

## SH11A-0383 0830h POSTER

## New 3D transport equations for solar energetic particles and cosmic ray propagation

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We present a derivation of both anisotropic and isotropic transport equations of energetic particles in three dimensions including magnetic focusing effect in inhomogeneous heliospheric magnetic fields, cross-field diffusion, and particle adiabatic cooling effect. To study solar energetic particles transport it is essential to have an anisotropic transport equation, but the anisotropic transport equation used by the community is only in one dimension. A 3-dimensional anisotropic transport equation may become necessary for the study of solar energetic particle propagation when there is a significant cross-field transport which is particularly true for later stage of SEP events. In cosmic ray modulation work, on the other hand, three dimensional isotropic transport equation is used by the community, but in the equation there is no focusing effect. It is found that the focusing effect may play a significant role in cosmic ray modulation even under the diffusion approximation. We plan to calculate solar energetic particles transport and make comparison with latest observational data from spacecraft.

## SH11A-0384 0830h POSTER

## Time evolution of probability density functions observed in solar wind plasma densities

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The variation of the solar wind densities observed by the ACE and Wind spacecraft is examined on time scales ranging from one minute to one week. The probability density function (PDF) of the differences of the logarithms of the plasma densities is well represented by a one-dimensional Kappa distribution. Kappa distributions of plasma velocities are found in various space environments including that near Earth, planetary magnetospheres and the solar corona. Compared to a Maxwellian velocity distribution which describes a plasma in a thermal equilibrium, a Kappa distribution is characterized by fat tails, frequently generated by anomalous Levy-type diffusion processes.

For time lags ranging from minutes to hours we find highly leptokurtic PDFs with Kappa indices of about 2. The slope of the variance (2nd moment) vs. time lag, and the observed power spectra are consistent with those found in a turbulent fluid flow. The Kappa index increases with time lag, and the PDF converges toward a Gaussian distribution on a time scale of a few days. The evolution of the observed PDF and the possible physical causes are discussed.

## SH11A-0385 0830h POSTER

## Energetic Particle Composition at High Helio-latitudes During the Declining Phase of Solar Cycle 23: Ulysses COSPIN/LET Observations

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One of the key questions to be addressed during the solar maximum phase of the Ulysses mission has been the nature of the ubiquitous energetic particle populations observed at all latitudes from equator to poles. In particular, studies of the elemental composition have been carried out in order to shed light on the likely sources of these particles. In the majority of cases, the composition signatures recorded by the COSPIN/LET experiment on board Ulysses during the

recent high-latitude passes were consistent with a Solar Energetic Particle (SEP) origin (e.g., Hofer et al., GRL, in press, 2002). This result adds further evidence to the finding that energetic particles are transported with relative ease from low to high latitudes, either by enhanced cross-field diffusion, or by direct propagation along field lines that connect the polar regions of the heliosphere to active regions at lower latitudes. During the current, post-maximum, phase of its mission, Ulysses has encountered the return to more stable solar wind stream structures, leading to the formation of Corotating Interaction Regions (CIRs), in addition to the CME-associated transients. In this paper, we present the latest composition measurements from the COSPIN/LET, and interpret them in the light of the changing heliospheric structure.

## SH11A-0386 0830h POSTER

## Large Increases of Low-Energy Ion Intensities at Voyager 1 (85 AU) in Mid-2002: Association with Solar Activity in Late-2001

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We report on observations of relatively large intensity increases of low-energy ions (~30 keV to ~10 MeV) that began at Voyager 1 in July 2002. At this time Voyagers 1 and 2 were at respective helioradii 85 AU and 68 AU, and at heliographic latitudes 34°N and 24°S. We use data from the Low Energy Charged Particle (LECP) instruments on each spacecraft. Thus far during the mid-2002 event (which was still evolving when this abstract was written), peak intensities of protons 0.6-1.8 MeV and 3-17 MeV have reached ~10% and ~30%, respectively, those observed by Voyager 1 in association with the powerful GMIR-driven shock in late-1991, when the spacecraft was at 45 AU (i.e., half as far from the Sun). The intensity increases at Voyager 1 are relatively rapid (~few days) and nearly coincident for ion energies from at least 30 keV to several MeV. This is strong evidence that the intensity increases arose from local acceleration at a heliospheric shock, probably that driven by an MIR formed by coalescence of ejecta from enhanced solar activity during the period October-November 2001. An estimate of the disturbance's average radial speed during the ~8-9 months it took to reach 85 AU is then ~600-550 km/s. In contrast to the situation at Voyager 1, energetic ion intensities at Voyager 2 have remained at relatively low levels during 2002. There is no evidence that the disturbance that began passage by Voyager 1 in July passed Voyager 2 ~1-2 months earlier, as one might expect for a uniformly expanding spherical disturbance. The disturbance is evidently non-spherical and is confined mainly to latitudes well north of Voyager 2. This is consistent with observations made in the inner heliosphere. The October-November 2001 solar activity produced high intensities of energetic ions not only near the ecliptic at 1 AU, but also at Ulysses, which was at ~2 AU and above ~70°N heliographic latitude during this period. We will discuss the Voyager 1 low-energy ion data, including angular distributions. We will also describe the effects, if any, of the disturbance on higher energy ions (e.g., Forbush decreases); however, such effects have yet to appear in the evolving intensity profiles.

## SH11A-0387 0830h POSTER

## Scattering of Superthermal Solar Wind Electrons Inside 5 AU

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Several theories invoke scattering of the outward propagating strahl electrons to populate the sunward directed part of the solar wind superthermal (halo) electron distribution. If such a scattering mechanism occurs then does it occur in the inner or outer heliosphere? We examine how the sunward moving and anti-sunward moving superthermal electrons vary with distance from the Sun and assess whether or not the source of sunward moving electrons lies between 1 and 5 AU. We use in-ecliptic Ulysses SWOOPS (Solar Wind Observations Over the Poles of the Sun) electron measurements from 1991 when Ulysses was on its way to Jupiter. We start with electron velocity distributions in magnetic coordinates, and determine if the magnetic field is pointing towards or away from the Sun. We then

integrate daily average distributions to determine the relative populations of superthermal electrons moving towards and away from the Sun, and assess their variations with distance.

## SH11B MCC: 134 Monday 0830h

Nicolet Lecture (joint with SA, SM)

Presiding: D N Baker, University of Colorado, Boulder

## SH11B-01 0830h INVITED

## Aeronomy: From Exploration to Data Assimilation

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Please see paper number SA11A-01 for abstract.

## SH12A MCC: Hall D Monday 1330h

Turbulence, Waves, and Particles in the Solar Wind Posters (joint with SM)

Presiding: S R Cranmer, Harvard-Smithsonian Center for Astrophysics

## SH12A-0388 1330h POSTER

## Compressive Fluctuations in High-Latitude Solar Wind

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Compressive fluctuations in solar wind have been extensively studied in the past using data from spacecraft on the ecliptic plane. In present analysis, based on Ulysses data, for the first time the nature of polar wind compressive fluctuations is investigated. Data are from the first out-of-ecliptic orbit of Ulysses, when solar activity is low. In such conditions, as well known, the high-latitude wind appears as a fast and relatively steady plasma flow. Correlation coefficients at hourly scale for several pairs of solar wind parameters like velocity, density, temperature, magnetic field magnitude, thermal pressure, magnetic pressure, and total plasma pressure are used to characterize the wind compressive state. Results appear to confirm the view that compressive fluctuations in solar wind are a complex superposition of MHD compressive modes and pressure-balanced structures.

