SH32C MCC: 2000 Wednesday 1600h

Roles of Electromagnetic Waves in Reconnecting Space and Laboratory Plasmas III *(joint with SM)*

Presiding: **H Ji,** Princeton Plasma Physics Laboratory, Princeton University**; W Daughton,** Los Alamos National Laboratory

SH32C-01 1600h

Magnetic Reconnection in The Magnetotail: In Situ Cluster Multipoint Observations

Andrei Runov[1] (+43 316 4120 572; Andrei.Runov@oeaw.ac.at)

Rumi Nakamura[1] (Rumi.Nakamura@oeaw.ac.at)

Wolfgang Baumjohann[1] (baumjohann@oeaw.ac.at)

Martin Volwerk[1] (Martin.Volwerc@assoc.oeaw.ac.at)

Rudolf Treumann[2] (tre@mpe.mpg.de)

[1]IWF OEAW, Schmiedlstrasse 6, Graz A-8042, Austria

[2]MPE, Postfach 1312, Garching 85741, Germany

Being a constellation of four spacecraft, Cluster allows to discriminate spatial structures and temporal variations and provides the tools to determine the local system of reference and spatial gradient estimation. Using four-point magnetic field measurements we calculate the magnetic field curl and curvature vectors within flow reversal regions. This technique allows to map the X-line position and investigate plasma properties and magnetic field structure near and within a reconnection region. In this paper we review attempts to apply the multi-point data analysis methods to survey the 3-D magnetic and electric field structure, ion properties and wave activity for several examples of flow reversals, detected by Cluster at geocentric distance of 19 R_E in the magnetotail.

SH32C-02 1625h

Ion-ion kink instability in the magnetotail: Linear Theory, Simulations and Comparison with Observations

Elisa Nash[1] (enash1@san.rr.com)

Dietmar Krauss-Varban[1] (varban@ece.ucsd.edu)

Homa Karimabadi[1] (homa@ece.ucsd.edu)

William Daughton[2] (daughton@lanl.gov)

Philip Pritchett[3] (pritchet@physics.ucla.edu)

[1]UCSD, Dept. of ECE, MC 0407, La Jolla, CA 92093-0407, United States

[2]Los Alamos National Laboratory, Plasma Physics Group X-1, Los Alamos, NM 87544, United States

[3]UCLA, Dept. of Physics, Los Angeles, CA 90095-1547, United States

The magnetotail current layer is subject to a variety of instabilities. One of these is the ion-ion kink mode, arising from the presence of two ion populations - the cold lobe ions and the current-carrying hot plasma sheet ions. We have used linear theory, 3D hybrid (fluid electron, kinetic ions), and full particle simulations to examine the properties of ion-ion kink mode. We find that this mode is primarily driven by a velocity shear arising from the presence of multiple ion populations. The instability saturates as a result of broadening of the current layer and reduction of the velocity shear. This instability, however, differs in important aspects from the standard Kelvin-Helmholtz instability (KHI). Its linear mode properties exhibit dependencies on the kinetic details of the secondary ion population and its nonlinear evolution is found to be significantly different from previous MHD and Hall MHD treatments of the instability as well as from the KHI. In particular, the usual formation of vortices and coalescence that occur for the Kelvin-Helmholtz instability are absent for the ion-ion kink mode. Recent Cluster observations of modulated and bifurcated current sheets are discussed within the context of the ion-ion kink mode. Hybrid simulations with open boundary conditions and using the parameters for this event demonstrate a very good agreement between the wavelength, period, and amplitude of the ion-ion kink mode and the observed wave-like disturbance. It is shown that the observed "bifurcated" current sheet can be explained in terms of a traveling kink mode in which the current layer has a single continuous displacement into both hemispheres.

SH32C-03 1640h

Whistler-mode phenomena in electron MHD plasmas

Reiner L Stenzel (stenzel@physics.ucla.edu)

Department of Physics and Astronomy, UCLA, Los Angeles, Ca 90095-1547, United States

While the linear properties of plane whistler waves are well known, many new phenomena of bounded wavepackets and nonlinear effects are worth to describe. The present talk will review laboratory observations of whistler filaments, whistler vortices, whistler wings, whistler-sound modes in high-beta plasmas, nonlinear whistlers forming magnetic null points, and magnetic reconnection in EMHD plasmas. The time-varying magnetic field of a spatially bounded whistler wave packet consists of 3-D vortices. Each vortex can be decomposed into linked toroidal and poloidal field components. The self-helicity is positive for propagation along the field, negative for opposite propagation. Helicity injection from a suitable source produces unidirectional propagation. Magnetic helicity changes sign, i.e., is not conserved, when the propagation direction along **B** changes, for example due to reflection or propagation through a magnetic null point. In ideal EMHD the electric and magnetic forces on the electrons are equal, $-ne\mathbf{E} + \mathbf{J} \times \mathbf{B} = 0$, i.e., the electron fluid is not compressed. Force-free vortices do not interact during collisions. Vortices are excited with pulsed magnetic antennas or pulsed electrodes. Both transient currents and fields can form vortices that propagate in the whistler mode. Moving dc magnets or dc current systems can also induce whistler modes in a magnetized plasma. These form a Cherenkov-like radiation pattern, a "whistler wing." Nonlinear phenomena arise from wave-induced modifications of the electron temperature, density and magnetic field. In collisional plasmas electrons are heated by strong whistlers. Modifications of the classical conductivity leads to current filamentation. On a slower time scale density modifications arise from ambipolar fields associated with electron heating. In a filamentation instability a strong whistler wave is ducted along a narrow field-aligned density depression. The ion density is also modified by the ac electric field of low-frequency whistlers in high-beta plasmas. Pressure-gradient driven instabilities near the lower hybrid frequency produce coupled density and magnetic perturbations that propagate at the sound speed nearly across the field, forming a new whistler-sound mode. The net magnetic field is modified when the whistler magnetic field exceeds the background magnetic field. A field-reversed configuration (FRC) with two 3-D null points is produced. This EMHD structure does not propagate in the whistler mode. It elongates and precesses, which are manifestations of magnetic fields frozen into the electron fluid flow. The free magnetic energy is converted into electron heat by field line annihilation in the toroidal current sheet. No reconnection is seen at the 3-D spiral nulls. The energy dissipation is anomalously fast due to current-driven ion sound turbulence. In contrast to linear vortices, two FRCs do interact and merge into a single one. These basic properties of EMHD fields will be applied to cases of interest in space plasmas such as reconnection, strong turbulence, and possible active experiments. Work performed in collaboration with J. M. Urrutia, M. C. Griskey, and K. D. Strohmaier with support from NSF PHY.

