SH32D MCC: 3000 Wednesday 1600h

Interplanetary Physics IV

Presiding: **H S Ahluwalia,** University of New Mexico**; G M Webb,** Institute of Geophysics and Planetary Physics, University of California, Los Angeles

SH32D-01 1600h

Further Study of Isolated Electrostatic Structures in the Solar Wind

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A large number of short (sub-millisecond) waveforms has been observed by the Waves Time Domain Sampler on Wind. Similar waveforms have been analyzed by Mangeney et al (1999). They and Lacombe et al (2002) concentrated on double layer-like waveforms having a net potential change, but this study concentrates on electron hole-like waveforms with little potential change. The waveforms are compact, having Debye-length scales. They are often shorter than the X antenna, 100 m tip to tip, and this allows determination of their size and velocity. In many cases they are associated with magnetic discontinuities, and also in many cases occur in close proximity to ion acoustic wave bursts, from which they may evolve. Like the cases analyzed by Mangeney et al, they are quite weak, leading to electric fields of a few tenths of a millivolt per meter. Their structures are generally consistent with electron holes. Lacombe, C., C.Salem, A.Mangeney, D.Hubert, C.Perche, J-L.Bougeret, P.J.Kellogg, K.Goetz, J-M.Bosqued, "Evidence for the interplanetary potential? WIND observations of electrostatic fluctuations", Annales Geophysicae, 20, 609-618, 2002 Mangeney A., C.Salem, C.Lacombe, J-L.Bougeret, C.Perche, R.Manning, P.J.Kellogg, K.Goetz, S.J.Monson, J-M.Bosqued, "WIND observations of coherent electrostatic waves in the solar wind" Annales Geophysicae 17, 307-320, 1999

SH32D-02 1615h

A Variational Principle For MHD Waves In Non-Uniform Flows

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A variational approach for the propagation of linear MHD waves in a non-uniform background flow, such as the solar wind is developed. The analysis is based on the work of Dewar (1970) who used an averaged Lagrangian method to describe the interaction of WKB, MHD waves with a non-uniform background flow. Dewar's variational principle is used to describe non-WKB, MHD waves in a non-uniform background flow,including the effects of gravity and entropy wave disturbances.The equations consist of coupled wave equations for the Lagrangian fluid displacement, ξ, representing the Alfvén and magnetoacoustic waves, and the entropy advection equation for the Lagrangian entropy perturbation ΔS. In the case of steady background flows, with no entropy wave perturbations, the equations reduce to related equations used by Frieman and Rotenberg (1960) to study the stability of steady MHD flows.The characteristics of the equations are obtained by determining the characteristic manifolds on which the Cauchy problem for the waves does not have a unique solution. The characteristics are used to discuss the characteristics and Mach cone for steady MHD flows. A discussion is also given of stress energy tensors for the waves and background flow.

SH32D-03 1630h

Observations of Two-Component Upstream Ions by Cluster

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We report on observations by Cluster of two simultaneous upstream ion populations in oblique to quasi-parallel geometries, while the spacecraft were near (probably $\leq$ 1 Re) the bow shock. One stable 1–4 keV component can be seen to gyrate with small pitch angles, while a second, previously un-reported, 10–20 keV population gyrates with much larger pitch angles. A representative case on 23 April 2001 showed a 3–4 keV field-aligned beam change to a 1 keV population having field-aligned velocities 40% lower and pitch angles of $\sim 15^{\circ}$. This change occurred as the IMF rotated 10 degrees, producing a transition from an estimated shock geometry of $\theta_{Bn} \sim 45^{\circ}$ degrees to $\theta_{Bn} \sim 36^{\circ}$. The IMF also changed from being very steady to supporting large ULF waves. As the wave amplitudes reached peak values, a 20 keV gyrating component emerged, and this was observed to have pitch-angles of 60–80 degrees, and a narrow spread in gyrophase. After briefly presenting these and similar observations, we will discuss possible sources/mechanisms leading to the emergence of the simultaneous energetic component.

