SH21A CC: 220 C-E Tuesday 0830h

Fresh Perspectives in Solar-Heliospheric Science III Posters

Presiding: **E Moebius,** University of New Hampshire**; N A Schwadron,** Southwest Research Institute

SH21A-01 0830h POSTER

Comparison of Voyager 2 and Pioneer 10 Lyman Alpha Data With Model Calculations and Possible Implications

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The Voyager 2 (V2) and Pioneer 10 (P10) Lyman Alpha measurements are important ingredients to the unique outer heliosphere Lyman Alpha diagnostic dataset, and which allow detailed probing of the Very Local Interstellar Medium (VLISM). The V2 data obtained between 39 and 55 AU in the upstream direction have been used to estimate the pristine local interstellar hydrogen and proton densities far from the sun and compared with that obtained using P10 data between 20 and 45 AU in the downstream direction. State of the art neutral-plasma heliospheric models and radiative transfer models have been used in the interpretation of the data. The results of the comparison and possible implications will be discussed.

SH21A-02 0830h POSTER

Lorentz Scattering of Small Dust Particles Within $10\,R_\odot$

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In the absence of coronal mass ejections (CMEs) the electromagnetic force acting on a dust grain orbiting the Sun at a large distance in the ecliptic is expected to average to zero because the grain spends half its time in each hemisphere of the solar magnetic dipolar field. Because of imperfect symmetry, the grain diffuses away from its unperturbed trajectory. At 1 AU the magnetic field intensity is small, and the diffusion process takes many years to produce an observable effect, as was demonstrated long ago. Closer to the Sun, however, the magnetic fields are strong enough to produce a significant perturbation of a small grain trajectory over less than half an orbit. We find that grains with radii of 1 to 3 microns need only a few orbital periods (days) to be deflected out of the ecliptic plane by the magnetic fields and broadly distributed in latitude. Our result is inconsistent with recent modeling results by other authors who found that, except for the smallest silicates at solar maximum, the grains are typically deflected only by a few degrees from the ecliptic over periods of months. Their result was obtained using a highly symmetric time-averaged magnetic-field model causing the main scattering effect to average out on a grain orbital period (much shorter than the averaging time of the fields). We further consider the effect of CMEs on the Lorentz scattering of dust particles. While trapping the smallest of the grains (with radii < 0.1 micron), the CME magnetic fields also scatter the grains of intermediate size (0.1-3 micron) in latitude, resulting in a higher isotropization in latitude at solar maxima. We estimate, however, that the fluctuations in the averaged latitudinal scattering times may not exceed roughly 10 percent between solar minimum and solar maximum because the scattering by the quiet solar wind magnetic fields is already very efficient. This efficient scattering precludes the formation of a ring of small dust grains close to $4\,R_\odot$ described in earlier works.

SH21A-03 0830h POSTER

Compositional Variability of the Solar Wind: The Need for an Ultra-High Temporal Resolution Mass Spectrometer for Studies of Solar Wind and Coronal Mass Ejection Boundaries

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Current *state-of-the-art* solar wind mass spectroscopy has clearly demonstrated the compositional uniqueness between slow/fast solar wind streams and slow/fast coronal mass ejections (CMEs). As such, solar wind composition measurements serve as an indicator of the sub-coronal and coronal processes responsible for the formation of these heliospheric features. While current instrumentation have identified temporal variations in solar wind/CME composition on the order of 10's of minutes, these detections have occurred during relatively quiescent periods, such as within the magnetic cloud portion of a CME, when temporal variations of the collective solar wind (including magnetic field variations) occur over periods in excess of the current minimum instrumental duty cycle of 5-minutes. Consequently, the compositional markers of the *microphysics* responsible for the formation of highly variable solar wind flows and for CME/prominence formation remain overlooked. To address the need for greater temporal resolution in solar wind compositional measurements, we have undertaken the development of a novel ultra-high temporal resolution ion mass spectrometer utilizing a helical ion path time-of-flight (TOF) system within a compact, low-mass, low-power instrument. The instrument is designed specifically to measure solar wind $^{3}He^{+2}$ < M/q < $^{56}Fe^{+6}$ ion plasmas from 0.3-20.0 keV/q with an order of magnitude greater geometric factor than current solar wind ion mass spectrometers, and produce 1-10 ms mass spectra with a mass resolution of $M/\Delta M \sim 200$ or greater, all within a duty cycle of < 90-s. These characteristics achieve a resolution sufficient to probe spatial/temporal dimensions down to an ion gyroradius in solar wind flow boundaries at 1 AU. This paper presents an overview of solar wind mass spectroscopy results to date, justification for solar wind composition measurements of greater temporal resolution, and an introduction to the helical ion path mass spectrometer (HIPS) instrument under development.

