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 ~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 ~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 ~1800 UT on 25 May to ~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.

Efforts at the Bartol Research Institute were supported by CIT subcontract PC251439 under NASA grant NAG5-6912 for support of the ACE magnetic field experiment and by the NASA Delaware Space College Grant. Work at Los Alamos was performed under the auspices of the U.S. Department of Energy with financial support from the NASA ACE program.

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

electric field, and the effects of the radial evolution of the latter in the presence of the focusing effects of the radial expansion of the solar wind. Scattering processes can be added to the test particle approach in the manner described by Giacalone (e.g. Adv. Space Res. 23, p. 581, 1999), but it is first instructive to gain perspective from the first order, scatter-free calculations. The results suggest how the combination of the spatial distribution of ion production and initial velocity of the parent neutral might combine to produce characteristic features in heliospheric pickup ion distributions from different sources.

SH11A-0376 0830h POSTER

Solar Wind Speed and Temperature Outside 10 AU and the Termination Shock

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We study the speed V and temperature T of the solar wind in the distant heliosphere obtained from pickup proton magnetohydrodynamic equations that treat interstellar pickup protons and solar wind protons as two distinct proton species. The study uses the 27-day average Omni plasma and magnetic field data as input. We obtain 336 sets of numerical solutions covering the period from the solar minimum of Cycle 20 in 1976 to the maximum of Cycle 23; each represents the extrapolation for the real solar wind conditions at 1 AU to the distant heliosphere following the fluid motion. The result shows that outside 10 AU near the ecliptic V and T at a given r are primarily functions of the 1 AU wind speed. The maximum of the 1 AU wind speed is 615 km/s occurred on March 1989, the minimum at 327 km/s occurred on February 1999. A straight line can be used to represent the relation between V and the 1 AU speed for each given r; and a parabola can represent the relation for T at each given r. These relations are attributed to the accumulated effects of pickup proton process in the distant heliosphere. Because pickup protons are expected to have similar effects on the solar wind at all latitudes on the upwind side of the heliosphere, the relationships for V and T are extended to study the solar cycle and latitudinal variation for the heliocentric distance of the termination shock. Wang and Sheeley have an empirical model to calculate the 1 AU wind speed as a function of latitude and longitude from the observed photospheric field. The calculated latitudinal variation is consistent with the observational results from Ulysses. We use the simulated 1 AU speed to calculate V and T at varying r following the fluid motion. Then we can calculate the solar cycle variation of the shock distance at all latitudes over a 26-years period. The averaged distance increases with the latitude; from ecliptic to the pole the distance increases by a factor of 2.

SH11A-0377 0830h POSTER

Solar Wind Modulation of Galactic Cosmic Rays

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A recent analysis of the annual mean hourly data for the solar wind speed, the interplanetary magnetic field intensity at the earth's orbit, and the neutron monitor rates for 1964-1998, indicates that galactic cosmic ray modulations observed at the high rigidities are mainly caused by their convective removal from the inner heliosphere by the solar wind. We are now able to explain why several different research groups (including this author), all over the world, have reported a strong correlation between the observed modulations of the galactic cosmic rays and interplanetary magnetic field intensity B. These correlations span a large range of time scales, such as: 11 years, 27 days, Forbush decreases, and steady state diurnal variations. We are also able to explain why there is a relationship between the temporal variations of the planetary indices (Kp, Ap, aa) and the long term modulation of galactic cosmic rays. However, several glitches remain to be resolved and many important questions need answers. We shall discuss the physical significance of our results and delineate their implications for the space weather forecasting.

SH11A-0378 0830h POSTER

Cosmic Electron and Positron Spectra Measured in 2002

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In August of 2002 we successfully carried out two balloon flights, extending our series of measurements of the time evolution of the spectra of cosmic ray electrons and positrons up to 2.5 GeV. Our positron detector, AESOP, flew for over 40 hours on a conventional balloon. On another flight, the electron detector LEE reached an altitude of 161,000 feet on a newly designed NASA balloon, which was the largest balloon ever successfully launched. Both flights, from Lynn Lake, Manitoba, were technically successful. We will report the preliminary analysis (now in progress) of the data from these flights in a continuation of our efforts to understand the origin of charge sign dependent effects in solar modulation.