## SH12A-0389 1330h POSTER

## Mechanism for Generating Differential Motion of Minor Ions in the Solar Wind

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Measurements with SOHO/CELLAS in high-speed solar wind show that some minor ions such as O<sup>6+</sup> have a relatively high drift velocity, however others such as Fe<sup>9+</sup> tend to lag behind oxygen by a few tens of km/s (Hefti et al. 1998). This subtle observational

feature has not yet been understood. A possible mechanism, based on quasi-linear theory of cyclotron resonance, for an understanding of this phenomenon is presented in this paper. The mass per charge of the ion  $O^{6+}$  and  $Fe^{9+}$  are different, a fact which results in different features of the resonance with ion-cyclotron waves. In a plasma with protons, alpha particles and electrons, the dispersion relation of cyclotron waves has two branches. The oxygen ions tend to resonate with the inward-propagating waves of the left-hand polarised (LHP) first branch and the outward-propagating waves of the LHP second branch. These resonances together may lead to a velocity distribution having a central velocity higher than the proton (solar wind bulk) velocity by about 50 km/s at 1 AU. The  $Fe^{9+}$  ions tend to resonate with both the inward and outward propagating waves of the first branch and may thus form a velocity distribution with the central velocity being very near the proton bulk velocity. These analytical results are shown to be supported by numerical results from a 2-dimensional simulation based on the quasi-linear diffusion equation.

SH12A-0390 1330h POSTER

Consequences of proton and alpha anisotropies in the solar wind: Hybrid simulations

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Alfvén-like fluctuations in the solar corona and solar wind may cascade from lower to higher frequencies where they transfer energy via cyclotron resonances to ions of successively higher charge-to-mass-ratios. This yields  $T_{\perp}/T_{\parallel} > 1$  for each ion species, where the subscripts refer to directions relative to the background magnetic field. If sufficiently large, these anisotropies drive electromagnetic ion cyclotron instabilities. This manuscript describes the use of two-dimensional hybrid simulations of a collisionless, homogeneous, magnetized plasma with both protons and alpha particles to study the consequences of scattering by enhanced field fluctuations from such instabilities. The most important new results are that both helium and proton cyclotron instabilities reduce initial differences between the proton and alpha particle anisotropies, and also reduce initial alpha/proton relative speeds. These simulation results are different from theoretical predictions of ion responses to their direct interaction with cascading Alfvén/cyclotron waves, but are consistent with observations from the *Ulysses* spacecraft.

SH12A-0391 1330h POSTER

Electron Plasma Waves Observed in the Earth's Foreshock by the CLUSTER/WHISPER Experiment

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Electrostatic noise at/near the solar wind plasma frequency is detected in the Earth's electron foreshock by the WHISPER relaxation sounder aboard the four CLUSTER spacecraft. The noise is observed when the interplanetary magnetic field line that passes through the spacecraft position connects to the shock surface. As expected, the noise intensity is largest along the magnetic field line that is tangent to the shock and the noise characteristics depend upon the position in the electron foreshock. Close to the tangent field line a narrow bandwidth noise occurs while far downstream of this boundary the noise spectrum appears to be broadened and may extend a little bit above and well below the solar wind plasma frequency. The WHISPER observations, the position of the spacecraft in the connection plane, and preliminary statistic maps are presented.

SH12A-0392 1330h POSTER

Radial Dependence of Intermittency in the Fast Polar Solar Wind Magnetic Field Using PDFs

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The *Ulysses* spacecraft, in a polar orbit of the Sun, spent almost three years sampling the pure polar coronal fast wind at solar minimum between 1994 and 1996. Turbulence in coronal fast wind, unaffected by stream shears with slow solar wind, evolves more slowly than fast wind turbulence in the ecliptic and is a more homogeneous system. However, it is still a highly intermittent and turbulent medium. We use the Castaing probability distribution to study the intermittent properties of the fast wind magnetic field components at different time lags within the inertial range, and present results on how intermittency in the magnetic field components depends on radial distance from the Sun. We find that for all distances, the transverse magnetic field components are significantly more non-Gaussian than the radial component. We also find that non-Gaussian behaviour at a given time lag increases with distance but that this can be explained by the corresponding extension of the inertial range to lower frequencies, so that the non-Gaussianity is constant at the integral scale, agreeing with theoretical predictions. We also find that the rate at which non-Gaussian deviations propagate through the cascade decreases slightly with distance.

SH12A-0393 1330h POSTER

Harmonic Langmuir Wave Turbulence Generated by Beam-Plasma Instability: Theory and Simulation

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The beam-plasma interaction is one of the most fundamental and important problems in plasma physics for both scientific and commercial applications. The weak beam-plasma (or bump-on-tail) instability and the ensuing generation of Langmuir turbulence is fundamental to many radio emission phenomena in interplanetary space, including solar and interplanetary type II and III bursts as well as radiation from the Earth's foreshock. It has also played a crucial role as a testbed for various nonlinear plasma theories, including quasilinear, weak, and strong turbulence theories. In particular, Langmuir wave turbulence generated by a beam-plasma interaction has been studied since the early days of plasma physics research. Mechanisms which lead to the quasi-power-law spectrum for Langmuir waves have been sought. Meanwhile, generation of harmonic Langmuir waves has been known for some time, in both laboratory and computer-simulated experiments. However, the phenomenon has not been adequately explained in terms of theory, nor has it been fully characterized by means of numerical simulations.

In this paper, a theory of harmonic Langmuir wave generation is put forth and tested against the *Vlasov* simulation results. It is found that harmonic Langmuir mode spectra can indeed exhibit quasi-power-law feature, implying multi-scale structure in both frequency and wave number space spanning several orders of magnitude. This indicates that the harmonic excitation process may be intimately related to the generation of high-frequency turbulence in plasmas.

SH12A-0394 1330h POSTER

Wind Observations of Extreme Ion Temperature Anisotropies Within the Lunar Wake

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We describe Wind observations of a lunar wake encounter which occurred on July 18, 2002. The observations were made at a distance of 15 lunar radii ( $R_L$ ) downstream, and the data suggest that the moon was immersed in magnetosheath plasma at this time. The large azimuthal flows associated with the sheath region mean that the wake crossing was completed some 90 minutes before the spacecraft entered the lunar shadow.

The most extensive observations of spacecraft encounters with the lunar wake reported previously occurred at 2  $R_L$  (*Explorer 35*) and 6  $R_L$  (*Wind*), thus, this is the first time such an event at this far distance has been reported on. A characteristic feature of the lunar wake is the presence of two ion beams moving with different velocities. Improvements in the analysis procedure for Wind/SWE mean that for the first time we are able to discern the thermal anisotropy of these ion components. We find that both ion components exhibit an extreme temperature anisotropy with  $T_{\perp} > 4T_{\parallel}$ . We present an examination of the possible causes and implications of this extreme anisotropy.

