbital period of FAST and the fact that most of the storms can last up to two hours. In a superposed epoch analysis we present maps of ion flux for different phases of a substorm, or as a function of time from onset.

SM42A-10 1330h POSTER

Polar Ionospheric Outflow Simulations and Observations

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We compare the ion field-aligned transport patterns simulated by an extended Dynamic Fluid semi-Kinetic (DyFK) model with those observed by the Thermal Ion Dynamics Experiment (TIDE) on board the POLAR satellite near 5000 km altitude over the southern hemisphere polar ionosphere. The DyFK model couples a moment-based fluid model for altitudes from 120 - 1100 km to a generalized semi-kinetic treatment for the topside through 3 RE region. Various processes, such as cleft/auroral soft electron precipitation, transverse ion heating by ion cyclotron waves and hot plasma-driven potential drops are incorporated into the generalized semi-kinetic treatment of topside ionosphere. The simulated field-aligned velocity is upward in the dayside cleft/aurora region, while it turns downward and tends to increase in magnitude across the polar cap from dayside to nightside. This pattern of the simulated flows is in good agreement with the observation. The simulated ion densities and field-aligned fluxes also follow the tendencies of those observed.

URL: <http://cspar.uah.edu/~tuj>

SM42A-11 1330h POSTER

Relationship of Vertical Ion Flows and Topside Electron Temperature

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We present four periods of vertical/field-aligned O^+ flow parameters observed by DMSP12 and DMSP13 at 840 km when they passed the southern polar region near simultaneously during April 1996, together with POLAR observations at 5000 km near the same measurement period. This presentation provides a snapshot of the O^+ vertical flow velocities and O^+ densities as they relate to electron temperatures along distinct satellite tracks passing through both the expected cleft and auroral regions, and the polar cap region. We find some correlation between vertical velocity and electron temperature along the DMSP spacecraft tracks, but only a weak correlation between the vertical velocity and electron temperature was shown in the statistics for the whole period when both flow velocity and electron temperature were measured. Downward O^+ flows occurred only for the lower (<4000 K) electron temperature regions. When electron temperatures were lower than 3000 K, the O^+ densities generally increased as the electron temperatures increased. However, when the electron temperatures were greater than 3500 K, the O^+ densities generally decreased as the electron temperatures increased. Different physical processes may correspond to these different correlation relations between O^+ densities and electron temperatures.

SM42A-12 1330h POSTER

Transport of Photoelectrons in the Nightside Magnetosphere

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Kinetic modeling results are analyzed to examine the transport of photoelectrons through the nightside inner magnetosphere. A natural filter exists on the nightside for these particles, with Coulomb collisions eroding the distribution at low energies and low L shells, and magnetospheric convection compressing the flux tubes as they corotate towards dawn. This leads to an electron population with very distinctive features. It is shown that, for low activity levels, a band of photoelectrons forms between L=4 and 6 that extends throughout the nightside local times and into the morning sector. Modeled energy and pitch angle distributions are presented to show the development and features of this electron band, as well as their influences on the thermal plasma. Such a population should be observable in satellite spectrometer measurements.

SM42B CC: Hall C Thursday 1330h

Progress in Magnetic Reconnection Research in Space and Laboratory Plasmas III - Posters (joint with SH)

Presiding: M Yamada, Princeton Univ.; D Rust, Johns Hopkins Univ.

SM42B-01 1330h POSTER

Diamagnetic Stabilization of Magnetic Reconnection

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Observations show that strong pressure gradients exist at both the earth's magnetopause and in tokamak sawtooth oscillations, but the effect of these gradients — and their accompanying diamagnetic drifts — on the nonlinear rate of magnetic reconnection is not completely known. Earlier fluid simulations of such tokamak configurations have suggested that the rate,

which decreases as the plasma β increases, can be significantly altered.

To address the question we present 2-D particle simulations of magnetopause-like configurations of the pressure and magnetic field. Our results show strong asymmetries in the region surrounding the X-line as well as a large, presumably diamagnetic, motion, of the X-line itself. We also discuss the impact of the pressure gradients on the reconnection rate.

SM42B-02 1330h POSTER

Simulation of Collisionless Reconnection: Embedding of Particle Hall-MHD Calculations Within a MHD Simulation

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Collisionless reconnection involves both Hall physics and kinetic effects occurring at small scales in thin current sheets. Including these effects in a large scale MHD simulation is essential to correctly model the magnetotail dynamics during substorms. To address the issue of how kinetic treatment for the ions affects the reconnection dynamics, a study of two-dimensional collisionless reconnection in a thin current sheet is conducted using hybrid and Hall-MHD simulations that include the full electron pressure tensor in Ohm's law while neglecting resistivity and electron inertia. Comparison of fluid-ion and particle-ion dynamics demonstrates that off-diagonal elements of the ion pressure tensor are important to correctly model the ion out-of-plane momentum transport from the X point. It is shown that these effects can be modeled efficiently in Hall-MHD simulations in a predictor/corrector manner that uses particle ions to implement the ion gyro-radius corrections. We investigate the micro-macro-scale coupling in the tail dynamics using a new integrated approach in which particle Hall-MHD calculations are embedded inside a MHD simulation. The propagation of waves between the two regions both along and across the magnetic field are examined. Initial results of the embedded simulation concerning current sheet thinning and reconnection dynamics are discussed.

