and versus the initial thermal velocity. This allows us to determine which part of the distribution function is responsible for nonadiabaticity. (ii) Two distinct nonadiabatic electron populations have been clearly identified: one is super-adiabatic (overheating), the other is sub-adiabatic (overcooling). Results are compared with recent theoretical calculations suggested to explain the existence of these two populations and to identify the underlying mechanisms responsible for their formation. Present results may be of importance for analysing new experimental data issued from CLUSTER-II mission.

NB: This work is supported by ISSI (Bern, Switzerland)

SH72A-0556 1330h POSTER

An Investigation of the Spatial Scales of the Change in Electric Field Observed at the Front of a Quasi-perpendicular Shock.

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Using data from the Cluster EFW instrument it is shown that there is a general increase in the level of the electric field observed as the shock is crossed and the extent of this region appears to be larger than that of the magnetic ramp. However, within this region, short scale spike-like features in the electric field are commonly observed. The scale size of these features is determined and their relationship to various upstream parameters investigated.

SH72A-0557 1330h POSTER

Predicting the Bow Shock Position for Average and Unusual Upstream Conditions

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The positions, shape and motion of the Earth's bow shock have been extensively studied for the last four decades. Although many bow shock models have been developed, they still do not sufficiently describe the observed bow shock. The models fail because they are intrinsically steady-state and (semi)empirical. On the other hand, physics-based 3-dimensional global MHD models of the Earth's magnetosphere are resident at the Community Coordinated Modeling Center (CCMC). These MHD models compute the configuration and evolution of the magnetosphere in response to the actual solar wind parameters. We will compare and discuss differences between the bow shock observations for average and unusual upstream conditions and predictions provided by the MHD numerical simulations or by the (semi)empirical models.

SH72A-0558 1330h POSTER

Analytic and Numerical Modelling of Langmuir Waves and Radio Emission from Earth's Foreshock

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We present theoretical predictions of the spatial distribution and flux levels of radio emission in Earth's foreshock due to Langmuir waves driven by backstreaming electron beams. We combine electron reflection and acceleration at Earth's bow shock with stochastic growth theory for the steady-state production of Langmuir waves and nonlinear wave processes for the emission of electromagnetic radiation at harmonics of the electron plasma frequency. We demonstrate that the model predictions agree remarkably well, both qualitatively and quantitatively, with observations.

SH72A-0559 1330h POSTER

Observations of Foreshock Langmuir Waves by the Cluster Wideband Data Plasma Wave Receiver

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The Wideband Data (WBD) Plasma Wave Receiver, which is part of the Cluster Wave Experiment Consortium (WEC), provides high-resolution measurements of waveform electric and magnetic fields in selected frequency bands up to 577 kHz. Continuous waveforms are transmitted to a DSN ground station in a 220 kbit/s real-time mode, making the Cluster Wideband Data Plasma Wave Receiver an excellent instrument for studying Langmuir waves in Earth's foreshock region. We will discuss the statistics of the frequencies and amplitudes of foreshock Langmuir waves observed by Cluster. We will also describe the characteristics of the observed electric field waveforms, and how the properties of the Langmuir waves depend on the spacecraft location within the foreshock region and on upstream solar wind conditions. We will examine the relevance of our Langmuir wave observations to various growth mechanisms and instabilities, such as the modulational instability and stochastic growth theory.

SH72A-0560 1330h POSTER

Ion Reflection, Acceleration and Transmission at the Quasi-Perpendicular Bow Shock: Cluster CIS Observations

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Two distinct populations of reflected and accelerated ions are known to come from quasi-perpendicular shocks, gyrating ions and reflected ion beams. Recent observations under such bow shock conditions with Cluster have shown that both particle distri-butions appear to emerge from the same reflection process. The beam results from effective scattering in pitch angle during the re-flection, with, for example, very strong scattering at high Mach number shocks. The Cluster spacecraft have crossed the Earth's bow shock many times and thus have accumulated an extended database of shock crossings. We have analyzed a number of quasi-perpendicular shocks with the Cluster Ion Spectrometry experi-ment (CIS). The spatial and temporal evolution of the reflected and transmitted ion populations is studied for a variety of shock angles, Mach numbers and plasma beta. The observed event-to-event differences and temporal variations of the ion populations are related to changes of these parameters and compared with models and simulations.

SH72B MCC: 124 Sunday 1330h

Energetic Charged Particle Transport in the Heliosphere II

Presiding: **J A le Roux,** University of California, Riverside**; W H Matthaeus,** Bartol Research Institute

SH72B-01 1330h INVITED

Quasi-linear Theory of Energetic Particle Spatial Diffusion in Static MHD Turbulence

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Quasi-linear theory of particle scattering parallel and perpendicular to the mean magnetic field B, is applied to static fully three-dimensional MHD turbulence described by its three-dimensional wave vector spectrum Pij(k). The method follows that of Forman et al. (Ap.J.,1974), but uses a more complete evaluation of the scattering tensor and does not assume that the particle pitch angle distribution is linear in the pitch angle. The form of Pij(k) derived by Oughton, et al. (1996) is essential to this new evaluation of the scattering tensor. The particle gyrophase distribution is assumed to be a simple cosine whose amplitude and phase are parameters to be determined, giving the perpendicular elements of the scattering tensor. In this picture, scattering parallel and perpendicular to the mean field is due to power, polarization, anisotropy and helicity in the power spectral tensor at (different sets of) resonant wavevectors perpendicular to the local mean field as well as in parallel and in intermediate directions.