URL: http://sprg.ssl.berkeley.edu/~wilber/AGUFallMeeting2003/

SH32D-04 1645h

Two-Dimensionally Isolated Potential Structure in Foot Region of Quasi-Perpendicular Shocks

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We have performed full-particle shock simulations in a two-dimensional system to study how the shock tangential structure is important for electrostatic potential structures, which are excited in the foot region of a quasi-perpendicular shock. In the two-dimensional system, the shape of the electrostatic potential structure is not stable and is quickly transformed to isolated structures in both shock normal and tangential directions. The solitary structure is a result of an electromagnetic effect. The electric currents excited by the electron ExB drift motion diverge the potential structures.

SH32D-05 1700h

MHD Simulation and Novel 3-D Visualization of Magnetic Holes in the Solar Wind

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We examine "magnetic hole" regions in the solar wind where the magnetic field has decreased to very low levels over a time varying from minutes to hours. The structure of the regions is made clearer using multispacecraft observations seen with new 3-D visualization methods. We also present 3-D MHD simulations of regions in and near the heliospheric current sheet that suggest that at least some of the magnetic holes are associated with a previously unsuspected type of field configuration in which a near-null line forms in the center of spiraling magnetic fields. The fields do not undergo dynamical reconnection in the wind, at least at this level of simulation, but rather are convected out from as yet poorly understood field configurations near the Sun.

SH32D-06 1715h

Spectral Properties, coherent structures and correlations in Nearly Incompressible Hydrodynamics

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Observational evidence from Voyager and Helios space-craft indicate that density fluctuations in the Solar wind follow Kolmogorov-like spectrum which cannot be explained on the basis of purely incompressible models. These observations have led to the exploration of the relationship between density fluctuations and incompressible fluid models. This has resulted in the development of nearly incompressible (NI) hydrodynamics, which retains compressibility to first-order, producing (magneto)acoustic modes as well as convective modes. Depending upon the amplitude of thermal, pressure and density fluctuations there exist two distinct approaches to incompressibility. When density and temperature dominate the pressure fluctuations, the NI regime is called heat fluctuation dominated (HFD). On the other hand, when all the fluctuations are comparable heat fluctuation modified (HFM) NI regime results. The HFD regime predicts density-temperature anti-correlations, while HFM shows a 'modified pseudosound' relation. NI hydro and MHD have been surprisingly successful in the solar wind where predicted correlation are seen frequently and predicted anisotropies are observed. However, the basic nonlinear development of NI hydro and MHD remain completely unexplored. We have therefore initiated a comprehensive project to explore the nonlinear features of NI theory. We discuss three sets of results. 1) We find that the density fluctuations are described in the HFM limit by passive scalar dynamics rather than pseudosound dynamics, resulting in a density spectrum which is globally Kolmogorov-like with an exponent close to $-5/3$. The density fluctuations are found to be anisotropic in wavenumber space. 2) The background low frequency and first order high frequency NI modes mutually interact to produce nonlinear shear flows, also known as zonal flows. The zonal flows are primarily generated by effective Reynolds stresses. 3) Finally, for the HFD case, we show that the nonlinear interaction of the incompressible and nearly incompressible modes leads to a turbulent relaxation in which self-organization through an inverse cascade mechanism results in the formation of large scale compressive coherent vortices. The density and thermal fluctuations are also found to be anti-correlated.

SH32D-07 1730h

Acceleration and Transport of Diffuse Protons in the foreshock region of the Earth's Bow Shock