URL: http://www.bartol.udel.edu/ ∼ *clem/aesoplee.html*

SH11A-0379 0830h POSTER

Spectra of Ulysses HISCALE Electrons, 2001

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Fluxes of low-energy (∼50 - 200 keV) electrons during Ulysses' solar south pole to north solar pole pass in 2001 were of sufficient magnitude to compute reliable power spectra in the frequency range where low-order and degree *g*- and *p*- solar oscillatory modes are expected. In the 100 to 1000 μHz frequency range the spectra are dominated by large peaks that are reproducible between different electron flux and energy channels. Moreover, almost all of these peaks correspond to predicted mode frequencies for $0 \leq l \leq 5$ to within a few microhertz, although there appear to be some systematic differences between predictions and observations. Several of the large peaks in the spectra are sufficiently isolated in frequency to allow hypothesis tests for spherical harmonic dependence in heliographic latitude. (The spacecraft's motion means that space and time are confounded so that one cannot reliably detect modes by simply testing for periodic components. Instead, one must include the amplitude and phase changes expected for a given mode along the orbit.) Preliminary tests using narrow band filters on some tentatively identified modes show the expected amplitude and phase characteristics.

SH11A-0380 0830h POSTER

Improved Representation of Heliospheric Magnetic Field Fluctuations in Ab Initio Models of Cosmic Ray Modulation

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We construct a theory of solar modulation of cosmic rays using a diffusion tensor based upon ab initio turbulence and scattering theories, employing direct numerical simulations of the steady state cosmic ray transport equation to examine important factors that affect modulation. In most numerical simulations the magnetic field fluctuations, a crucial element in scattering theory, are calculated from very simple theories. Moreover, it is hard to determine these quantities everywhere in the heliosphere from these simple theories and hence these quantities are usually extraploated within 1 AU. An improved procedure would be to numerically solve the governing equations for Elsasser variables in the entire heliosphere taking into account large scale variations of density, solar wind speed etc in the inner and outer heliosphere. Added to it, the fluctuations depend on the abundance and properties of pickup ions and cross helicity of magnetic field. Hence we have taken up the task of finding the fluctuations in every point of our heliospheric domain which extends to almost 100 AU by directly integrating the equations for fluctuations in terms of Elsasser variables . More importantly, we intend to distinguish the inward and outward travelling sense of velocity-magnetic field correlation which has not been taken up in earlier modulation work. Our plan is to use the computed distribution of fluctuations in our ab initio modulation theory.

SH11A-0381 0830h POSTER

"Spaceship Earth" Observations of the Easter GLE

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The largest relativistic (∼1 GeV) solar proton event of the current cycle occurred on Easter (April 15) 2001. This event was observed as a ground level enhancement (GLE) by the 11-station "Spaceship Earth" network of neutron monitors. We derive density and anisotropy time profiles and fit these with numerical solutions of the Boltzmann equation. Interplanetary transport was rather diffusive in this event, with a radial mean free path in the range 0.1-0.2 AU. We also find that particle injection at the Sun peaked at 13:47 UT. In comparison, the type II radio burst started at 13:48, type IV at 13:52, and the soft X-ray peak (an X14.4 event) was at 13:50. Supported by NSF grant ATM-0000315 and the Thailand Research Fund.

URL: http://www.bartol.udel.edu/∼neutronm/

SH11A-0382 0830h POSTER

A Novel Technique to Determine Ionic Charge States in Large Solar Particle Events

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We present a novel technique to measure average ionic charge states of high energy (/geq 10 MeV/nuc) solar energetic particles (SEPs) in large solar events. It is found that in some large SEP events, the characteristic decay times of SEP fluxes decrease with increasing energy, in a manner consistent with a diffusion coefficient that increases with rigidity. From this dependence average ionic charge states are inferred for nitrogen, oxygen, neon, magnesium, silicon, sulfur, and iron in several SEP events between 1997 and 2002. There is considerable variation in the charge state of iron from event to event. For those SEP events for which charge states have been determined with SAMPEX/MAST using the geomagnetic cutoff technique, the results from both techniques are seen to be consistent.

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 forcusing effect. It is found that the forcusing 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.

SH

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^{6+} have a relatively high drift velocity, however others such as Fe^{9+} tend to lag behind oxygen by a few tens of km/s (Hefti et al. 1998). This subtle observational