To make the theory tractable, the Pij(k) are assumed to be cylindrically symmetric about the local mean magnetic field. Results are presented for the slab + 2D model; that is, Pij(k) is non-zero only at wavevectors parallel or perpendicular to the mean magnetic field.

I find that the 2D component wavevectors perpendicular to the mean field have no effect at all on pitch angle scattering. There could be parallel scattering by wavevectors at oblique angles, not included in the present theory. For perpendicular scattering, the slab component contributes a "power at zero frequency" term as known before, but the 2D component contributes a similar term for particles with gyroradius large compared with the correlation length of the field. If the slab power is a fraction F of fluctuations, this theory predicts a parallel diffusion coefficient 1/F times larger than if all the power in fluctuations were slab modes. The perpendicular diffusion coefficient is not changed at large rigidities, but is reduced by a factor F at rigidities where the gyroradius is small compared to the correlation length.

This work was supported by NASA grant NAG510995.

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SH72B-02 1350h INVITED

The global transport of energetic particles in the heliospheric magnetic field

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We present new results from modeling the global propagation of energetic particles (greater than $\sim$ 50 keV) in the heliosphere. Our models are applied to the interpretation of some observed events which provide information about the large-scale heliospheric magnetic field itself. Examples include the recurrent particle events at high heliographic latitudes associated with corotating interaction regions at lower latitudes, impulsive solar-flare events showing fine-scale intensity variations at 1 AU, and large global events, such as the one which occured on Bastille day, 2001. We show that the diffusion of charged particles across the average magnetic field naturally explains many of the observed features of particle events. The physics of cross-field

diffusion and the effect of field-line braiding and meandering on the particle diffusion are discussed. Additionally, we compare the results from the brute-force numerical integration of particle trajectories in synthesized magnetic fields with a cosmic-ray transport model in order to determine transport coefficients. We also discuss the constraints imposed by the observations of both the heliospheric magnetic field and the particles in the context of existing models.

SH72B-03 1410h INVITED

Velocity Distributions of Suprathermal Ion Observed With SWICS on Ulysses and ACE

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Spectral characteristics and anisotropies of solar wind and pickup ions provide important clues concerning the injection, acceleration and transport properties of suprathermal particles. Elemental and charge-state composition of these ions give information on sources of accelerated particles in the heliosphere. Comprehensive and continuous measurements of H+, He+, and He++ with the Solar Wind Ion Composition Spectrometers (SWICS) on both Ulysses and ACE, are giving us a wealth of data that can be used to study pitchangle scattering, momentum diffusion and spatial diffusion of these particles in the solar wind. The observed velocity distribution functions in the range of W (ion speed/solar wind speed) between about 0.5 and 10 are found to be in general anisotropic. They are always non-maxwellian and have pronounced suprathermal tails. We will present velocity spectra found in the disturbed solar wind behind CIR and CME-driven shocks, and compare these to distributions in the quiet wind, far removed from shocks. Implications of these observations will be discussed.

SH72B-04 1430h INVITED

The Sources, Transport, and Acceleration of Pickup Ions in the Heliosphere

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Pickup ions in the heliosphere have four major sources: the interstellar source, the inner source caused by interaction between the solar wind and grains near the Sun, discrete sources such as comets, and the recently discovered outer source caused by sputtering of grains from the Kuiper belt. Much has been learned due to observations from Ulysses/SWICS and Wind/STICS about these sources, about their scattering among magnetic irregularities embedded within the solar wind, and about their acceleration near shocks and due to wave-particle interactions. In each of these areas, the theories of pickup ion interactions have improved our understanding, but important questions remain. Interstellar pickup ions are a known source of anomalous cosmic rays (ACRs) which are thought to be accelerated by diffusive shock acceleration at the solar wind termination shock. Recent ACR observations have revealed an "additional" population of ACRs that cannot be explained by the traditional interstellar source. The inner and outer pickup ion sources are the most promising candidates to explain these "additional" ACRs. The detailed nature of pickup ion acceleration inside the termination shock determines how these sources contribute to ACRs. The presentation will review these topics, with attention to the current challenges and revisions of understanding that have been triggered by pickup ion and energetic particle observations made over the last decade.

