the calculation of particle trajectories in these fields shows that the first adiabatic invariant can be well-preserved in spite of large changes in the fields over a particle gyro-radius. This opens the possibility of finding analytic relations between the parallel and perpendicular energies in an accelerating field. These relations can be exploited to obtain moments of the distribution functions.

We describe preliminary results from these studies and indicate how they might be further extended to help understand reconnection processes in the magnetosphere.

SM61A-0479 0830h POSTER

FULL PARTICLE SIMULATION OF SLOW WAVESFULL PARTICLE SIMULATION OF SLOW WAVES

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Magnetohydrodynamic theory predicts that the slow shock pairs should be generated by magnetic reconnection in the Earth magnetotail. One question is focussed on conditions/mechanisms responsible for the survival time of such waves. For this purpose, kinetic and nonlinear effects of the slow waves dynamics are analyzed with the help of a 1-2/2-dimensional electromagnetic full particle code (1-D in x-space and 3-D in velocity space) with periodic boundary conditions. At the initial time of the simulation, the particles are loaded with sinusoidal density perturbation (30% of its background value) in x-space with consistent sinusoidal magnetic field in z; these pertubations are provided by results issued from MHD equations. Magnetic field and density profiles have opposite phase as a slow wave nature. The simulations are performed for one long slow wave period that is considered to be enough for the wave steepening. Results show that kinetic effects speed up the slow wave steepening process so that $T_{steepening,PIC} << T_{steepening,MHD}$. Main difference between MHD theory and full particle simulation is that a strong competition between steepening and damping processes are observed. The wave steepening time is much less than the wave damping time ($T_{steepening,PIC} << T_{damping,PIC}$). In addition, both processes (i) have characteristic times less than one ion gyroperiod ($T_{steepening,PIC}$, $T_{damping,PIC} < T_{ci} << T_{slow}$), (ii) may complete in the initial stage of the simulation; this cause the linear growth of the longitudinal electrostatic field energy of the wave. After the wave is fully steepened, both processes may balance and cause the saturation in the growth of the longitudinal electrostatic field energy. Thus after the saturation, electrostatic field energy is mainly transferred to the ion kinetic energy; at the same time, a strong change in the magnetic field polarization is also observed.

SM61A-0480 0830h POSTER

Hall MHD and hybrid simulations of the magnetic reconnection: A comparative study

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Using hybrid simulations, it has been established that the sequence of discontinuities formed during the magnetic reconnection process do not match those predicted by single fluid MHD. It has also become clear that the Hall term plays a significant role in the reconnection process. So the natural question is whether the inclusion of Hall term alone will be sufficient to resolve the discrepancies observed between kinetic and MHD simulations of the reconnection process. To this end, we have made Hall MHD and hybrid (electron fluid, kinetic ions) simulations of both symmetric and asymmetric current sheets for anti-parallel as well as non-coplanar configurations. The Hall MHD simulations are made using two different models of constant as well as variable temperature. We specially focus on the detailed structure of the resulting core field (out- of-the-plane field component corresponding to BM component in boundary normal coordinates) in the two simulation methodologies. Hybrid simulations show (i) large-scale core fields that can extend to tens of ion inertial length across the current layer, (ii) current sheet instabilities in certain parameter regimes that lead to modulation of the current layer, and (iii) magnetic and plasma asymmetries about the neutral line for non-coplanar configurations. The extent and the level to which these features are captured in the Hall MHD regime will be examined in detail. Such a comparison will also help distinguish between kinetic and Hall MHD effects in the reconnection process.

SM61A-0481 0830h POSTER

Magnetic reconnection in symmetric and asymmetric configurations

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Magnetic flux ropes or plasmoids are observed both at the Earths magnetopause as well as in the magnetotail. The flux ropes are typically observed to have large out-of-the-plane component (the so-called core field). Such large core fields drastically change the mobility of the ions as well as the topology of the plasmoid/flux ropes. A number of explanations have been put forward to explain this core field. We have tested each concept, as well as several new possibilities in various domains. Our main tools of investigation were 2D and 3D hybrid codes (fluid electron, kinetic ions) running on parallel machines. The proper study of the core field required extending the simulations to much larger system lengths than before and running them for much longer times. Our findings regarding the validity of the various concepts for core field generation will be presented. The presence of an asymmetry in the current layer can have profound effects on the stability of the current sheet as well as the formation of the core field. This dependency will be explored in detail. Finally, we will show results on the possibility of the intermittent reconnection in 3D geometries.