SM42B-03 1330h POSTER

Reduction of momentum transfer rates by parallel electric fields: a two-fluid demonstration

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Momentum transfer between an ionized gas cloud moving relative to an ambient magnetized plasma is a general problem in space plasma physics. Obvious examples include the Io-Jupiter interaction, comets, and coronal mass ejections. Active plasma experiments have demonstrated that momentum transfer rates associated with Alfvén wave propagation is poorly understood. Barium injection experiments from the Combined Release and Radiation Effects Satellite (CRRES) have shown that dense ionized clouds are capable of $E \times B$ drifting over large distances perpendicular to the magnetic field. The CRRES "skidding" distances were much larger than predicted by MHD theory and it has been proposed that parallel electric fields were a key component in the "skidding" phenomenon (Delamere et al., *Physics of Plasmas*, 7, 2000). A two-fluid code was used to demonstrate the role of parallel electric fields in reducing momentum transfer between two distinct plasma populations. In this study, a dense plasma was initialized moving relative to an ambient plasma and perpendicular to B . Parallel electric fields were introduced via a friction term in the electron momentum equation and the collision frequency was scaled in proportion to the field-aligned current density. The simulation results showed that parallel electric fields decreased the decelerating magnetic tension force on the plasma cloud through a magnetic diffusion/reconnection process.

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SM42B-04 1330h POSTER

The Excitation of Electrostatic Lower Hybrid Waves in the Plasma Sheet Region: A Kinetic Description

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We investigate the excitation of electrostatic lower hybrid waves in the magnetic field reversal region of the plasma sheet using a gyro-kinetic description for electrons and Vlasov's equation for ions. Considering a two-dimensional magnetic field configuration for the tail, we examine the effects of curvature drift and gradient-B resonances and derive an eigenvalue differential equation for studying the electrostatic wave characteristics. We show that the gradient in the x-component of the equilibrium magnetic field drives the electrostatic mode unstable in the field reversal region. The growth rate solutions for various tail parameters are plotted as a function of wavenumbers. This work highlights a possible dissipation mechanism for triggering magnetic reconnection processes and subsequent substorm onsets.

SM42B-05 1330h POSTER

The Effect of Single Particle Dynamics in Collisionless Reconnection

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The question of which mechanisms can allow rapid changes of the magnetic field topology in collisionless plasmas is addressed in a laboratory experiment, based on the MIT Versatile Toroidal Facility (VTF). In this presentation we focus on mechanisms that are present at the level of single particle orbits, for cases in which the strength of the magnetic field perpendicular to the reconnection plane (the guide field) is comparable to, or smaller than that of the field on the reconnection plane (the cusp field).

Similarly to space plasmas, the electron mean free path is much longer than the characteristic length of particle orbits, considered for the VTF case of the order of the dimensions of the plasma cross-section. Hence, particle orbits are expected to influence the macroscopic plasma dynamics during the development and sustainment of reconnection.

We find analytically and demonstrate experimentally that reconnection driven by an electric field along the X-line can take place in a collisionless plasma, in a magnetic cusp with a relatively weak guide field without a macroscopic current layer, consistently with the effect of particle orbits. This study led to three main conclusions.

First, because particles are mirror trapped, a reconnection electric field, E_z , does not provide acceleration of the particles in its direction parallel to the X-line. This allows the reconnection to proceed at the externally imposed rate, the same as in vacuum.

Second, in the limit of massless particles, an electrostatic potential, Φ , is developed self-consistently by the plasma on the reconnection plane to avoid charge separation. This potential was calculated analytically and has been measured experimentally for the first time.

Third, particles drift across the plane perpendicular to the X-line at the Ware-pinch velocity (E_z/B_{xy}). This drift speed is independent of the electrostatic potential Φ . This "frozen in law" at the single particle level is expected to break along the separatrix where different mechanisms can remove the steep gradients in Φ . High resolution measurements of the structure of the electrostatic potential are being performed to identify such mechanisms, and will be discussed at the conference.

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SM42B-06 1330h POSTER

Imaging of Turbulent Mode Patterns in the Magnetic Reconnection Experiment

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Turbulent plasma motions have been observed to accompany the process of magnetic reconnection in the Magnetic Reconnection Experiment. Probe measurement shows large amplitude fluctuations with broad spectrum to be present during reconnection. These fluctuations may contain a clue to the nature of the anomalous resistivity responsible for the fast non-classical reconnection of the magnetospheric and coronal magnetic fields. However, the identification of the nature of the instability and its propagation properties with probes is made extremely complicated due to the lack of data on the orientation of the three-dimensional wavevector. The Planar Laser-Induced Fluorescence (PLIF) Imaging technique provides a possibility to obtain 2-dimensional images of metastable ion density with high spatial resolution with exposure times of a fraction of the characteristic time scale of the fluctuations of interest. Equilibrium profiles of the ion density obtained with PLIF in MRX are compared to probe data and theoretical Harris equilibrium. PLIF image pairs obtained with a two-frame capable imager allow background emission subtraction and are expected to achieve theoretical photon-statistics-limited noise performance. The images will reveal the mode patterns of the density fluctuations. By showing turbulent wavefronts in 2D the PLIF images will provide wavenumber information in unprecedented detail and at least partially remove the uncertainty in the propagation measurement by probes.