SH12A-0395 1330h POSTER

The Interaction of Turbulence with Shock Waves

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The interaction of turbulence and shock waves is considered self-consistently so that the back-reaction of the turbulence and its associated reaction on the turbulence is addressed. This approach differs from previous studies that considered the interaction of linear modes with a shock. The most basic model of hypersonic flow, described by the inviscid form of Burgers' equation, is used. An energy-containing model, which couples the turbulent energy density and correlation length of the flow and the mean flow, is developed. Upstream turbulence interacting with a shock wave is found to mediate the shock by 1) increasing the mean shock speed, and 2) decreasing the efficiency of turbulence amplification at the shock as the upstream turbulence energy density is increased. The implication of these results is that the energy in upstream turbulent fluctuations, while being amplified at the shock, is also being converted into mean flow energy downstream. The variance in both the shock speed and position is computed, leading to the suggestion that, in an ensemble-averaged sense, the turbulence-mediated shock will acquire a characteristic thickness given by the standard deviation of the shock position. Lax's geometric entropy condition is used to show that as the upstream turbulent energy density increases, the shock is eventually destabilized, and may

emit one or more shocks to produce a system of multiple shock waves. Finally, turbulence downstream of the shock is shown to decay in time according to  $-2/3$  law.

## SH12A-0396 1330h POSTER

### Truncated Levy-flight Statistics Recovered from Interplanetary Solar Wind Velocity and Magnetic Field Fluctuations

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Interplanetary solar wind fluctuations have been studied in the inner heliosphere and within the MHD range of scales. Fluctuations are such that velocity and magnetic field vectors, which initially keep their orientation around a given direction in space during a certain time interval, abruptly change to fluctuate around a new orientation. This behavior is then repeated several times per hour. Most of the time the largest directional jumps are also accompanied by larger intensity variations. This kind of phenomenon resembles a Levy-flight behavior and stimulated us to compare these observations with a Levy statistics, particularly sensitive to long range correlations. In particular, we considered the cumulative distribution function of velocity and magnetic field vector differences evaluating the probability to have differences larger than a given threshold that was repeatedly set at different values. This analysis showed that our observations can be reasonably fitted by a Truncated-Levy-Flight (TLF) distribution. Moreover, we found a clear radial dependence of these fluctuations to evolve from Gaussian to TLF only within fast wind. We provide an explanation for what we observe in terms of a competing action between stochastic, propagating fluctuations and convected structures, both contributing to solar wind turbulent fluctuations.

## SH12A-0397 1330h POSTER

### Ion heating due to plasma microinstabilities in coronal holes and the generation of the fast solar wind

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There is growing evidence that the heating of ions in coronal holes is due to cyclotron resonant damping of ion cyclotron waves. At the same time, the origin of these waves is much less understood. Recently, we suggested [Eos Trans. AGU, 82(47), Fall Meet. Suppl., Abstract SH11A-0695, 2001] that the source of the waves in the coronal holes is a heat flux coming from the Sun. The heat flux excites shear Alfvén and electrostatic ion cyclotron waves through plasma microinstability, and then the waves heat the ions. We used a new view according to which the heat flux is launched intermittently by small-scale reconnection events (nanoflares) at the coronal base. This allows the heat flux to be sporadically large enough to drive the instabilities, while at the same time to satisfy the time-averaged energy requirements of the solar wind. Here we develop this model further. We show that the unstable waves can become strongly ion-resonant. This results in ion heating in the inner corona that is efficient enough, in the quasilinear limit, to generate the fast solar wind.

## SH12A-0398 1330h POSTER

### Beam-Plasma Interaction and Associated Ion Heating

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Ion heating through wave-particle interaction is of great interests in space plasma physics. A series of 1-D and 2-D hybrid simulations have been carried out to investigate the ion heating process in beam-plasma interaction, in which Alfvén turbulences are produced via nonlinear evolution of beam-plasma instabilities. In the nonlinear stage of instability driven by high speed ( $> V_A$ ) ion beams, the excited waves evolve to Alfvén turbulence following  $\omega = k \cos \alpha V_A$  in the plasma frame, where  $\alpha$  is the angle between the wave vector  $\mathbf{k}$  and the background magnetic field  $\mathbf{B}_0$ . The power law spectra  $E(f) \sim f^{-\gamma}$ , where  $\gamma \sim 1.0 - 1.8$ . The background ions are accelerated to a bulk flow speed  $V \sim V_A$  relative to their original speed. The background plasma is heated significantly, saturated at a final temperature  $T$ . The heating rate  $T/T_0$  can reach 10 to 200 for typical plasmas in the solar corona, where  $T_0$  is the initial temperature of background plasma. It is found that the ion heating in obliquely propagating waves ( $\alpha \neq 0$ ) is more effective than that in the case of  $\alpha = 0$ . The physics of the beam-plasma interaction and the ion heating is investigated. Heating of heavy ions by such mechanism is also simulated. Application to ion heating in the solar corona and solar wind will be discussed.

## SH12A-0399 1330h POSTER

### A Reassessment of Turbulent Heating Due to Interstellar Pickup Protons in the Outer Heliosphere

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The measurements of the solar wind core proton temperature at Voyager 2 exhibit a sharp and continuing increase beyond 40 AU from the Sun. The location of this feature suggests a connection with the pickup of inflowing interstellar hydrogen. Recent papers by Matthaeus, Smith, Zank and co-workers have discussed the possibility that this temperature increase is due to the turbulent dissipation of fluctuations originally generated by the scattering of pickup protons to a bispherical shell soon after their ionization. However, the turbulent evolution model used in those papers was shown to strongly overestimate the observed heating unless the energy input from pickup-proton-generated waves was reduced from the bispherical values by at least a factor of 25 - 50. We point out that the original quasilinear analysis of this wave generation, under the usual assumptions of conditions in the outer heliosphere, actually yields zero net energy input for this process. We show how relaxing these assumptions can plausibly allow for energy input to the turbulent cascade at a level of a few percent of the bispherical value, thus resulting in a model solar wind heating consistent with the observations.

## SH12A-0400 1330h POSTER

### The Effect of Hall and FLR terms on the Development of MHD Turbulence Spectra

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Solar wind magnetic spectra often show a steepening of the  $k^{-5/3}$ -power law inertial range cascade at scales shorter than the ion gyro radius. Density spectra often show flattening at adjacent scales. We include the Hall term and a Finite Larmor Radius (FLR) term in a two-and-one-half-dimensional compressible magnetohydrodynamic (MHD) system of equations to model high frequency solar wind power spectra near the Doppler-shifted ion-cyclotron frequency. The system is closed by adopting a polytropic equation of state. The Hall term gives rise to steepening of the magnetic field spectra for high-cross helicity states and a range of plasma

beta  $4 \leq \beta \leq 1/4$ . The FLR term gives rise to flattening of the density spectrum for both high- and low-cross helicity states and the same range of plasma beta. We separate the terms in the system of equations into linear and nonlinear components. The magnitude of the nonlinear term is comparable to, and in some cases stronger than, the linear term at the ion gyro radius scales.

