the interior using a small halogen lamp, adsorbed neutral particles can be removed from the probe surface, allowing accurate plasma parameter measurements to be made. We present data indicating the effective times required for decontamination and any subsequent recontamination in the absence of heating under a variety of plasma and neutral gas conditions.

*Work supported by ONR.

SM51B-0527 0830h POSTER

In-situ observation of aurora fine structure and simulation of satellite-plasma interaction

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INDEX satellite is scheduled to be launched in 2004 by ISAS/JAPAN in order to investigate the aurora fine structure. This satellite is designed to fly polar orbit with hight of 680km. Main instruments are the electron/ion analyzer, the aurora camera and the impedance probe. All insturments are designed to measure small scale plasma parameters down to 100m scale. In order to distinguish background plasma phenomena from the disturbances due to the satellite itself, we have developed a new simulation code which simulates electromagnetic environment in the vicinity of a spacecraft. This code solves plasma particle behavior as well as background electric and magnetic field. The simulation code adopts unstructured-grid as the spatial coordinate system. This enables us to model 3-dimensional shape of the spacecraft. We will be able to show the results from the spacecraft charging simulations and possible applications to the observation of plasma fine structure in the earth's auroral region.

URL: http://www.isc.nipr.ac.jp/˜mokada

SM51C MCC: 133 Friday 0830h

Magnetic Reconnection: Theory and Observation *(joint with NG, SH)*

Presiding: **M Shay,** University of Maryland**; A Otto,** University of Alaska, Fairbanks

SM51C-01 0830h

The Cessation of Magnetic Reconnection

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Collisionless magnetic reconnection has been a subject of continuing research for many years. Over the last ten years, considerable progress has been made in our understanding of the physics of the dissipation region. More recently, a number of research activities have focused on the onset of magnetic reconnection. The question of how and why magnetic reconnection terminates, however, remains largely unaddressed by past and present research. In order to shed some light on this problem, we present results from particle-in-cell simulations of magnetic reconnection, which take into account the presence of different plasmas in the reconnection inflow region. We will show that sufficiently massive plasma populations, such as potentially provided by oxygen beams of ionospheric origin, can substantially slow down or terminate the reconnection dynamics. Further emphasis will be on the acceleration of such plasmas in the reconnection process.

SM51C-02 0845h INVITED

Observations of Electron Holes and Their Relationship to Magnetic Reconnection

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Recent observations from the Polar satellite and new 3d particle simulation results have provided evidence suggesting that electron holes may play an important role in the dynamics of reconnection. Solitary waves (the electric field signature of electron holes) are commonly observed in and near the magnetopause current layer during subsolar, equatorial crossings of the magnetopause. The solitary waves had amplitudes up to 40 mV/m, velocities from 150 km/s to >2000 km/s, and scale sizes the order of a kilometer (comparable to the Debye length). Almost all the observed solitary waves were positive potential structures with potentials of 0.1 to 5 Volts. Positive potential solitary waves moving with velocities of 1000s of km/s are consistent with electron phase-space holes. Drake et al. [2002] have shown that electron holes develop in 3d particle simulations of reconnection, which include a guide magnetic field. The electron holes strongly scatter the electrons, and produce anomalous resistivity. The experimental and theoretical results provide strong support for the idea that electron holes play a critical role in the reconnection process at the Earths magnetopause and may, therefore, be important in other regions where reconnection occurs. We will discuss Polar and Cluster observations of electron holes at the magnetopause to adress this idea.

SM51C-03 0905h INVITED

Development of Electron Holes and Anomalous Resistivity in 3-D Magnetic Reconnection

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Magnetic reconnection with a guide field is explored with full particle simulations and theory to understand the development of turbulence and anomalous resistivity and its impact on the rate of reconnection and particle heating. Electrons around the magnetic x-line and separatrices are accelerated to high velocity by the reconnection electric field. The resulting magnetic-field-aligned electron beams are unstable to Buneman as well as current driven lower-hybrid waves. The Buneman instability evolves into distinct nonlinear structures consisting of localized regions of bipolar parallel electric field with net positive charge, "electron holes". The electron holes are localized both parallel and transverse to the magnetic field with scale lengths of 10's of Debye lengths. The holes couple strongly to a current driven lower-hybrid wave. The complex nonlinear interaction bewteen the electron holes and lower hybrid wave controls both the lifetime and the spatial distribution of electron holes parallel to the magnetic field. The interaction of the electron beam with the turbulence produces extended tails on the electron velocity distributions. The turbulence induced anomalous resistivity is spatially patchy and highly time dependent. Comparisons are made with recent observations of electron holes at the Earth's magnetopause [Cattell, et al., 2002]. Implications for magnetic reconnection and particle energization in space and astrophysical plasmas are discussed.