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We study the physical characteristics of diffuse protons in the region upstream of the earth's bow shock using the GEOTAIL data set of June-October 1994 which covers not only the nominal nose region (X>0) but also both the pre-dawn (X<0, Y>-70Re) and the post-dusk (X<0, Y<+60 Re) regions. (Note that the diffuse protons are observed in the post-dusk foreshock region when the IMF is in the 'anti-Parker' spiral direction.) What we have found are: (1) The diffuse protons in the pre-dawn and post-dusk regions have lower intensities and softer energy spectra than in the nose foreshock region. The exponential functional form of their energy spectra, exp(-E/Ec), which have been known from the earlier observations in the nose region, continue to the pre-dawn and post-dusk regions with reducing Ec. (As known in the nose region, we observe that Ec depends on the solar wind velocity and the IMF geometry. That Ec also depends on the spatial position is our new finding.) (2) These diffuse protons are more or less isotropic in the nose foreshock region but have anisotropic pancake distributions in the pre-dawn and post-dusk foreshock regions being convected with the ExB motion of the solar wind plasma. These observations provide important information on the acceleration and transport processes of diffuse protons in the foreshock region of the earth's bow shock.

SH32D-08 1745h

Large Scale Hybrid 2D Simulations of the Relaxation of an Initially Isotropic Spectrum of Alfven Waves

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In many situations observed in space plasmas, large MHD scales are believed to act as reservoir for a nonlinear cascade, bringing fluctuation energy to scales where kinetic processes (Landau or cyclotron resonnances) can transform them into thermal energy. These kinetic processes operate at smaller spatial scales and more rapid time scales, so that a numerical simulation describing both the nonlinear cascade and the kinetic processes were, untill recently, out of reach. The rapid increase of computing efficiency allows now to study the competition between these two processes in more realistic simulations. We present here 2D hybrid simulations (the protons are treated as particles and the electrons as a massless fluids) of the relaxation of an initially isotropic spectrum of Alfven waves. The dimensions achieved in these simulations can be as high as 1000x1000 cells in phsysical space (and 1000 particles per cell), with a resolution of a few tenth of proton inertial lentgh (the electric resistivity being chosen so that the "magnetic Reynolds" number is of the order of 50-100). By changing the plasma beta and the typical wavelength of the initial perturbations, we vary the relative efficiency of the cascade processes and the cyclotron absorption. The results shows a subtle interplay between these two processes, which depend on the initial level of fluctuations (which fixes the nonlinear overturning time). We shall also discuss the relvance of these simulations for the heating of the outer corona and solar wind.

SH41A MCC: 2010 Thursday 0800h

Coronal Magnetic Fields: Models to Measurements I

Presiding: **J Burkpile,** NCAR High Altitude Observatory**; J Kuhn,** University of Hawaii

SH41A-01 0800h INVITED

Pre-Eruptive and Eruptive Magnetic Structures in the Solar Corona

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One of the greatest difficulties in the development of models of coronal mass ejections (CMEs) and flares is the lack of information about the coronal magnetic field prior to its eruption. The situation is exacerbated by the fact that only the component of the magnetic field generated by currents flowing in the corona contributes to the energy release. The amount of energy released during a CME or flare implies that net change in the total magnetic field in the corona is no more than about 10 percent on average. However, there may be localized regions where the changes are significantly greater, perhaps on the order of 100 percent. The pattern of these localized changes can be used to distinguish between various models. For example, flux rope models of CMEs and eruptive flares imply that the transverse field at the base of the corona can reverse sign in the region immediately below the flux rope, but that the transverse field further away increases. Recent observational studies suggest that such CME and flare associated changes in the coronal magnetic field will not penetrate to the level of the photosphere, but will be confined to regions above an altitude of 400 km or higher. Thus, observations of the chromospheric and coronal fields are needed to make progress in understanding the mechanism of solar eruptions.

SH41A-02 0820h INVITED

The Coronal Magnetic Field Predicted by the Breakout Model

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Although there has been intense theoretical work in the past decade on coronal mass ejections/eruptive flares, the mechanism for their initiation is far from accepted. The problem is that the triggering of these events is believed to be magnetically-driven and to take place in the corona, but until very recently, the field there has not been observed directly. We discuss how the new developments in coronal field instrumentation will allow us to determine the mechanism for CME/eruptive flare initiation. We focus, in particular, on the so-called breakout model in which reconnection in the corona is postulated to be the triggering process. First, we present the latest numerical results on breakout. Then, we determine the predictions of the model for coronal magnetic observations, and discuss definitive tests of breakout that will be possible with the proposed new instrumental capabilities. This work was supported in part by ONR and NASA.