## SH12A-0401 1330h POSTER

### Formation of minor ion charge states in the fast solar wind: roles of differential flow speeds of ions of the same element

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To investigate the possibility of differential flow speeds between ions of the same element and their roles in the determination of ionic fractions, this paper extends our latest minor ion model to a 5-fluid model, describing the behavior of five species of minor ions of one given element in the fast solar wind. We solve the five sets of mass, momentum and energy equations simultaneously to include the effects of ionization, recombination and heating. The five species of minor ions are taken as test particles flowing in a background plasma consisting of electrons, protons and alpha particles. The parameters of the background gas are calculated using a previous 3-fluid wave-driven magnetohydrodynamic model for the fast solar wind. These background parameters are modeled as closely as possible to observed values. Using this background of fast solar wind parameters, the 5-fluid minor ion model has no problem reproducing the frozen-in charge state distributions observed in the fast solar wind for C and O ions, while the modeled ionic fractions of Si, Mg, and Fe show significant shifts to lower charge states compared with the observed values. It is found that the majority of C and O ions are frozen-in below 1.2 solar radii while most Si, Mg and Fe ions are frozen-in beyond 1.3 to 1.5 solar radii. Comparing the cases with and without differential flows shows that even though differential flow speeds between ions of the same element do develop beyond a certain heliocentric distance (e.g., 1.2 solar radii for Si ions), they can not account for the high ion charge states observed in situ.

## SH12A-0402 1330h POSTER

### Plasma Heating Due to Spectrum of Obliquely Propagating Alfvén Waves

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It has been shown recently that, contrary to conventional analysis, significant perpendicular heating of a magnetized plasma can be effected by waves with frequencies well below the ion cyclotron frequency. It was preliminarily shown that a perturbation consisting of a spectrum of modes results in an increased heating efficiency as compared with a single mode. Motivated by this result, we have undertaken a detailed study of the dependence of the heating efficiency, due to a spectrum of obliquely propagating Alfvén waves, on the wave energy density, spectral indices, and perpendicular wave scales. We have simulated the interaction of an initially cold plasma with the low and high frequency halves (with respect to the cyclotron frequency) of a given wave spectrum, acting both independently and in unison. It is found that a spectrum including only modes below the cyclotron frequency could indeed impart significant heating, while the higher frequency modes remain most efficient. In addition, it is found that the perpendicular wave scale, which allows for the nonlinear cyclotron resonance, also limits the attainable particle perpendicular energy, due to the finite Larmor-radius averaging effect. This work serves as a promising model for heating of the solar corona as it does not rely on the primary cyclotron resonance. Both analytical and numerical detailed results will be presented. Work supported in part by US DOE, NSF and UCI UROP grants.

SH12A-0403 1330h POSTER

Ulysses Observations of VLF Wave Activity in the Solar Wind and the Photoelectron Effects on the Measurements

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We present observations of VLF waves (0.2 to 448 Hz) made by Ulysses during its second orbit (during the solar maximum) and compare the observations with those during the first orbit, when the solar activity was approaching a minimum. The occurrences and properties of the waves are found to be similar during the solar maximum and solar minimum periods for slow and intermediate speed solar wind. In the fast solar wind streams, which are seen during the first orbit when Ulysses was at high latitudes, the spacecraft observed nearly continuous electric wave activity with peak power near and below the local electron gyrofrequency. In the second orbit this is not observed since the Sun was approaching maximum activity conditions, and the spacecraft was traveling in the slow and intermediate solar wind at all latitudes and no entry into the fast solar wind. The maximum intensity of the electromagnetic waves for the two solar cycle periods is comparable. These similarities suggest that the plasma conditions for the waves' excitation are similar for the slow and intermediate solar wind in both solar maximum and minimum phases. It is also found that the electric field noise detected in the low band channels of the Wave Form Analyzer, which are measuring less than 9 Hz signals, is contaminated by the spin modulation of the electric field due to photoelectrons around the spacecraft, especially when the ambient plasma density is low. This effect enhances with the increase of the solar aspect angle.

SH12A-0404 1330h POSTER

Dynamics of Electrostatic Decay of Beam Driven Langmuir Waves

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Nonlinear electrostatic Langmuir decay is important for type III solar radio emissions, and other emissions in space plasmas. For instance, to generate the observed levels of emission in type III bursts, it is important to produce backscattered Langmuir waves to participate in the emission of radiation at the second harmonic of the electron plasma frequency, and ion-acoustic waves to stimulate fundamental emission. In this work, the evolution of Langmuir waves and ion-acoustic waves in time, space and wave number, stimulated by a hot electron beam and coupled by Langmuir decay processes in an initially homogeneous plasma is investigated numerically using kinetic theory. The nonlinear dynamics of Langmuir waves and ion-acoustic waves for parameters appropriate to the solar wind at 1AU is studied in detail. Nonlinear Langmuir decay is observed to effectively scatter the beam-driven Langmuir waves out of resonance. The scattered Langmuir waves then undergo further decays and condense sequentially toward small wave numbers, until decay is prohibited kinematically. At a given spatial location, the levels of the product Langmuir waves initially are lower than those of the resonant Langmuir waves, they increase and eventually reach as high as or exceed those of the beam-driven Langmuir waves, which become weaker as the beam passes this position. The ion-acoustic waves generated are relatively weak and subject to damping at large times. Fine structures in scattered Langmuir waves and ion-acoustic waves are observed, due to the depletion of their energy when decay and coalescence processes proceed. Furthermore, quasilinear relaxation of the beam is not affected significantly by the decay, and hence the main features of resonant Langmuir waves are very similar to those when nonlinear decay is absent. The decay process is thus slaved to the primary beam-plasma evolution, as assumed in previous works. We investigate also the effects of varying beam and ion parameters. We found that the electron to ion temperature ratio affects not only the intensity of the ion-acoustic waves through effects on the damping rate, but also the dynamics of a decay processes via effects on the decay rate, which was usually overlooked in previous studies. These results

for the Langmuir and ion-acoustic waves will be used as input to calculate electromagnetic emission in type III bursts using wave-wave interaction theory, with further inclusion of spatial inhomogeneity in the background plasma.

SH12A-0405 1330h POSTER

Are Whistler Waves Regulating the Electron Heat Flux in the Solar Wind at 1 AU ? Wind Observations.

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Electron heat conduction provides a major means of energy transport in collisionless plasmas. Yet, the mechanisms which determine the electron energy transport and dissipation in the solar wind are far from being understood. The electron heat flux is observed to be actively dissipated as the solar wind expands into interplanetary space, and neither collisionless expansion along the interplanetary magnetic field nor collision dominated thermal transport can well describe the average observed value of the electron heat flux at a given heliocentric distance. Besides Coulomb collisions, whistler wave-particle interactions have been suggested as an other possible source of the dissipation necessary to regulate the electron heat flux.

Using high-time resolution particle and wave data from the WIND spacecraft, we analyze here the electron heat flux in relation to the level of whistler-like magnetic field fluctuations, during 50 days close to the last minimum of solar activity. We show that WIND observations lead to the conclusion that whistler waves are likely to play a role in the regulation of the heat flux in the solar wind, while recent Ulysses observations were not conclusive on this point.