SH21A-04 0830h POSTER

Temporal Variations in the Composition of Light Elements Associated With Solar Energetic Particle Events

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Repeatedly, characteristic temporal variations in the light-element composition of >4 MeV solar energetic particles are found. In the early phase of the event, energetic ions often show high helium-to-proton ratios significantly above typical coronal values. In the later phase, typically after several hours into the event, the He/p ratio changes into a composition more resembling that of the solar corona. A survey of events with the above characteristics is performed in comparison with the LASCO coronal mass ejection list. Furthermore, the MeV ion composition is compared with observations at suprathermal energies. The systematics and implications of the findings will be discussed in the context of the current paradigm that distinguishes between impulsive and gradual solar energetic particle events.

SH21A-05 0830h POSTER

Magnetic Effects and the Properties of the Heliospheric Neutral Sheet Properties in the Heliosheath

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How does the solar magnetic field affects the properties of the Heliosheath? What happens with the heliospheric neutral sheet in that region? In this talk we will cover both aspects presenting an unprecedent high spatial resolution numerical simulations. Only with such high spatial resolutions we are able to resolve the heliospheric current sheet and capture aspects such as a presence of a jet of accelerated flow at the current sheet. We will discuss the formation of the jet-sheet structure due to a Laval nozzle effect at the Termination Shock and it's subsequent large period oscillations due to magnetohydrodynamic instabilities. We will compare with 2D resistive magnetohydrodynamic simulation obtaining an excellent agreement. We show that the sinuous mode is the dominat mode that develops into a velocity-shear-instability with a growth rate of $0.027 years^{-1}$. We discuss the influence of spatial resolution on the width of the jet showing that with resolutions greater that 1 AU at the current sheet we get grid convergent result and the width tend to a finite value of $4AU$. We show that as a result of the solar magnetic field effects the heliosheath presents remarkable dynamics, such as turbulent flows caused by the jet. Further study, e.g., including the tilt of the solar rotation from the magnetic axis, is required, before we can definitively address how this outer boundary behaves. Already we can say that the magnetic field effects are a major player in this region changing our previous notion of how the solar system ends.

URL: http://butch.engin.umich.edu/~merav

SH21A-06 0830h POSTER

New Observational Results on the Thermal Anisotropy of the Core and the differential Speed of the Beam of Solar Wind Protons

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A new analysis of the old solar-wind plasma and magnetic field data obtained in 1976 by the Helios 2 spacecraft in high-speed streams reveals a high statistical correlation between the proton core plasma $\beta_{\|c}$ and the core temperature ratio $T_{\perp c}/T_{\|c}$. The empirical linear fit obtained may be written as $T_{\perp c}/T_{\|c} = c \times \beta_{\|c}^{(-0.625\pm0.003)} - 1$, where $c = exp(-.011\pm0.005)$, and $\beta_{\|c}$ ranges between 0.06 and 1.0. Here $\beta_{\|c}$ is the proton core plasma beta, which is based on the proton core thermal velocity component parallel to the magnetic field. We also find a good correlation between $\beta_{\|c}$ and the proton beam drift speed when measured in units of the local Alfven speed. This relation reads: $v_d/v_A = (2.16\pm0.03)\times\beta_{\|c}^{(0.281\pm0.008)}$, for $\beta_{\|c}$ ranging from 0.1 to 0.5, whereby v_d is the proton beam drift speed relative to the core and v_A the local Alfven speed. Both correlations place tight constraints on theoretical models, which attempt to describe the formation of the core thermal anisotropy and beam drift speed in the proton velocity distributions. It is shown that the thresholds derived for various linear electromagnetic instabilities do not seem to provide reasonable explanations of these observations. Yet, quasi-linear resonant diffusion driven by cyclotron waves may be a good candidate for explaining the results.