SH72B-05 1450h

Perpendicular transport of solar energetic particles: Ulysses observations at high heliographic latitudes

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One of surprising discoveries by Ulysses at high heliographic latitudes during the 2000-2001 solar maximum is that essentially all the large gradual solar energetic particle events can be observed at Ulysses and Earth simultaneously despite their large separation in longitude and latitude. The particle fluxes at the two locations often become comparable within a few days after the onset and the fluxes often remain comparable for several weeks during the decay phase of the solar energetic particle events. These observations suggest that energetic particles can transport across heliographic longitude and latitude fairly easily, or that the particle sources extend considerably in latitude and longitude. In the paper, we present compelling evidence, obtained from the analysis of anisotropy measurements of the Bastille Day 2000 solar particle event and other events, for substantial transport of fast 40-90 MeV solar energetic protons across the local magnetic field. The large source extent in latitude is not necessary to explain the observations. The observed anisotropy of the particle intensity is often directed at significant angles (sometimes 90 degrees) to the measured magnetic field direction for periods of many hours, and its magnitude exceeds 10% (sometimes 50%), which is much too large to be accounted for by the Compton-Getting effect. The anisotropy direction is not correlated with the polarity of the magnetic field. We believe the observation can only be explained as cross-field diffusion flow in the presence of a particle gradient. A simple diffusion model is found to fit the direction of particle flows with a large inferred kappa perpendicular to kappa parallel ratio of as much as 25%. Similar large values of this ratio were found from observations of energetic particles in association with corotating interaction regions at low latitudes (Dwyer et al., 1997).

SH72C MCC: 124 Sunday 1515h

The 19-25 May 2002 Solar Wind Event *(joint with SM)*

Presiding: **K W Ogilvie,** NASA Goddard Space Flight Center**; A J Lazarus,** Massachusetts Institute of Technology

SH72C-01 1515h

A View of the Inner Heliosphere during the May 23-24, 2002 Low Density Anomaly

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For a two day period in May 2002, the solar wind density dropped to anomalously low values, similar to those reported previously for a May 1999 solar wind density dropout. The low density event was observed by WIND and ACE on the trailing edge of a high speed stream from a coronal hole. Using the MHD inverse mapping technique, we trace the solar wind plasma and magnetic field observables for CR1990 to create a map of the inner heliosphere to a distance of 0.3 AU. We also examine in detail the limits of such a mapping. Specifically, it is assumed that the solar wind flow is super-Alfvénic, but we find notable exceptions particularly during low density/low velocity temporally-short periods for this and other low density anomalies. Another limit to the technique is the requirement that the solar wind structures be part of the corotating plasma system. We find that this and other anomalies are parts of the corotating structures, making the model application appropriate. The physics of the anomaly formation will be discussed.

SH72C-02 1530h

Unusual Solar Radio Event: May 18-22, 2002

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From May 18 to 22, 2002 an intense, wideband (500 kHz to 5 MHz) solar radio event was observed by the WAVES receiver on the Wind spacecraft. This unique event, which was observed continuously for 5 days, was characterized by fine frequency structures (16 sec), 1.5 to 2 hour periodicities, and by nearly 100% circularly polarized emission. This is the only such event observed by Wind in its 8 years of operation. (The only other example of an event of this nature may have been observed more than 20 years ago by the ICE spacecraft.) The direction-finding analysis for this event indicates that the radio source may lie somewhere between 0.08 and 0.2 AU from the sun and that the source is relatively small. The corresponding frequency spectrum has a peaked distribution, with peak frequency decreasing with time–perhaps suggesting radiation trapped in an expanding structure (at the time of the radio event three interacting solar ejecta appeared to be passing over the Wind spacecraft). The radio event could possibly be a unique kilometric manifestation of a moving type IV burst. The radiation mechanism is unknown–possibilities include plasma emission, gyro-synchrotron, and cyclotron maser. Indeed this emission has characteristics more typical of planetary emissions than of solar emissions. This unusual radio event was almost immediately followed by the unique period of extremely low solar wind density.

SH72C-03 1545h

GEOTAIL Observations of a Moving Type IV Solar Radio Burst, Type III Solar Radio Bursts, Type II Solar Radio Bursts, and Solar Wind and Magnetospheric Plasma Wave Emissions During the May 19-25 Solar Wind Event

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The GEOTAIL Plasma Wave Instrument (PWI) continuously detected a moving Type IV solar radio burst from 800 kHz down to as low as 400 kHz from May 19-23, 2002. The emissions were almost without vertical structure in contrast to that from the leading edge onsets of the Type III solar radio bursts observed before, during, and after the event. Type II solar radio bursts were also detected from May 22 to May 25. Cyclic enhancements in the intensity of both the Type II and Type IV emissions with periods from about half an hour to several hours were observed. On May 24 and May 25 the lower cutoff frequency of Type III solar radio bursts as well as the detected electron plasma oscillation frequency showed that at times the solar wind density was as low as 0.1 e-/cc. The GEOTAIL PWI observations will be compared to those of the WIND Radio Science Experiment (WAVES) during the event and to other pertinent GEOTAIL PWI and WIND WAVES observations including Type III solar radio burst storms and to other low density solar wind events.