SH12A-0406 1330h POSTER

Proton random forcing and generation of electron suprathermal tails in the solar wind

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The observed core-halo structure of the electron distribution function in the solar wind can be interpreted in two ways. In the first type of interpretation, the core adjusts adiabatically to the local solar wind conditions while the suprathermal particles results from the collisionless expansion of the coronal plasma (see for example Scudder and Olbert, 1979, JGR, 84, p2755). The second interpretation is fully local, the halo electrons resulting from the particle-wave interactions (see for example, Leubner, 2000, Planet. Sp. Sci., 48, p133), as observed in practically all low density collisionless plasmas. The source of the waves is thought to be found in some non equilibrium feature of the distribution function.

In this work we explore this last interpretation, using numerical simulations of the Vlasov - Poisson equations. As in Viñas et al., 2000, APJ, 528, p509, we propose that the source of the waves able to interact with the thermal electrons is to be found in the cascade from large scale -fluid- fluctuations towards small -kinetic- scales; while Viñas et al., studied the relaxation of a large scale spatially periodic electric field supposedly resulting from this cascade, here we choose to represent this effect by a random force acting on the protons; the electrons move to maintain charge neutrality and excite a "suprathermal" level of plasma waves which produce a suprathermal tail on the electron distribution function. We discuss the role of the statistical properties (as example the degree of intermittency) of the random force on the efficiency of the production of suprathermal electrons and compare the results with solar wind observations.

SH12A-0407 1330h POSTER

Proton Heating in the Extended Solar Corona Resulting From Kinetic Alfvén Turbulence

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Spectroscopic observations of the solar corona have made it clear that the "coronal heating problem" comprises not only the local deposition of heat immediately above the transition region, but also extended heat deposition throughout the (collisionless) acceleration region of the solar wind. The dissipation of magnetohydrodynamic (MHD) waves and/or turbulence has been considered as a likely heating mechanism in the solar wind for several decades. However, it is still not well understood how MHD fluctuations are generated, how they evolve in frequency and wavenumber, or how their damping leads to the observed proton, electron, and ion properties of the fast wind. We present a model of MHD turbulence that specifically addresses the issue of kinetic dissipation and particle heating in the collisionless extended corona. The nonlinear cascade is modeled as a combination of advection and diffusion in wavenumber space, with the dominant cascade occurring in the direction perpendicular to the background magnetic field. This leads to a highly anisotropic fluctuation spectrum (as expected, based on many earlier simulations and scaling models) with a rapidly decreasing power-law tail in the parallel wavenumber direction. In the low-plasma-beta corona, the dominant oblique fluctuations (with dispersion properties of kinetic Alfvén waves) are dissipated by electron Landau damping, with only a tiny fraction of the energy going to high-frequency ion cyclotron waves. This implies strong parallel electron heating and weak proton and ion heating, which is not what is observed. We discuss the probable nonlinear evolution of the electron velocity distributions into parallel beams and discrete phase-space holes (similar to those seen in the terrestrial magnetosphere) which can possibly heat protons via stochastic interactions.

This work is supported by the National Aeronautics and Space Administration under grants NAG5-11913 and NAG5-11420 to the Smithsonian Astrophysical Observatory, by Agenzia Spaziale Italiana, and by the Swiss contribution to the ESA PRODEX program.

SH12A-0408 1330h POSTER

On the Origin of Perpendicular Cascades Among Nonlinear Alfvén Waves

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We examine the effects of mildly oblique, low-frequency Alfvén waves on cross-field magnetic structures of varying scales. The magnetic structures correspond to the type of zero-frequency modes which can arise when ingoing and outgoing Alfvén waves interact with one another. Such modes are important to the development of nearly perpendicular cascades in magnetohydrodynamic (MHD) turbulence. In linear theory, the structure remains static and the Alfvén wave generally refracts into the perpendicular direction and is resonantly absorbed. Resonant absorption is a perpendicular cascade since small perpendicular wave features are generated. However, it differs from a turbulent cascade in that it is a phase-ordered process. Given a small wave amplitude, linear theory is valid when the structure's gradient scale is of order or larger than the Alfvén wavelength. However, when the gradient scale becomes smaller than the wavelength, nonlinear effects appear due to the Alfvén wave advecting and bending the magnetic structure. The magnetic structure acquires parallel scales and also a velocity field since moving the magnetic field of the structure induces an electric field and so also a velocity field. This renders the structure indistinct from a wave at a given moment although there is no net propagation. The Alfvén wave still undergoes resonant absorption but now without the refraction of the Alfvén wave and at a reduced rate. Instead of refraction, the Alfvén wave reflects and generates a backward Alfvén wave flux because advection of the structure gives Alfvén speed gradients along the background magnetic field. The reflection saturates when the wave flux in each direction along  $B_0$  becomes equal. In this case, we have a mildly oblique Alfvén wave with the nonlinear capability of cascading power perpendicularly without changing its wave vector orientation and without its entrainment into the nearly perpendicular direction. We will also show that power accumulation along the advecting resonant field

lines can be quenched by ion cyclotron resonant heating when small parallel scales develop in association with the advection. We relate this evolution to MHD simulations of isotropic spectra of Alfvén waves which develop nearly perpendicular cascades. We suggest that the cascade originates not simply from the development of zero-frequency modes but rather from the nonlinear modifications of resonant absorption.

## SH12A-0409 1330h POSTER

## Helium in the Solar Wind as a Tracer of Coronal and Interplanetary Processes

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The bulk of the solar wind is fully ionized hydrogen and helium, with helium contributing 5% – 45% of the total mass density. Knowledge of the kinetic properties of helium (velocity, density, temperatures) is needed to understand the dynamics of the solar wind, and to this end we have analyzed observations of ion distribution functions by the Solar Wind Experiment Faraday Cup instruments on the Wind spacecraft. From each 92-second spectrum we have extracted velocities, densities, and anisotropic temperatures for hydrogen and helium.

In addition to local dynamics, comparison of hydrogen and helium parameters tell us about both kinetic and large-scale processes which occur in the solar corona and in the interplanetary medium during the expansion of the solar wind. Modulation of the abundance ratio  $He/H$  traces the evolution of the coronal magnetic field within the solar cycle. Relations between ion temperatures, either equal temperatures or equal thermal speeds, tell us about fluctuations and the prevalence of collective wave-particle interactions. Our separate study of the equilibration of parallel and perpendicular temperatures allows us to distinguish mechanisms for this coupling.

## SH12A-0410 1330h POSTER

## MHD Simulation Attempts to Explain the Spectral Symmetry and Minimum Variance Directions in the Solar Wind

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Solar wind fluctuations are known to be anisotropic, both in wave vector and in field fluctuation directions. Various sets of two-spacecraft observations, in addition to ensembles of correlations from a single spacecraft, show there is some preference for wave vector directions nearly perpendicular to the mean magnetic field. Many studies have also shown that magnetic field (and to a lesser extent the velocity field) has a minimum variance direction typically along the mean magnetic field direction, and that this persists even as the mean field turns to nearly perpendicular to the radial in the outer heliosphere. The requirement that the wave vectors and fluctuations must turn with the mean field eliminates simple views of planar Alfvén waves or quasi-two-dimensional fluctuations or superpositions of these. In previously reported simulation work, we have shown that inhomogeneity transverse to the radial flow direction as well as nonlinear interactions are required to explain the observations. We now have added to our simulation code non-radial wave vectors to the in-flow population of waves, as well as three-dimensional microstreams (radial flows that depend on both transverse directions). This paper will explore the extent to which these additions aid in solving the anisotropy and minimum variance problems. Preliminary results are similar to those found with 2-D simulations which showed some turning of wave vectors due to shear, but as yet no clear minimum variance signature. We will use higher resolution simulations to determine if part of the problem is that the scale of our assumed population of fluctuations is too large.