SM61B MCC: 123 Saturday 0830h

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

Presiding: **P Chi,** University of California, Los Angeles**; K Takahashi,** Applied Physics Laboratory**; R E Denton,** Dartmouth College

SM61B-01 0830h

Ground-based ULF Wave Studies of the Plasmapause

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More than 25 years ago a major research effort was undertaken to examine the possibility of diagnosing the Earth's plasmapause through the use of ground-based magnetic field measurements of ULF waves. While the spatial resolution of the measurements was more broad than is desirable today, the program at that time, using an instrumented array of latitudinally-spaced stations in the northern hemisphere and a conjugate station at Siple Station, Antarctica, was a significant success by any measure. In addition to providing the first diagnostics of the plasmapause by ULF waves, the research also carried out joint "calibrations" of the technique using complementary and contemporaneous measurements by VLF waves, by total electron content (TEC), and by spacecraft. This talk reviews some of the intellectual background for the 1970's research program, presents a number of the central discoveries and understandings from the research, and provides a perspective on what might be used from that program to advance contemporary research in this field.

SM61B-02 0845h INVITED

Remote Sensing Plasma Dynamics of the Inner Magnetosphere Using ULF Waves

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Ground-based observations of ultra low frequency (ULF) magnetic field line resonant (FLR) oscillations may be used to remote sense cold plasma number densities in the magnetosphere. Detecting FLRs on the ground can be achieved in a number of ways. Several of these experimental methods will be illustrated.

For mid to high latitudes, the plasma mass density remote sensing techniques based on simple exponential plasma density models give reasonable agreement with spacecraft electron density measurements. For the inner magnetosphere, the Alfven speed varies along the magnetic field direction in such a way that the lower altitude plasma population becomes important. Techniques for freeing the estimates of plasma mass density from density models can be devised if harmonics of the resonant oscillations can be obtained. The development of these methods is important for remote sensing the inner magnetosphere. The few techniqes developed so far will be discussed.

SM61B-03 0905h

Theory and Data Analysis of ULF Field Line Resonances : Comparisons with Global MHD models

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ULF Alfven waves, propagating inside closed flux tubes of Earth's magnetic field, can form standing waves in the magnetosphere. These standing waves are known as field line resonances (FLRs) and are commonly detected by ground-based instruments and by satellites. The properties of FLRs are related to global magnetospheric topology and to the plasma density along their path. Therefore, their study can provide three-dimensional information about the structure of the magnetosphere, and of the processes driving large scale magnetospheric dynamics. We use magnetic field lines and ion densities generated by the BATS-R-US global MHD model to estimate FLR frequencies for several characteristic sets of solar wind parameters, as well as for several specific dates when FLRs were observed. We find that despite numerous approximations of the MHD model, and our simple technique for the frequency calculation using a WKB and full-wave approximation, we get reasonable estimates for observed FLR frequencies. We present results for discrete FLRs, and for the Alfven continuum.

SM61B-04 0920h INVITED

The Role of the Plasmapause in Magnetospheric MHD Waves

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The plasmapause as the boundary region between the inner and outer magnetosphere provides a complex

barrier for compressional MHD waves. Through analytical and numerical methods, we investigate various properties of MHD wave dynamics near the plasmapause. At this barrier, we quantitatively estimate in an exact manner how compressional waves are reflected and transmitted as well as converted into shear modes. It is found that compressional MHD waves are strongly absorbed or piled up near the plasmapause without the mode conversion, which arises owing to the fact that the Alfven speed has a crest rather than a monotonic inhomogeneous profile. In addition, we discuss the effect of dipolar geometry, which is important in the plasmaspheric ULF wave activities. It is shown how the azimuthal size of the driving source is associated with the plasmaspheric wave domain. We also introduce recent numerical studies on the effect of non-axisymmetric plasmasphere by adopting a realistic three-dimensional density profile, which is obtained from the IMAGE satellites. Wave signatures of polarization and frequencies are examined at various local times.

SM61B-05 0940h INVITED

ULF Waves as a Diagnostic Tool: Results From Cluster

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ULF waves are ubiquitous in the Earth's magnetosphere, and have been used as a diagnostic tool for some time now. The only problem that prevailed was simultaneous observations by spacecraft close together. Only accidental conjuctions of spacecraft occurred. Since the launch of Cluster and full operability starting late 2000, we have obtained 4 similar spacecraft that simultaneously measure the magnetospheric environment. In this talk we will highlight some of the diagnostic possibilities of ULF waves and show examples of how Cluster expands the power of this diagnostic tool.