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SH21A-07 0830h POSTER

Daily Interplanetary Magnetic Field Polarities Near The Earth

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As satellites and space probes do not monitor continuously the interplanetary space, the techniques allowing to estimate the daily interplanetary magnetic field polarity near the Earth from ground-based observations are of great interest. Here we discuss the reliability of the polarities inferred from the CR anisotropy (shortly, CR polarities; Laurenza et al., JGR 108(A2), 1316, doi: 10.1029/2002JA009509, 2003) and from the perturbations of the polar geomagnetic field due to the Svalgaard -Mansurov effect (GEOM polarities) in the time interval 1965-1999. In particular, we show that when GEOM and CR polarities agree with each other they are also consistent with those observed by the satellites (SAT polarities) for 96 % of the time. A preliminary data set of "combined" daily interplanetary magnetic field polarities ([CR+GEOM] + SAT) is obtained for its use on medium- and long-term studies, covering the interval 1971-1992.

SH21A-08 0830h POSTER

Radial Evolution of the Electron Distribution Functions of the Fast Solar Wind Combining Measurements From the HELIOS, WIND and ULYSSES Spacecraft

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Observed electron distribution functions of the solar wind permanently exhibit three different components: a thermal core and a supra-thermal halo, which are always present at all pitch angles, and a sharply magnetic field aligned "strahl" which is usually antisunward-moving. If the Coulomb collisions could explain the relative isotropy of the core population, the origin of the halo population and more specifically the origin of its sunward-directed part remains unknown. Various processes like scattering of strahl electrons by shocks, corotating interaction regions or other wave/particle interactions have been invoked. We look for possible observational constraints on these processes by examining the radial evolution of the different populations of the electron distribution functions in the solar wind. For this purpose we combine HELIOS (0.3 to 0.7 AU), WIND (1 AU) and ULYSSES (1.3 to 3 AU) observations performed during fast solar wind periods at minimum of activity.

SH21A-09 0830h POSTER

LARGE-SCALE STRUCTURE OF THE SOLAR WIND: ELECTRON DENSITY, TEMPERATURE AND KAPPA DEDUCED FROM ULYSSES RADIO MEASUREMENTS BY QUASI-THERMAL NOISE SPECTROSCOPY.

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We will revisit and discuss the electron density and temperature derived from the electrostatic noise measurement made with the URAP-RAR dipole electric antenna on Ulysses, as this probe flew by pole-to-pole during the minimum solar activity (1994-95). The electron parameters are obtained by fitting a model of the voltage power spectrum to the voltage measured at the terminals of an electric antenna. This method is generically known as "quasi thermal noise spectroscopy". In the present work, the model of spectrum is depending on only 3 parameters and computed by assuming that the electron velocity distribution is a generalized Lorentzian or "kappa" distribution. The 3 fitted parameters are thus the electron density, temperature and kappa value of the distribution, and we will discuss their variations with heliocentric distance, latitude and temporal solar activity. We will also compare these new results to those obtained by our team from the same data set but assuming instead a classical "core + halo" distribution for the electron velocity, that is a sum of two Maxwellian distributions. With this later method, the only temperature that could be determined with enough precision was the core temperature, while our new processing provides the total temperature of the solar wind electrons. We will finally focus on the total temperature gradient with distance we find when using such a kappa distribution.