## SH12A-0411 1330h POSTER

## Statistics of Langmuir and Ion Acoustic Waves associated with Type-III solar bursts in the Solar Wind

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Type III solar radio bursts, which are characterized by a rapid frequency drift rate, are generated by interactions between electron beam-driven Langmuir waves and the solar wind. Wave-wave theories of plasma radio emission require the presence of both Langmuir waves around  $f_{pe}$  and ion acoustic waves below 10kHz in the source region of the radio burst. We use data from the Wind WAVES and 3DP instruments to study the statistics and properties of these waves in 10 in situ type III bursts observed between 1995 and 2002. We show the probability distributions of wave amplitude and dimensionless energy  $W = \epsilon_0 n_e E^2 / n * k_b * T_e$ .  $W$  is generally too small for strong turbulence to be important. We also show that the observed bandwidth of Langmuir waves suggests a small role for nonlinear wave-wave processes. The occurrence of ion acoustic waves in type III sources is not statistically significant nor dependent on solar wind ion/electron temperature ratios.

## SH12A-0412 1330h POSTER

## MHD Turbulence in an Open Magnetic Region With Alfvén Waves Weak Reflection.

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We have shown in a previous work (Dmitruk et al, Phys. Plasmas 8, 2377, 2001) that in order to sustain MHD turbulence in an open magnetic region driven by injected waves through the boundary, it is necessary to have reflections of those waves and to impose boundary conditions which allow the presence of non-propagating structures. However, an important objection is how strong the reflections have to be, in order to get turbulence sustainment. We show here, by doing numerical simulations of the RMHD equations in an inhomogeneous medium, that even in the case of very weak reflections (1 percent energy in reflected fluctuations) corresponding to a system very close to a minimal cross helicity state, MHD turbulence can still be sustained, a broadband energy spectrum can be developed, small scale structures appear and the system is efficient on dissipating the injected energy, provided an appropriate timescale ordering is maintained by the forcing. Moreover, we study the timescale conditions under which MHD turbulence will be even more favored. The basic model presented here could have interesting implications for the understanding of the problem of the heating of the lower solar corona in magnetically open regions. This research supported by NSF grants ATM-9977692 and ATM-0105254.

## SH12A-0413 1330h POSTER

## One-Point Electric Field Statistics in the Solar Wind

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The induced electric field, a fundamental quantity in magnetohydrodynamics (MHD) that has important implications in turbulence and in particle scattering, is examined both theoretically and observationally in the solar wind context. We present observations of the field distribution and strength at 1 AU using four day samples of one hour data. The induced turbulent electric field, is computed from the velocity and magnetic field obtained from the OMNI tape dataset, spanning about 30 years of hourly data. We find that the induced electric field component probability distributions are exponential or exponential-like, in accordance with the degree and type of correlations present. The results are consistent with the theoretical expectation [1] based upon the assumption of normally distributed velocity and magnetic field fluctuations.

[1] L. Milano, W. H. Matthaeus, B. Breech and C. W. Smith, Phys. Rev. E, 65, 026310, 2002

## SH12A-0414 1330h POSTER

## Properties of Electric Fields Observed by Polar across Earth's Bow Shock

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To date Polar has made several traversals of Earth's bow shock. With Polar's apogee being at  $9 R_E$ , these bow shock crossings tend to be extreme. We present electric and magnetic fields from DC to 8000 Hz observed at Earth's bow shock. Polar provides the first 3-axis measurements of electric fields across the shock layer proper, allowing for a better evaluation of the electric field properties than previous missions. Preliminary analysis of shock electric and magnetic fields indicate large amplitude (as large as 20-100 mV/m) electromagnetic waves from the ion cyclotron frequency and above. Large amplitude solitary-like electrostatic waveforms are also seen in the magnetic ramp and into the shock overshoot region. We discuss the characteristics of the electric fields across these shocks, including orientation, polarization, wavelength, parallel electric fields, and relation to fine structure in the magnetic fields. These results provide new insights on shock structure and its relation to plasma energization and thermalization across collisionless shocks.

## SH12A-0415 1330h POSTER

## Simulations of wave particle interactions in the expanding solar wind in the presence of particle beams

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We use the Expanding Box Model, which has been updated to include the effects of the mirror force, to carry out 1D simulations of wave-particle interactions in the fast solar wind in the presence of particle beams. The aim is to understand the effects of beams on wave dissipation as well as the role of turbulence in the regulation and possible generation of the proton beam in the fast solar wind.

## SH12A-0416 1330h POSTER

## Decay of turbulent energy in a collisionless plasma: Hall MHD

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Low frequency plasma turbulence such as that observed in the solar wind, is typically studied in a magnetohydrodynamic (MHD) limit. The usual expectation in MHD turbulence (as in hydrodynamic turbulence) is that the energetic large scale fluctuations, or "energy-containing eddies" regulate the dynamics of the cascade process, including the rate of decay of fluctuation energy. In this view the specific nature of

small dissipative processes are not important in regulating decay rates. One might then expect that addition of small scale modifications appropriate to a low-collisionality plasma would have no effect on turbulence decay rates. On the other hand, recent studies of spontaneous magnetic reconnection indicate that collisionless effects can be very important, increasing the rate of reconnection, and that the Hall effect correction to Ohm's Law is perhaps the most crucial modification to MHD results. In the latter perspective one might expect that Hall effect facilitates the small scale reconnection events that typify MHD turbulence cascade and dissipation. The question naturally arises then as to whether Hall effect indeed does modify turbulent decay rates, and whether control of decay by large scale eddies remains relevant in collisionless plasma turbulence. We address this issue by comparison of direct high resolution simulations of ordinary compressible resistive MHD and Hall-modified MHD (HMHD) equations. We conclude, for low cross helicity turbulence over a substantial range of plasma beta, that Hall effect has no substantial effect on turbulent decay rates, which remain well described by a cascade theory controlled by large scale fluctuations. This research supported in part by NSF grants ATM-0105254, ATM-9977692 and ATM-0096324.

## SH12A-0417 1330h POSTER

## Acceleration and Heating of the Fast Solar Wind by Ion-Cyclotron and MHD Waves

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The basic plasma properties of the fast solar wind as deduced from observations suggest that both, high frequency ion-cyclotron waves, and low frequency MHD waves play a role in the acceleration and heating of the coronal hole plasma. The heating due to high-frequency waves is particularly important in minor ions, such as  $O^{5+}$ . I will present the results of 3-fluid, simulations of the solar wind plasma that combine the effects of ion-cyclotron, and MHD waves. The low frequency waves are included self-consistently as the source of momentum and heating of protons and electrons. Additional heat and momentum input terms due to ion-cyclotron waves are included in protons and minor ions. The 3-fluid gyrotopic model allows for  $T_{\perp} > T_{\parallel}$  of the ions in accordance with observations. The heating term that contributes mostly to the perpendicular temperature of minor ions is constructed using the saturated state of the hybrid kinetic model of the solar wind plasma at several locations in the coronal hole, with the plasma  $\beta$  and other parameters varying with radial distance. Iterative update of these parameters is planned in a future study. The temperature anisotropy estimated from SOHO UVCS spectral observations is used to constrain the hybrid kinetic modeling. Ulysses and Helios observations are used to constrain the asymptotic solar wind speed and mass flux.