SM61B-06 1020h

Electromagnetic Ion Cyclotron Waves and Enhanced Plasma Regions or Plumes in the Middle Magnetosphere: CRRES Results

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One of the possible contributors suggested for ring current particle loss processes in the middle magnetosphere is pitch angle diffusion by electromagnetic ion cyclotron (EMIC) waves. While there have been numerous satellite and ground observations of EMIC waves reported during the main and recovery phases of geomagnetic storms there have been very few observations of the plasma environment conditions under which these waves are observed. The question may be asked; do they occur in detached plasma regions convected away from the plasmapause bulge in the classical sense, or are they related to plasma dynamics associated with plasma plumes and other plasmapause phenomena recently seen by the IMAGE spacecraft? In this study we use EMIC wave and plasma data from the magnetic and electric field, and plasma wave experiments onboard the CRRES spacecraft and observed outside the plasmapause. Of particular interest is the association of EMIC wave amplification and propagation within enhanced plasma regions and the characteristics of these regions. A number of individual events will be discussed in this context.

SM61B-07 1035h INVITED

Geosynchronous Observations of Quasi-Periodic Variations in the Dayside Magnetospheric Magnetic Field

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A variety of processes have been invoked to explain isolated and quasi-periodic events seen near the magnetopause and in the ionosphere at the feet of magnetic field lines that map to the vicinity of the dayside magnetopause. Geosynchronous orbit offers an excellent vantage point to distinguish between these mechanisms. Recent work indicates a one-to-one relationship between compressional perturbations in the dayside geosynchronous magnetic field and solar wind dynamic pressure variations on time scales greater than 10 min, obviating any need to invoke cavity mode resonances. The geosynchronous signatures of magnetic reconnection and magnetopause erosion are far weaker, and can only be identified on quiet days or via statistical methods. While compressional perturbations in the dayside geosynchronous magnetic field on time scales ranging from 1 to 15 min generally cannot be associated with solar wind dynamic pressure variations seen by spacecraft far upstream, they can often be associated with pressure perturbations generated by kinetic processes within the foreshock. This close relationship, the fact that the events move in the direction predicted for solar wind features striking the magnetosphere, and the absence of any tendency for the events to occur during periods of high solar wind velocity or southward IMF orientation, suggests that pressure variations drive magnetopause motion with amplitudes far larger than those associated with bursty merging or the Kelvin-Helmholtz instability. Pressure pulses generated within the foreshock also offer an opportunity to explain observations of nearly constant magnetopause motion and the large scatter noted when the locations of magnetopause crossings are binned by solar wind parameters. When the fast mode waves launched by the solar wind dynamic pressure variations intersect abrupt density and pressure gradients at the inner edge of the low-latitude boundary layer (and possibly the outer edge of the plasmasphere), they generate field-aligned currents and corresponding isolated and quasi-periodic ionospheric events. Geosynchronous observations can be used to distinguish between the various models proposed to account for these events.

SM61B-08 1055h INVITED

ULF waves and energetic electron dynamics in the outer zone

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The presence of magnetospheric ULF waves serves not only as an indicator of the physical processes and changes occurring within the magnetosphere, but may also serve as a source of energy driving the dynamics of various magnetospheric particle populations. Observations show a high correlation between the presence of ULF waves and increases in energetic electron fluxes in the outer zone radiation belts. In this region, waves with periods of tens of minutes can drift-resonantly interact with energetic electrons, efficiently transporting the electrons into regions of different magnetic field strength and adiabatically changing their energy. With appropriate gradients in the distribution of energetic electrons, this can lead to a net increase in the fluxes observed in the outer zone. In this work we review observational evidence for the association between ULF waves and energetic particle events, discuss conditions under which ULF waves may adiabatically energize particles, and examine evidence for particle distributions that might lead to a net increase in radiation belt fluxes. A case study, that of the September 24-26, 1998 geomagnetic storm, is used as a context for discussing that part of energetic electron dynamics which might be attributed to interactions with magnetospheric ULF waves.