SM51C-04 0925h

Small Scale Magnetopause - Cluster Interferometric Measurements

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Recent observations by Cluster spacecraft have shown the existence of very narrow boundaries within the magnetopause having large electric fields associated to them. These narrow layers can be associated with large Poynting flux and several hundred volt potential drops. We study in detail the structure of these narrow regions using interferometry measurements between different probes (100m) on the same spacecraft as well as between different spacecrafts (100km). Thus we can estimate the phase speed of the narrow structures with respect to the magnetopause as well as their temporal and spatial character. We study several events with different large scale properties of the magnetopause to see the possible relation between the narrow structures and the large scale phenomena at the magnetopause (e.g., reconnection).

SM51C-05 0940h INVITED

Study of Fast Reconnection in Laboratory Plasmas

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With abundant data from space satellites and the recently developed laboratory experiments, there exist many opportunities for collaborative study between space and laboratory experimental research. In this talk, we highlight the recent laboratory experimental data from the MRX device [1] in comparison with the space observations [2] as well as with the recent numerical simulations[3] addressing a major question why the observed reconnection rates are much faster than predictions by the classical theories, such as the Sweet-Parker model. There exist two leading theories for the underlying physics: one based on laminar 2D structures due to the Hall terms in the generalized Ohms law and another based on resistivity enhancement (or the so-called anomalous resistivity) due to the inherently 3D micro-instabilities. Experimental efforts are under way to study both mechanisms in MRX, where the fast reconnection rates have been regularly observed in the low collisionality regime. A fine structure probe with spatial resolution of 1 mm (2-3 electron skin depth) is being installed. Also a special focus will be put on the electrostatic and magnetic turbulence which have recently been identified in the neutral sheet. The details of the characteristics of the turbulence measured by Hodogram probe and internal pick-up probes will be presented along with theoretical interpretations and discussions on its relation with the observed fast reconnection in space. Work supported by DOE, NASA And NSF. 1. M. Yamada et al., Phys. Plasmas 4, 1936, (1997) 2. F. Mozer et al, Phys. Rev. Letts. 15002, 1, (2002) 3. M.A. Shay et al J. Geophys. Res. 103, 9165 (1998)

URL: http://w3.pppl.gov/˜mrx/

SM51C-06 1000h

Laboratory Observation of Fast Collision-less Magnetic Reconnection

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Plasma dynamics around a magnetic X-point and magnetic reconnection in the collisionless regime are studied on the Versatile Toroidal Facility. Ar and H plasmas are created by ECRH with densities and temperatures in the range of 10^{17} m^{-3} and 20 eV. The magnetic configuration is based on a magnetic cusp forming an X-line at the center of the device and a toroidal magnetic field. Reconnection is driven by inducing a toroidal electric field using an ohmic transformer.

The response of the plasma is measured in terms of poloidal distribution and time evolution of plasma density, flows, magnetic flux and currents. Fast collisionless reconnection is observed experimentally. The detailed evolution of the profiles of plasma density, current density, and electrostatic potential at the onset of driven reconnection is reconstructed experimentally in the collisionless regime, for the first time. Despite a constant, externally imposed reconnection drive, we show that the reconnection does not proceed in a steady-state manner. The formation and decay of the current is shown to be related to the evolution of the electrostatic potential and the associated ion polarization currents.

The size of the diffusion region is inferred from the detailed knowledge of the electrostatic potential, and is shown to be insensitive to the ion mass and plasma density. Within the limit of two fluid theories it is shown that electron momentum balance can only be fulfilled with the inclusion of off diagonal terms in the electron pressure tensor.

SM51C-07 1035h

Unraveling the Nature of Steady Magnetopause Reconnection Versus Flux Transfer Events

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Magnetic reconnection is a fundamental mode of energy and momentum transfer from the solar wind to the magnetosphere. It is known to occur in different forms depending on solar wind and magnetospheric conditions. In particular, steady reconnection can be distinguished from pulse-like reconnection events which are also known as Flux Transfer Events (FTEs). The formation mechanism of FTEs and their contolling factors remain controversial.

We use global MHD simulations of Earth's magnetosphere to show that for southward IMF conditions: a) steady reconnection preferentially occurs without FTEs when the stagnation flow line nearly coincides with the X-line location, which requires small dipole tilt and nearly due southward IMF, b) FTEs occur when the flow/field symmetry is broken, which requires either a large dipole tilt and/or a substantial east-west component of the IMF, c) the predicted spacecraft signature and the repetition frequency of FTEs in the simulations agrees very well with typical observations, lending credibility to the the model, d) the fundamental process that leads to FTE formation is multiple X-line formation caused by the flow and field patterns in the magnetosheath and requires no intrinsic plasma property variations like variable resistivity, e) if the dipole tilt breaks the symmetry FTEs occur only in the winter hemisphere whereas the reconnection signatures in the summer hemisphere are steady with no bipolar FTE-like signatures, f) if the IMF east-west field component breaks the symmetry FTEs occur in both hemispheres, and g) FTE formation depends on sufficient resolution and low diffusion in the model – coarse resolution and/or high diffusivity lead to flow-through reconnection signatures that appear unphysical given the frequent observation of FTEs.