URL: http://solartheory.nrl.navy.mil

SH41A-03 0840h INVITED

The Magnetic Fields of Quiescent Prominences

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Since the discovery of coronal mass ejections (CMEs) in the 1970s, we have known that they have a high association (> 70%) with prominence eruptions. This association is also reflected by the many three-part CMEs having the associated erupted prominence as the dense core trailing behind the leading dense shell of the CME. The magnetic fields in a quiescent prominence are thus an important observable clue to the hydromagnetic environment capable of producing a CME. This was not appreciated in the observational efforts in the 1970s and 1980s to detect prominence magnetic fields by spectro-polarimetric methods, largely because it was a discovery phase of this observational development. The current renewed efforts to observe magnetic fields both in prominences and in the million-degree corona will offer an unprecedented opportunity to probe the coronal origin of CMEs. This talk will center upon certain interesting prominence and related properties useful to keep in mind in anticipation of that opportunity. The National Center for Atmospheric Research is sponsored by the National Science Foundation.

SH41A-04 0900h

Eruptive Behavior Originating in Active Regions

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Coronal mass ejections (CMEs) are spectacular manifestations of solar acitivy. These immense eruptions of plasma and magnetic field are propelled outward from the sun with velocities as high as 2000 km/s. The fastest CMEs typically originate from active regions on the Sun. MHD models of the eruption of large scale coronal fields have demonstrated significant energy release in idealized 2D (Antiochos et al., ApJ 512, 985, 1999) and 3D (Linker et al., Phys. Plasmas 10, 1971, 2003) geometry. Eruptive behavior has also been shown for a 3D localized arcade (Amari et al., ApJ 529, L49, 2000). In active regions on the Sun, both the localized field due to the active region and the overlying fields in the large scale corona are important. We describe MHD computations of the eruptive behavior of a localized active region field (modeled as a localized bipole) within a large-scale dipolar configuration. We discuss the differences between this more realistic configuration and the idealized configurations that have been considered previously. Work supported by NASA and the Center for Integrated Space Weather Modeling (an NSF Science and Technology Center).

SH41A-05 0915h

Models of Three-dimensional Flux Ropes and Their Stability

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A crucial problem in the study of coronal mass ejections is the understanding of the evolution prior to the eruption and the development of initial configurations and boundary conditions that can produce an eruption of the field configuration and the identification of observable features from these configurations. We present a general framework to derive approximate equilibrium configurations suitable to describe pre-eruption states, using an approach originally developed for the Earth's magnetotail but including magnetic shear and gravity. We illustrate the approach by deriving configurations for both force-free and non-force-free states. The variable models contain a twisted flux rope, connected to the photosphere and anchored in the corona by an overlying arcade. The models may also include a magnetic configuration above the flux rope typical for helmet streamers. Using three-dimensional MHD simulations, we also ivestigate the models for their stability.

SH41A-06 0930h

Turbulent Diffusion of the Radial Magnetic Field at the Solar Surface.

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We discuss the physics of the diffusion of passive additives embedded within a turbulent fluid. Simple numerical experiments are performed. These are designed to determine the relevant diffusion equation associated with the additive's motions. Our results are compared with analytic theory. We find that for the case in which the fluid is incompressible (zero divergence) and spatially inhomogeneous, the standard diffusion equation describes the spatial distribution of passive additives. However, for the case in which the turbulent fluid has a nonzero divergence, a different "diffusion" equation is needed to describe their spatial distribution. For this case, the equation derived by Parker ("Interplanetary Dynamical Processes", 1963) and more recently by Fisk and Schwadron (Astrophys. J., 560, 425, 2001) is applicable. Implications of these results will be discussed, particularly how they relate to the transport of the radial magnetic field at the solar surface due to photospheric motions.

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