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.

SH72C-04 1600h

UNUSUAL PLASMA CONDITIONS DURING MAY 23-25, 2002

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We present an overview of the plasma conditions under the extreme tenuous plasma (Ne $<$ 0.2 part/cm^3) which started on May 23, 2002 and lasted for almost three days. During this unusual interval at times the magnetosonic speed is well above 300 km/s, and unusual close values in the ratio of plasma to cyclotron electron frequencies (fpe/fce 10). Using waves and solar wind parameters from the Wind WAVES, EPAC, MFI and SWE experiments, we compare this event with other intervals during this solar cycle which also showed strong hindrance in the flow of the interplanetary solar wind. We further inquire on the nature of the event by looking at the earth's polar cusps response to the solar wind conditions, as illustrated by observations by satellites POLAR and POES, and investigate, using fluxrope models and energetic particles, the nature of this intriguing interplanetary structure.

SH72C-05 1615h INVITED

Plasma and Magnetic Field Observations Related to the Solar Wind Density Minimum: May 23 through May 25, 2002.

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From 2100 UT on May 23 to 1800 UT on May 25 the solar wind number density remained below 1 proton/cm^3 and reached minimum values of approximately 0.1 /cm^3. This low density period followed an interplanetary shock near 1050 UT on May 23. Those densities are among the lowest ever observed. This report will describe field and plasma observations from the Wind and ACE spacecraft.

SH72C-06 1630h INVITED

Energetic Electrons and Ions Associated with the 19-25 May 2002 Solar Wind Event

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The population of low energy ions (60 keV-5 MeV) and near-relativistic electrons (38-315 keV) measured by ACE/EPAM during the period of unusually low solar wind density following an interplanetary shock 10:16 UT on 23 May 2002 could initially be associated with a complex of solar flare and CME activity very late on 21 May and early on 22 May. The onset at ACE of a beam-like injection of near-relativistic electrons $\sim$00:30 UT corresponded to a GOES-8 C9.7 xray flare beginning 23:14 UT with a maximum 00:30 UT in Region 9948 (S25W64). SOHO/LASCO images showed the launch of a pair of CMEs (extrapolated back to 1 $R_\odot$ using their height-time profiles), one at 23:38 UT with a velocity of 888 km/s and the other at 03:27 UT with a velocity of 1199 km/s, both off the western limb at position angles $\sim 230^\circ$. Thereafter, the electron intensities remained elevated and then began a gradual rise (as did the 2-5 MeV ion intensities which had not exhibited a prompt injection), culminating in an extraordinarily large electron and ion spike some 2 hours wide centered on the arrival of the interplanetary shock at 10:16 UT on 23 May. During most of the remainder of the day both the interplanetary magnetic field (IMF) and the energetic particles exhibited considerable variation, but when the IMF became remarkably quiet at 21:30 UT, so did the particle intensities, decaying very slowly and smoothly until a sudden drop $\sim$2100 UT on 24 May. This period of quiet IMF and a "reservoir" of energetic particles corresponded to the period of lowest solar wind densities ($<$0.3/cc). While the IMF remained quiet for almost another day and the solar wind densities slowly recovered $\sim$1800 UT on 25 May to $\sim$2/cc, the drop in the energetic particle intensities a day earlier on 24 May coincided with the end of the post-shock high-speed solar wind stream as it abruptly dropped back to a nominal velocity of 400 km/s. Thus the energetic electron and ion populations were: 1) initially injected in association with a western flare and CME launches; 2) further accelerated dramatically by the interplanetary shock; and 3) decayed very slowly within the high-speed, low density, quiet IMF solar wind stream following the shock. The possible role in this sequence of events of the equatorial coronal hole that was rotating through the western hemisphere remains to be determined.

SH72C-07 1645h

Low Density Periods in the Solar Wind

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A long period of low solar wind density was observed between 5/24/0530 and 5/25/1200 UT of 2002. The density was below 0.1/cc for part of this time, and below 2.0/cc for all of it, making the event similar to the examples given in "Electrons in the Low Density Solar Wind", Ogilvie, Fitzenreiter and Desch; J. Geophys. Res., 105, 2000. In the present paper we investigate the solar and interplanetary conditions at the time of this event. A CME at 5/21/2338, perhaps associated with a flare at 5/21/2322 UT, drove a large discontinuity that passed Wind at 5/23/1200. At this time the solar wind speed rose to 850-900 km s-1 and the pressure to 1.1 x 10-8 ergs/cm3. The rarefaction following this discontinuity appeared to be responsible for the long period of low density. These occurrences will be discussed in detail, and compared with similar earlier events, to support the notion that periods of abnormally low density are rarefactions following high speed discontinuities driven by CME material. The low probability for the occurrence of a high speed CME sending its associated disturbance in the earth's direction, accounts for the rarity of these long duration low density events.

SH72C-08 1700h

Wave Refraction During the May 2002 Rarefaction Event

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In previous work [*Smith et al.*, 2001] we examined IMF wave refraction during the May 1999 rarefaction interval known as "The Day The Solar Wind Disappeared." On that day, Alfvén speeds remained elevated over an extended region. Analysis of the recorded ACE fields and plasma data revealed depressed magnetic fluctuation levels, reduced compression in the fluctuations, and a reduced wave-like component within the region of elevated Alfvén speed, all consistent with wave refraction. The May 2002 event provides a third such period (the second identified event occured 2 weeks prior to the May 1999 period) and it again demonstrates properties which are consistent with refraction.

Smith, C. W., D. J. Mullan, N. F. Ness, R. M. Skoug, and J. Steinberg, Day the solar wind almost disappeared: Magnetic field fluctuations, wave refraction and dissipation, *J. Geophys. Res.*, *A106*, 18,625–18,634, 2001.

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SH11A MCC: Hall D Monday 0830h

Energetic Charged Particle Transport in the Heliosphere III Posters

Presiding: **J Giacalone,** University of Arizona**; R A Burger,** Potchefstroom University

SH11A-0374 0830h POSTER

Propagation of energetic particles to high heliographic latitudes

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We present observations of energetic particles in the energy range 0.3 MeV to 100 MeV made by the COSPIN instrument on board the Ulysses spacecraft during the recent second northern polar pass. At this time, the Ulysses spacecraft was at high heliographic latitude and was immersed in high speed solar wind flow coming from the northern polar coronal hole. Three large solar energetic particle events were observed at this time. We present a detailed analysis of the propagation of these energetic particles in the relatively homogeneous plasma of the high speed flow. We examine the particle time intensity profiles and anisotropies over a wide range of energies, and discuss this in the context of current propagation models.

SH11A-0375 0830h POSTER

Characteristics of Scatter-free Behavior of Heliospheric Pickup Ions

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Theoretical treatments of heliospheric pickup ion behavior generally focus on the solution of various forms of the Boltzmann or transport equation. Like their cosmic-ray counterparts, these approaches often presume a radial geometry for the interplanetary magnetic field, and focus on diffusive processes acting on already energetic particles. At the opposite extreme lies the test particle picture of pickup ions, wherein one can treat the problem from the birth of the ions through their motion in a Parker Spiral field with a radially flowing solar wind. This approach thus explicitly includes the initial pickup process by the convection