## SH12A-0418 1330h POSTER

## Hybrid simulations of plasma expansion

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We study effects of radial expansion of solar-wind plasma on temperatures of protons and alphas, and on a drift velocity between the two populations. The double adiabatic approximation predicts that the radial expansion leads to an important ion temperature anisotropies, since the perpendicular temperature decreases and the parallel one is constant. The adiabatic approximation also predicts that the ratio between the drift velocity and the local Alfvén velocity increases during the expansion. Such phenomena are not observed in the solar wind and there are different physical mechanisms that can explain this effect. One of the mechanisms is a local generation of instabilities driven by a temperature anisotropy and/or by a drift velocity. We use a modified version of one and two dimensional hybrid code, a Hybrid Expanding Box (HEB) code. We study the evolution of an expanding plasma consisting of protons and alphas with a drift between them in two cases: for cold protons and alphas and for hot protons and alphas. The HEB simulations show that the locally driven instabilities are able to destroy the adiabaticity in the two cases. We discuss the results and compare them with linear theory and observations.

## SH12A-0419 1330h POSTER

## Theoretical Predictions for Interplanetary Type II Radio Bursts

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Type II solar radio bursts have been observed for more than 50 years. However, only in 1998 were the first in situ observations obtained of an interplanetary type II source. These observations showed electron beams, Langmuir waves, and radio emission produced upstream of a rippled CME-driven interplanetary shock. We present here a semi-quantitative model of interplanetary type II radio bursts which involves: electron reflection and acceleration at the shock front; beam formation upstream of the shock via time-of-flight effects; Langmuir wave growth driven by the electron beams; and the conversion of Langmuir waves into freely propagating radiation by nonlinear wave-wave processes. We use the model to investigate: (i) the beam properties and volume emissivities of radiation as functions of location; (ii) trends in the radiation flux seen by a distant observer for varying solar wind and shock parameters; and (iii) dynamic spectra for a shock propagating from the solar corona to 1AU. Our predictions are qualitatively and semi-quantitatively consistent with available observations. The predicted emission depends most sensitively on the speed of the shock relative to the solar wind. Strong correlations are also predicted between the intensity of fundamental emission and the level of nonthermal electrons present in the tail of the incident solar wind electron distribution. Harmonic emission is predicted to be most sensitive to variations in the solar wind electron temperature. These results indicate that the bursty nature of typical type II observations is consistent with a shock propagating through an inhomogeneous solar wind.

## SH12A-0420 1330h POSTER

## Some new statistical studies on MHD turbulence in the solar wind

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MHD turbulence is ubiquitous in space. In particular, those found in the foreshock region of the earth's bowshock typically have normalized magnetic field amplitude equal or even greater than unity, and are thus regarded as excellent examples for nonlinear wave research. With an emphasis on elucidating nonlinear processes contained in the data, we present our recent progress in analyzing the foreshock magnetic field data obtained by GEOTAIL spacecraft from some new perspectives. In particular, we discuss presence, evolution, and origin of phase coherence among MHD waves. Details of the method of the analyses and the results will be presented at the meeting.

## SH12A-0421 1330h POSTER

## Anomalous diffusion of energetic particles in MHD turbulence

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Diffusive transport of charged particles in a collisionless plasma is one of the central issues in space plasma research. Most of the conventional arguments are based on a classical diffusion model, a second order linear diffusion equation with a prescribed diffusion coefficient. Underlying assumptions are the low turbulence level and the lack of phase coherence among the waves. In real MHD turbulence in space, however, both of these assumptions are likely to be violated in many circumstances. We introduce a simple mathematical model to describe particles trajectories in the turbulence field, where the turbulence is assumed to be composed of multi-scale eddies. Details of the model as well as comparison of the results with test particle simulations will be presented.

## SH12A-0422 1330h POSTER

## Downshifted waves in electron foreshock region: Cluster observations and interpretation

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WHISPER measurements onboard four Cluster satellites during the Earth's bow shock crossing on January 24, 2001, have shown the presence of two types of high frequency electrostatic waves in the electron foreshock region: Langmuir and downshifted waves with the frequencies between electron and ion plasma frequencies. The downshifted waves are observed upstream of the shock front and they grow up just in the vicinity of the forward edge of the whistler precursor wave train. An analysis of electron distribution function does not show any signature of a high energy beam, however, it shows the growth of low-energy nonthermal electron fluxes. The electron distribution function integrated over the perpendicular velocity components does not have a resolution that is sufficient to identify unambiguously the presence of the beam-type feature, but gives an indication that a beam can exist. Theoretical analysis of the characteristics of the reflected electron population with the use of the measured magnetic and electric fields gives strong arguments in favor of such a hypothesis. Stability analysis shows that the two wave modes can be simultaneously generated due to a plasma-beam instability in a plasma, where the relative velocity of cold and hot components is comparable with the thermal velocity of the hot component. An estimate of the saturation level of the waves gives characteristic amplitudes which are similar to observed.

## SH12A-0423 1330h POSTER

## High Mach Number Nonstationary Shocks: Heating and Acceleration of Electrons

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Collisionless quasispherical shock waves with Mach number larger than some critical value,  $M > M_{cr}^*$ , undergo a quasiperiodic reformation process that consists in overturning of the shock front and formation of the new one from the growing precursor whistler wave train upstream of the previous shock front. The overturning process results in the growth of magnetic field gradients up to very large values and in the formation of the region with extremely large amplitudes of the electric field.

The electric field in the vicinity of the overturning point in MHD approximation grows explosively up to infinity. The growth can be arrested either by the kinetic effects, or by dispersion and/or dissipation. However, within a quite narrow region in the shock front the electric field can become large enough to ensure about 1/3 of the total potential jump across the shock front. This electric field increase can provide additional

mechanisms of the energy dissipation and particle acceleration. Two possible effects are shown to play an important role: the growth of the efficiency of the surfing acceleration mechanism and direct acceleration due to the explosive growth of the electric field.

#### SH12A-0424 1330h POSTER

##### Kinetic simulation of ion heating by ion cyclotron waves

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The heating of ions by ion cyclotron waves in a low beta collision-less plasma such as the inner corona is investigated by fully non-linear kinetic simulation. It will be shown that ions are preferentially in the direction perpendicular to the magnetic field in the first stage leading to a strong temperature anisotropy. However, ions in the parallel direction will also be strongly heated. Detailed ion velocity distributions will be presented. Ion cyclotron waves are able to make ion velocity distributions extremely non-Maxwellian. The implications for the coronal heating by ion cyclotron waves will be discussed.