SH21A-10 0830h POSTER

Plasma heating via parametric beating of Alfvén waves, with heliospheric applications

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This work advances a novel mechanism to explain the dissipation of the Alfvén waves that carry much of the energy in heliospheric and astrophysical turbulence, with specific applications to solar wind heating. The essential point is that the non-linear beating of relatively low-frequency Alfvén waves, which are abundant in the solar wind, drives a compressible magnetosonic response whose damping can dissipate significant energy. This mechanism involves both kinetic and magnetohydrodynamic (MHD) processes. The damping of the magnetosonic waves is a kinetic process. The non-linear beating of Alfvén waves, which produces the magnetosonic waves, is most easily described by MHD theory. Near the Sun where significant unexplained heating occurs, this mechanism may dominate the more traditionally treated heating due to the cascade of turbulent energy to small-scale, high-frequency Alfvén waves that are dissipated by ion-cyclotron damping. The MHD analysis in this paper reveals that the fast magnetosonic mode dominates the dissipation when the plasma beta is near unity, and that the timescale of dissipation in the heliosphere can vary from hours to a year depending upon the direction of the driven wave and the plasma parameters where it is driven. A more detailed kinetic approach to understanding the same phenomenon yields similar results for a broad range of regimes, where the plasma density differs. The damping of the driven magnetosonic waves also helps to explain the observed high-energy particle distributions almost always observed in the slow solar wind.

SH21A-11 0830h POSTER

Physical Mechanism for the Formation of Particle Reservoirs in the Heliosphere

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Using measurements of energetic electrons (> 38 keV) by the EPAM experiment on the ACE spacecraft, we examine the dependence of the characteristic decay time scales of solar electron events on the large-scale structure of the Interplanetary Magnetic Field (IMF) and the resulting implications for particle containment and the formation of particle reservoirs in the heliosphere. The technique of mapping the solar wind and extrapolating the frozen-in magnetic field is used to obtain the large-scale IMF structure within and beyond the location of the spacecraft. Colliding slow and fast solar wind streams originating at different locations in the solar corona give rise to extended regions with compressed magnetic field which can serve as reflecting magnetic mirrors along the path of the injected energetic electrons. From the study of a number of events we find that electron events observed within a converging IMF structure exhibit a remarkably longer decay phase compared to electron events that propagate inside diverging configurations of the IMF. Our results provide strong evidence for the physical mechanisms that determine the establishment and maintenance of particle reservoirs in the heliosphere based upon the inferred locations of magnetic "barriers" in space beyond 1 AU. We use these understandings to interpret measurements of electron and heavy ion reservoirs that are observed simultaneously in the ecliptic by EPAM and out of the ecliptic, at high heliolatitudes, by the HI-SCALE instrument on the ULYSSES spacecraft.

SH21A-12 0830h POSTER

Out-of-Ecliptic Solar Wind in the Outer Heliosphere

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Dynamics of the solar wind in the outer heliosphere is governed by the pickup proton MHD equations. In this study the interstellar pickup protons and solar wind protons are treated as two distinct proton species, a hot hydrogen model is used to calculate the number density of interstellar neutral hydrogen at all latitudes, and real observational data are used as input function. We integrate the pickup proton MHD equations to obtain the radial evolution of the solar wind following the fluid motion in the outer heliosphere. There are two sets of data for the out-of-ecliptic solar wind speed: (i) the directly measured solar wind from Ulysses along its trajectory; (ii) the simulated 1 AU wind speed at all latitudes from the empirical model of Wang and Sheeley. The Carrington rotation average wind speeds from the two sources agree quite well. This study uses the simulated wind speed as input, that are calculated using a best-fit conversion function of WS model and the observed photospheric field maps. The calculated results show that the properties of the solar wind in the outer heliosphere are latitude dependent and solar cycle dependent. The simulated wind speed is the dominating parameter that determines the wind speed and temperature following the fluid motion; these relationships are attributed to the accumulated effects of the ionization process on heating and deceleration of the solar wind.