URL: http://www.physics.ucla.edu/plasma-exp/research/

SH32C-04 1705h INVITED

Electromagnetic waves and anomalous resistivity in magnetopause reconnection

Stuart D. Bale[1] (bale@ssl.berkeley.edu)

Forrest S. Mozer[1] (fmozer@ssl.berkeley.edu)

[1]University of California, Berkeley, Space Sciences Laboratory University of California, Berkeley, CA 94720-7450, United States

Collisionless magnetic reconnection requires the presence of small-scale regions of intense electric fields near the x-line to break the frozen-flow condition and allow magnetic reorganization; this physics is embodied in the generalized Ohm's law. One such source of electric fields is that due to 'anomalous' resistivity associated with wave-particle interactions. Several wave modes have been suggested as agents of resistivity and, over the years, a body of data has been accumulated. We review observations of lower hybrid and whistler range electromagnetic waves at the terrestrial magnetopause, including new results from the Polar spacecraft near the neutral point. The potential role of anomalous resistivity is discussed in the existing data; typical wave amplitudes are a few orders of magnitude too small to account for significant resistivity, however, it may be that linear theories of wave-particle interactions are insufficient. We also propose observations required to identify the role of resistivity.

SH32C-05 1720h

Cluster Observations of Electromagnetic Waves in the Vicinity of a Reconnection X-Line at the High-Latitude Magnetopause

Tai D Phan[1] (phan@ssl.berkeley.edu); Stuart D Bale[1] (bale@ssl.berkeley.edu); Forrest S Mozer[1] (fmozer@ssl.berkeley.edu); Goetz Paschmann[2] (gep@mpe.mpg.de); Malcolm W Dunlop[3] (M.W.Dunlop@rl.ac.uk); Andre Balogh[4] (balogh@imperial.ac.uk); Nicole Cornilleau-Wehrlin[5] (nicole.cornilleau@cetp.ipsl.fr); Henri Reme[6] (reme@aneto.cesr.fr)

[1]UC Berkeley, Space Sciences Laboratory UC, Berkeley, CA 94720, United States

[2]MPE Garching, MPE, Garching 85740, Germany

[3]Rutherford Appleton Laboratory, Rutherford Appleton Laboratory, Oxford 0X11 0QX, United Kingdom

[4]Imperial College, Physics Department Imperial College, London SW7 2AZ, United Kingdom

[5]CETP, 10-12 Avenue de l'Europe, Velizy 78140, France

[6]CESR, CESR, Toulouse 31029, France

On March 18, 2002, under northward interplanetary field conditions, the Cluster spacecraft observed reconnection signatures and the passage of an X-line at the large (175 deg.) magnetic shear high-latitude magnetopause [Phan et al., 2003]. The X-line passage was indicated by the detection of reconnection jet reversal while the spacecraft were in the magnetopause. Here we examine the particle and field properties as a function of the distance from the X-line. In the vicinity of the X-line, intense electric field fluctuations are observed with amplitudes reaching 150 mV/m. The electric field fluctuation level is much reduced in the outflow region. In contrast to the electric field behavior, the magnetic field fluctuations are smaller in the vicinity of the X-line than in the outflow region. In terms of particle properties, D-shaped ion distributions (with low-energy cutoff at the deHoffmann-Teller velocity) are seen close to the X-line as well as in the outflow region. Phan et al., Simultaneous Cluster and IMAGE observations of cusp reconnection and auroral proton spot for northward IMF, Geophys. Res. Lett, 30(10), 1509, doi:10.1029/2003GL016885, 2003.

SH32C-06 1735h

Hall magnetohydrodynamics of inhomogeneous current layers

L Rudakov[1] (rudakovl@wam.umd.edu)

J D Huba[2] (huba@ppd.nrl.navy.mil)

[1]Berkeley Scholars, Inc., Backlick Rd, Springfield, VA 20434, United States

[2]Naval Research Laboratory, Plasma Physics Division, Washington, DC 20375, United States

Analytical and numerical results of the dynamics of inhomogeneous, reversed field current layers in the Hall limit (i.e., characteristic length scales less than or comparable to the ion inertial length) are presented. Specifically, the two and three dimensional evolution of a current layer that supports a reversed field plasma configuration and *has a density gradient along the current direction* is studied. We find that a density inhomogeneity along the current direction can dramatically redistribute the magnetic field and plasma via magnetic shock-like or rarefaction waves. The relative direction between the density gradient and current flow plays a critical role in the evolution of the current sheet. One important result is that the current sheet can become very thin rapidly when the density gradient is directed opposite to the current. Our results are applied to laboratory and space plasmas.

Research supported by NASA and ONR.