SM61B-09 1115h

Compressional Trapped-Particle Mode : A New Generating Mechanism for ULF Waves

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A new plasma instability mechanism is proposed here for ULF magnetic pulsations in high beta magnetospheric plasmas. Here, beta is the ratio between plasma and magnetic pressures. In previous theoretical models,such pulsations are generated via either mirror mode or Alfven-ballooning mode(ABM) and their variations. While the mirror mode requires stringent high beta and/or strong anisotropy plasma conditions, the ABM is often stablized by the trapped-particle compression and takes the form of weaker instabilities via the drift-bounce resonances. Given high beta and sharp pressure gradients, however, we note that the plasma may form magnetic well, and, hence, the magnetic-gradient drift being opposite to the diamagnetic drift. A slow-magnetic compressional instability may then be excited; as noted by Rosenbluth two decades ago. We have , in the present work, further developed Rosenbluth's theory by including wave-partcile resonance and ,assuming specific velocity distributions, derived a dispersion relation variationally. Both analytical and numerical results on the instability properties and the implications to observations such as the storm-time Pc5 pulsations will be discussed. Work supported by DoE and NSF Grants.

SM61B-10 1130h

Synoptic Studies of the Plasmasphere's Shape by Imaging

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Regular imaging by the IMAGE Extreme Ultraviolet Imager reveals the shape of the plasmasphere and the sharpness of the plasmapause over a variety of geomagnetic conditions. Each image characterizes the plasmasphere at a wide range of local times, and so is equivalent to many simultaneous in-situ measurements. To take full advantage of this new capability, new techniques in data interpretation are needed. We have developed an approach based on binning large numbers of images according to selection criteria such as the Kp index, Dst, and the time derivative of Dst. Each composite image so formed represents the time-averaged configuration of the plasmasphere under the conditions defined by the selection criteria. To reduce errors introduced by changing viewing perspective as IMAGE moves in its orbit, we select images from near apogee. As a further step in compensating for changes in viewing perspective, before adding we transform each image from the plane of the sky as seen by EUV to the plane of the magnetic equator. The transformation algorithm identifies the geomagnetic field line that is tangent to each pixel's line of sight, and assigns the pixel's brightness to the intersection of the field line with the equatorial plane. We show examples of the composite images derived by this procedure for a range of conditions, and compare the plasma distributions inferred from these images to existing models and measurements of the plasmasphere.

SM61B-11 1145h

First start-to-end global imaging of a sunward propagating giant undulation event: IMAGE/FUV observations

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During intervals of very high convection, large-scale "giant undulations" are sometimes observed to develop on the duskside equatorward edge of the diffuse aurora and are thought to be due to the onset of a velocity shear instability at the plasma sheet-plasmasphere interface. Although these features were first identified in space-based auroral imager data (DMSP in the early 1980's), their dynamics have been explored almost exclusively with ground-based all-sky camera data (and consequently over only a limited spatial extent). Several high time resolution frames from the Freja imager have been reported previously, but the images were acquired over a very small time window and no motion of the undulations was detected. Here, we present the first ever high-time resolution global imaging of a sunward propagating giant undulation event from start to

S
M

finish. The event occurred on November 24, 2001 during a very disturbed storm interval. The giant undulations began to develop at around 13UT and persisted for approximately 2 hours. The sunward propagation speed was on the order of 0.6 km/s. In addition to the IMAGE/FUV observations (WIC, SI-12, and SI-13 passbands), numerous other datasets will be presented including ground magnetometer data which show that the undulations were associated with Pc5 type magnetic pulsations. Geosynchronous particle data and other IMAGE datsets will also be presented. Possible generation mechanisms for the giant undulations will be discussed.

SM62A MCC: Hall D Saturday 1330h

Discontinuous Cusp and Magnetospheric Boundary Layers I Posters

Presiding: **M J Engebretson,** Augsburg College**; Q Zong,** Boston University

SM62A-0482 1330h POSTER

Solar Wind Control of the Cusp Aurora for Northward IMF

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The Imager for Magnetopause-to-Aurora Global Explorations (IMAGE) Far Ultraviolet Instrument (FUV) images the auroral oval in doppler-shifted Lyman-alpha. On the dayside, a bright spot poleward of the auroral oval can be seen occasionally. This ionospheric spot can be interpreted as the location of the cusp created by intense proton precipitation through reconnection of magnetospheric lobe field lines for northward interplanetary magnetic field (IMF) conditions. In order to deduce the orientation of the IMF with regards to the Earths magnetic field during such a reconnection process, event conditions were selected between the end of May 2000 to mid-December 2001 during which the IMF was northward, steady, and had an higher than average density and velocity. Of these 344 events, 56 showed a bright spot. The occurrence frequency of a spot appears to be higher for small values of Bx/Bz. For the 56 cases with a bright spot, the spot location was compared with the predicted location of anti-parallel regions using the 1996 Tsyganenko model. The majority of the anti-parallel reconnection sites tailward of the cusp when mapped to the ionosphere coincide with the observed spot. For many of the cases, the solar wind parameters were outside of the Tsyganenko model. This may account for some of the discrepancy between the model and observations. The agreement between the model and observations for the majority of the cases is consistent with the hypothesis that reconnection occurs at anti-parallel regions for northward IMF.