SM51C-08 1050h INVITED

Comparison of Concepts and Simulations of the Sub-solar Magnetopause With Measurements

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The Polar Satellite experienced more than 1000 sub-solar magnetopause crossings during three spring months in 2001 and 2002. Features of these crossings that both agree with and differ from the static, two-dimensional, picture of the magnetopause will be discussed. In particular, the simple flow of plasma and Poynting flux into the magnetopause in the plus and minus x-directions and out along the plus and minus z-directions will be contrasted with an actual, much more complex, flow. Also, the measured current distributions and power dissipation will be compared with models.

SM51C-09 1110h INVITED

Magnetic reconnection in the magnetotail

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Observations with the spacecraft Geotail have added significantly to our knowledge of magnetic reconnection in the magnetotail. The structure and dynamics of magnetic reconnection have been studied at the MHD level. Detailed characteristics of ion and electron behaviors have been revealed with measurements of distribution functions with a high time resolution. An intriguing characteristic for ions is counterstreaming ions on the field lines that have a convection motion with a high speed. For these ions, one component moves parallel to the magnetic field and the other component moves anti-parallel to the magnetic field, and both have the same speed. These features are well reproduced in simulations for magnetic reconnection in hybrid and full particle codes. An unexpected characteristic for electrons is seen in the tail lobe-plasma sheet boundary near the reconnection site. High-energy electrons flow out of the reconnection site, while low-energy electrons flow into the reconnection site. These electrons are found to form part of the Hall current system. Furthermore, ions and electrons show motions to different directions, indicating the ion-electron decoupling. This is what is expected in the immediate vicinity of the magnetic reconnection site. Hence, various characteristics of magnetic reconnection have emerged at the kinetic level.

SM51C-10 1130h

CLUSTER Observation of Magnetic Reconnection in the Magnetotail: Comparison with Hall Physics Effects.

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During the August 17, 2001 ~16:20 substorm event, CLUSTER S/C were at apogee (~20 R_E) in the midnight region (~0100 MLT) and very close to the reconnection site. High velocity (~1000 km/s) tailward ion field aligned and ExB flows were observed while the B_Z component of the magnetic field was negative. These tailward flows were followed by two Earthward reversals. Low energy O^+ was observed in the inflow region with a dawnward direction while energetic O^+ was observed tailward of the reconnection site. The plasma sheet was very thin, ~1100 km, very variable in thickness and tilted in the Y-Z plane due to a strong B_y component of the IMF. Due to this very thin plasma sheet CLUSTER S/C probed almost simultaneously all regions, from the neutral sheet to the lobes. Variations in the magnetic field are consistent with the quadrupole structure produced by the Hall current system while the presence of electron beams towards the reconnection site indicate that we are observing the Hall current carriers. Electric field data show very strong low frequency fields. These observations will be compared to the theoretical models of collisionless magnetic reconnection and more specifically to the Hall physics effects.

SM51C-11 1145h

Formation, Characteristics, and Diagnostic Usage of Energetic Ions in the Near and Mid Tail

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The interaction of the solar wind with the Earth's magnetosphere results in global changes of the magnetic field topology and alters many plasma properties, with pronounced effects on both thermal and energetic particle populations. In our work, we investigate the energetics and dynamics of the magnetotail during active times. We have studied the ion-kinetic physics surrounding substorm onset and the development of near-Earth reconnection using large-scale, three-dimensional hybrid simulations (kinetic ions, electron fluid), in conjunction with models that describe the interaction with the ionosphere. Here, we concentrate on characterizing the origin, location, and timing of energetic ion fluxes. These particles are self-consistently energized in the simulations, reaching fluxes that significantly affect the energy and momentum balance of the system. When the ions reach geostationary orbit or low altitudes, their localization and timing serve as an excellent means of mapping and linking the respective magnetospheric and ionospheric regions and processes. We show how this linkage is in many ways more directly tied to relevant tail processes than that provided by alternative ionospheric signatures. Observationally, the presence of energetic ions is detectable not only in situ, but also remotely from the ground and by spacecraft (such as the IMAGE satellite) via characteristic emissions. We discuss our results in the framework of such observations.

SM52A MCC: Hall D Friday 1330h

ULF Waves and Their Role in Diagnosing the Plasmasphere I Posters *(joint with SA)*

Presiding: **B J Fraser,** University of Newcastle**; D L Gallagher,** NASA Marshall Space Flight Center

SM52A-0528 1330h POSTER

Measurements of the Mass Density Dependence Along Field Lines Using Toroidal Alfvén Frequencies Observed by the CRRES Spacecraft

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