#### SH21A MCC: Hall D Tuesday 0830h

##### Heliospheric and Interplanetary Physics Posters (joint with SM)

Presiding: N U Crooker, Boston University

#### SH21A-0473 0830h POSTER

##### ICME Identification from Solar Wind Ion Measurements

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In the solar corona, coronal mass ejections are generally identified as an outward moving density enhancement. At 1 AU their interplanetary counterparts are generally identified as a twisted and enhanced magnetic structures lasting of the order of a day. In an effort to better classify ICMEs we attempt herein to identify their start and stop time by their signatures in ion data obtained by Wind and ACE solar wind instruments. We search for periods in which the solar wind speed is linearly decreasing and the ion temperature is cool, with a thermal speed of less than 20 km/s. We required a simultaneous enhanced magnetic field but required no special signature of this enhancement. We compared these identifications with those made by D. Larson and R. P. Lepping and published on the web. Of 14 events, 4 were not identified as ICMEs by either Larson or Lepping. Similarly they identified many events that we did not, often because the ion temperature was above our classification threshold, but also because there was no clear speed decrease as the event crossed the spacecraft as would signal an expanding structure. The best events in Larson and Lepping's list had a rate of speed decrease that, if due to the expansion of the structure with distance from the sun moving at the average observed speed, would bring the structure from zero width to the present size in its calculated transit time. We conclude that cold ion temperatures and a declining solar wind velocity are frequent ICME signatures but are neither necessary nor sufficient for ICME identification.

#### SH21A-0474 0830h POSTER

##### Halo CME's Will They Hit or Miss Earth?

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To optimize the information from maps of the sky that cover large elongations we have developed a Computer Assisted Tomography (CAT) program that models these using a time-dependent three-dimensional heliospheric model to fit Thomson scattering or STELab

(Nagoya University) interplanetary scintillation (IPS) observations. The duration of a CME event (typically several days) imposes the restriction that the reconstruction model primarily uses outward solar wind motion to give perspective views of each point in space. The results to date are commensurate with the observational coverage, temporal and spatial resolution, and signal to noise available from the original data. We provide remote observer views of IPS-based reconstructions of halo CMEs also observed by the LASCO coronagraphs. We practice our modeling techniques by making these views available in real time to forecast halo CME Earth-arrival. Here we explore the locations and shapes of a few select halo CMEs and their three-dimensional velocity structure in order to determine whether they will hit or miss the Earth.

This work is supported by NASA grant NAG5-8504 and AFOSR grant F49620-01-1-0054.

URL: <http://casswww.ucsd.edu/solar/>

#### SH21A-0475 0830h POSTER

##### How Magnetically Open are Magnetic Clouds Beyond 1 AU?

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From suprathermal electron measurements, we know that magnetic clouds at 1 AU contain a mix of primarily open and closed magnetic field lines and that the open field lines constitute roughly 40%, on average. Presumably these open field lines are created gradually by interchange reconnection in one leg of the cloud back at the Sun, where an open field line reconnects with a field line in the cloud that is attached to the Sun at both ends, thus interchanging a closed loop in the heliosphere for a closed loop in the corona. What is not known is whether interchange reconnection continues well beyond 1 AU until clouds become completely open. The answer to this question has important implications for the heliospheric magnetic flux budget, since closed fields in interplanetary coronal mass ejections (ICMEs) build up flux in the heliosphere. Although clouds are a small fraction of all ICMEs, they provide more accurate measures of total open flux because their boundaries are independent of the counterstreaming electron signatures used to identify closed fields. We analyze the clearest clouds in Ulysses data to determine the percentage of open flux in each case, taking into account the fact that the percentage of open flux in clouds at 1 AU decreases with increasing cloud size and that cloud size increases with distance from the Sun. Preliminary results suggest that clouds beyond 1 AU are only slightly more open, implying that the rate of interchange reconnection in the leg of an ICME slows significantly when its leading portion is not far beyond 1 AU.

#### SH21A-0476 0830h POSTER

##### Numerical Test of a Three-Dimensional Flux Rope Model for Coronal Mass Ejections Based on Ideal MHD Processes

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A series of simulation runs in Cartesian coordinates are carried out, using the BATS-R-US code, to investigate the loss of equilibrium of the 3D flux rope configuration of Titov & Démoulin (1999) as a potential CME initiation mechanism. All numerical experiments are fully 3D and involve ideal magnetohydrodynamics.

Our results show that the criterion  $R > \sqrt{2}L$ , derived in the earlier study by neglecting the effects of line-tying of the poloidal field, may be a necessary condition for a loss of equilibrium, but it is not a sufficient one. The line-tying of the ends of flux rope leads to a much more stringent condition for an eruption to occur.

The question remains whether it is possible to get a loss of equilibrium with the Titov & Démoulin model which will lead to a CME-like eruption. We do find evidence for a loss of equilibrium, but the resulting evolution of the system more closely resembles an impulsive-type flare rather than a CME. Whether there is a region of the model's parameter space where CME-like eruptions can occur remains to be determined.

#### SH21A-0477 0830h POSTER

##### The First Year of Solar-Wind Data From the GENESIS Mission

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The GENESIS mission was launched in August, 2001, and has been in an L1 halo orbit for over a year. The primary purpose of the mission is to collect solar-wind samples that will be returned to Earth in 2004 for high-precision isotopic and elemental analyses. GENESIS uses conventional ion and electron spectrometers to record solar-wind conditions during collection, and to make real-time determinations of the solar-wind regimes to facilitate collection of separate samples of interstream (IS), coronal hole (CH), and coronal mass ejection (CME) flows. Of particular interest is the use of a bi-directional electron (BDE) index to determine the presence of CMEs. And although GENESIS lacks a magnetometer, the field vector, with sign ambiguity, is determined by the electron direction, and matches other spacecraft magnetometer data well. GENESIS in-situ data and on-board regime determinations are available on the web.

The data from Fall, 2001 were characterized by numerous CME regimes (comprising 32% of the time in the 4th quarter, based on the on-board algorithm), with little CH flow (only 2%). A strong CH flow was observed every solar rotation from mid-January through late May. June was quiet, nearly all IS flow. The first and second quarters of 2002 were approximately 28% CME flow, with CH flow dropping from 18% to 6%. The discovery of unexpectedly noticeable BDE signals during CH flows at 1 AU (Steinberg et al., 2002) caused us early on to modify our regime selection algorithm to accommodate these. The on-board algorithm intentionally errs on the side of overestimating CME flows in order to keep the CH sample more pure. Comparisons have been made of various compositional parameters determined by Genesis (Barraclough et al., this meeting) and by ACE SWICS (Reisenfeld et al., this meeting) for times corresponding to the Genesis collection periods for each of the three regimes.

The Genesis L1 halo orbit is  $\sim 0.8 \times 0.25$  million km radius, somewhat larger than the  $\sim 0.3 \times 0.2$  and  $\sim 0.7 \times 0.2$  million km orbits of ACE and SOHO, respectively, presenting excellent opportunities for multi-spacecraft observations at L1.

URL: <http://genesis.lanl.gov>

#### SH21A-0478 0830h POSTER

##### A Density Model of Flux-Rope Coronal Mass Ejections

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A density model is developed for a coronal flux rope with a specified magnetic field configuration. We find that the flux-rope plasma density is depleted on axis, where the magnetic field lines are least twisted. Assuming that a flux-rope coronal mass ejection (CME) results from the eruption of a pre-existing coronal flux rope, the CME density is obtained.[1] The resulting model CME is tested against the data by computing synthetic coronagraph images.[2] In the case that these model CMEs are consistent with both the analytical calculation and with prior simulations of "flux