SM62A-0483 1330h POSTER

Evidence for closed structures at the magnetopause: the case for multiple reconnections.

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We analyze two LLBL crossings made by Interball Tail satellite under southward magnetosheath magnetic field. Observed ion velocity distributions within LLBL include: (a) D-shaped distributions, (b) ion velocity distributions consisting of two counter-streaming components of magnetosheath-type, and (c) distributions with three components one of which has nearly zero parallel velocity and two counter-streaming components. We interpret these distributions as a natural consequence of the formation of spiral magnetic flux tubes consisting of a mixture of alternating segments originating from the magnetosheath and from magnetospheric plasma. The shapes of ion and electron velocity distributions and their evolution with decreasing number density in LLBL indicate that a significant part of LLBL is located on magnetic field lines of long spiral flux tube islands at the magnetopause, as has been proposed and found to occur in magnetopause simulations. Anomalous magnetosheath-like plasma flow with Bz component opposite to magnetosheath one was observed while IMF Bz remained negative. We consider these observations as evidence for multiple reconnections between magnetosheath and magnetospheric flux tubes.

SM62A-0484 1330h POSTER

Properties, Structure and Dynamics of the Exterior Cusp Under Northward IMF, Cluster Multi Event Analysis

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We have studied in detail multi-spacecraft observations of four Cluster exterior cusp passes during the years 2001 and 2002. All of them occurred during northward Interplanetary Magnetic Field (IMF) intervals. A well-bounded region where the magnetic field exhibits very low diamagnetic values and the ions display high levels of isotropisation is sampled. We refer to this region as the Stagnant Exterior Cusp (SEC). We show that the overall picture of the region is compatible with a reconnection site poleward of the cusp for all four events. The global topology of the exterior cusp and SEC can be inferred and reveals that the solar-wind plasma at least partly gets access to the magnetosphere through a sharp boundary delimiting the SEC from the unperturbed magnetosheath. Multi spacecraft data analysis further permits to highlight that the whole region is highly dynamic. The SEC-magnetosheath boundary presents abrupt changes in the magnetic field and plasma parameters and is shown to be rotational in nature. We will put particular emphasis on the exact characteristics and possible nature of this key boundary of the magnetosphere.

SM62A-0485 1330h POSTER

An Event Comparison of Global MHD Simulation and SuperDARN HF Radar in the North Polar Cusp

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On June 5, 1998 a number of the Northern Hemisphere SuperDARN HF radars recorded good backscatter in the cusp region from ∼14:00 to 16:00 UT, from which maps of ionospheric convection and backscatter widths have been derived. For comparison the time-varying Lyon-Fedder Global MHD model of this event has been simulated using IMP-8 and WIND spacecraft measurements of solar wind input. The time interval of interest is characterized by negative IMF Bz and negative IMF By following a positive IMF Bz interval. Good correspondence is found between the MHD model and the SuperDARN ionospheric convection patterns confirming that this is an excellent event for a detailed comparison of model and observation. The parameters to be compared include: ionospheric footprints of the MHD cusp plasma versus the location of large SuperDARN backscatter widths; MHD dayside open-closed field line boundaries versus SuperDARN determined open-closed boundaries and the convection flows relative to these boundaries; footprints of MHD merging regions versus features in the SuperDARN convection and backscatter widths. The overall purpose of these comparisons is to understand the SuperDARN observations in the context of the 3D magnetosphere and to investigate how SuperDARN can be used to identify cusp and magnetic merging regions.

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Multi-Spacecraft Observations of the Mid-Altitude Cusp

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Many aspects of the magnetospheric cusps, from how it should be defined to how various altitude measurements relate to each other, remain to be resolved. The Cluster mission, with its unique multi-spacecraft capabilities offer exciting new insights into the nature and structure of the mid-altitude cusps. Previous studies have shown the low-altitude cusps to be consistent with the Crooker antiparallel merging model. At high-altitudes, observations reported by Savin using Interball and Prognoz data indicate large amplitude, low-frequency waves in the Turbulent Boundary Layer just