SM42B-07 1330h POSTER

The Structure of Reconnection Layer and Ion Heating in a High Temperature Laboratory Plasma

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A high level of naturally occurring magnetic turbulence in the plasma of the MST reversed field pinch opens possibilities in studying the dynamics of reconnection in laboratory conditions. The plasma is in a toroidal configuration and is characterized by a high guiding magnetic field (0.5 T), high magnetic shear, high temperature (0.5 keV) and a corresponding Lundquist number of 10^6 . The fluctuations are identified as non-linear resistive tearing modes. The amplitude of the fluctuation is high enough so the separate magnetic islands overlap. In addition, this tearing activity exhibits sawtooth-like bursts when the fluctuation amplitude increases several-fold. Local, time resolved measurements of majority and minority plasma ion temperature reveal a large increase in the ion temperature during those discrete reconnection events; the ion temperature more than doubles. The change in the ion thermal energy is comparable to the magnetic energy released during the reconnection. The ions are heated throughout the entire plasma volume and the ion distribution function remains Maxwellian during the reconnection event with $T_{\perp} = T_{\parallel}$. The fluctuations in magnetic field and plasma current (the current sheet) associated with reconnection have been measured by probes in the plasma edge. The reconnection current layer is broad in the radial (cross-field) direction with the width larger than resistive MHD and electron skin depth. The layer width is comparable to a magnetic island width and also comparable to the ion skin depth.

SM42B-08 1330h POSTER

The Resistive Tearing-Mode Instability in Anisotropic Plasmas: Linear Analysis

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Tearing-mode instability may occur in various regions of space environment; for example, observational evidence has shown that the magnetopause current is often imbedded with a series of magnetic islands (Hau and Sonnerup, 1999). In this study, the tearing-mode instability of a tangential-discontinuity current layer is examined within the framework of two-dimensional, numerical, linear MHD model with anisotropic pressure which is the characteristic of space plasma as shown by the satellite data. The energy equations used to close the MHD model are the double-polytropic laws with two polytropic exponents, γ_{\parallel} and γ_{\perp} , which for $\gamma_{\parallel} = 3$, $\gamma_{\perp} = 2$ become the CGL laws and for $\gamma_{\parallel} = 1$, $\gamma_{\perp} = 1$ describe the isothermal state (Hau et al., 1993). It is shown that the dependence of the linear growth rate on p_{\perp}/p_{\parallel} and γ_{\parallel} , γ_{\perp} is consistent with the mirror instability criterion based on the double-polytropic MHD model (Hau and Sonnerup, 1993); in particular, the growth rate is larger for smaller values of γ_{\parallel} and γ_{\perp} . For sufficiently large p_{\perp}/p_{\parallel} greater than 1, the tearing perturbations no longer grow exponentially but contains oscillatory modes with the growth rate being greatly enhanced.

SM42B-09 1330h POSTER

Can Anomalous MHD Slow Waves Steepen Into Shocks?

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Since Petschek [1964] proposed his reconnection model, intensive studies have focused on the structure of slow shocks. The identification of slow waves or shocks from the enormous spacecraft data has been largely based on the criterion that across such structures the plasma density and magnetic field perturbations exhibit a negative correlation, a well known result based on the isotropic MHD theory. Linear MHD and Hall MHD theories have shown that slow waves propagating in a homogeneous anisotropic plasma may exhibit four anomalies: positive density-magnetic field correlation, faster propagation speed relative to the intermediate wave, right-handed polarization and steepening of rarefaction rather than compression wave. This study examines whether these anomalous slow waves can actually steepen into shocks by means of non-linear gyrotopic MHD and Hall MHD simulations. It is shown that slow shocks with the first three anomalies may form through the steepening of the corresponding large-amplitude slow waves, whereas the expansion slow shock can form only for certain forms of energy equations.

SM42C CC: 207 Thursday 1330h

Magnetic Storm Development: Relative Roles of Convection, Particle Sources, and Substorms II (joint with SA)

Presiding: Y Kamide, Nagoya Univ.; G Rostoker, Solar-Terrestrial Environment Lab.

SM42C-01 1330h

IMAGE/HENA: ENA Observation of a Substorm Onset

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We present ENA images from above the north pole of a substorm onset on the 24 September, 2000. ENA emission appears at 1532 UT around $L=6$ at local midnight while Pi2 pulsations are observed at local midnight at approximately 1538 UT. The ENA emission is not visible above 40 keV due to the fall off of the charge exchange cross section with energy. However, there is no ENA emission below 16 keV for this event, which