during 2002/07-2003/02. In this paper we will try to reconcile recent Voyager observations with other diagnostics of the heliospheric interface and discuss different scenarios. Wolff, B., D. Koester and R. Lallement, Evidence for an ionization gradient in the local interstellar medium: EUVE observations of white dwarfs, Astron. Astrophys. 346, 969-978, 1999.

SH12C-04 1645h

Evidence of Dynamical Variations in the Termination Shock

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In the vicinity of the termination shock, changes in the spectra of anomalous cosmic ray (ACR) He and O ions will reflect changes in the location of the shock and in the intensity of ACRs at the shock where they are accelerated. Comparing the evolution of the ACR spectra at Voyager 1 and 2 over the last two years indicates the shock has moved inward during that time while the ACR source intensity at the shock increased. This is consistent with the recovery of the shock from a collision with a Merged Interaction Region in early 2001 as modeled by Zank and Mueller and Jokipii et al. and suggests that the termination shock is likely very dynamic with transient motions of several AU driven by collisions with regions of high pressure solar wind. This work was supported by NASA under contract NAS7-1407.

SH12C-05 1700h

Anomalous-Cosmic-Ray and Plasma Signatures of the Termination Shock

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We consider the response of anomalous cosmic rays (ACR) and the solar-wind plasma to a transient radial incursion of the solar-wind termination shock, in the context of recent Voyager observations. Such an incursion is likely to *not* be global and have limited extent in the transverse directions (latitude and longitude). We find that the (ACR) spectrum and anisotropy have temporal variations which depend on the time and transverse spatial scale of the radial incursion, its speed, and the energetic-particle transport coefficients. For reasonable parameters, the energy spectrum of the very-low-energy particles shows the largest effect, and the spectrum of the higher-energy particles the least. The transverse component of the heliospheric magnetic field must increase by a factor equal to the ratio of preshock to post-shock solar wind speed. Finally, the shock-accelerated energetic-particle anisotropies near, but upstream of the shock will have a signficant *diffusive* anistropy comparable and opposite to the Compton-Getting anisotropy. We conclude that the ACR spectrum and anisotropies expected at or near a shock crossing may be consistent with the observed spectra if one considers the likely case of transient,localized incursions of the termination shock.

SH12C-06 1715h

Structure of the Heliospheric Termination Shock Revisited

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With the possibility that the Voyager spacecraft are flirting with a termination shock crossing, the question of just what might be observed is assuming greater importance. Although the shock is expected to be quasi-perpendicular, suprathermal pickup ions and superthermal anomalous cosmic rays are likely to play a fundamental role in determining the shock structure and associated scale-lengths. This has led to a model termination shock in which upstream pickup ions decelerate the incident solar wind flow, reflected pickup ions determine the scaling of the foot ahead of a sub-shock transition, and anomalous cosmic rays create a smooth precursor ahead of the shock which scales with the anomalous cosmic ray diffusive length scale. The general picture is therefore one of a smoothed shock with well-defined length scales. However, the structure of a cosmic ray mediated termination shock is unlikely to be as simple as suggested. We show that the gradient in shock accelerated anomalous cosmic rays can generate strong compressive instabilities in the foreshock and strong incompressible instabilities along the face of the quasi-perpendicular termination shock. The latter are particularly effective in promoting the growth of large magnetic fields at the shock. These cosmic ray gradient driven hydrodynamic and MHD instabilities are analogous to a generalized form of Rayleigh-Taylor instability. Secondly, we show that the pickup ions themselves can drive a buoyancy-like hydrodynamic instability which is further amplified in combination with the cosmic ray driven instabilities. The picture of the termination shock that emerges is instead one that is highly turbulent on hydrodynamic and MHD scales and bears little resemblance to the conventional smoothed cosmic ray mediated shock model. In view of the highly turbulent nature of the shock, we reconsider particle transport in the presence of a highly perturbed flow field and find that the usual cosmic ray transport equation is modified substantially. The new transport equation is solved for conditions appropriate to the termination shock and the resulting anomalous cosmic ray spectra described.

SH12C-07 1730h

Anisotropies of anomalous and galactic cosmic rays upstream and downstream of the termination shock

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Anisotropies of low-energy anomalous and galactic cosmic rays observed in the heliosphere can come from the Compton-Getting effect, particle diffusion and gyration effect associated with particle density gradient. When the spacecraft is connected to the particle source at the termination shock by magnetic field lines within a few particle mean free paths, particle streaming may also contribute to the anisotropy. A straightforward determination of solar wind speed based on the simple assumption that the anisotropy comes from the Compton-Getting effect may derive an incorrect value. This is particularly true near and upstream the termination shock where the particle gradient could be large enough to yield a diffusive anisotropy that cancels the Compton-Getting effect. In this paper, we present the results of a calculation of anomalous and galactic cosmic ray anisotropy using a heliospheric model that includes the termination shock and a heliosheath. Comparison with recent Voyager observations at 85-89 AU will be discussed. This work was supported in part by NASA Grant NAG5-11036.

SH12C-08 1745h

Interstellar Ne and Ar in the Heliosphere: Diagnostics of Interstellar Ionization and Outer Heliosphere Processes

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Interstellar material dominates the mass density in the heliosheath, and the physical properties of the heliosheath regions are shaped by the interaction of the interstellar medium (ISM) with the solar wind. The characteristics of pickup ions, anomalous cosmic rays, and He observed inside of the solar system depend on the chemical composition and ionization of the cloud surrounding the solar system. Currently, radiative transfer models of the surrounding cloud, constrained by observations of ISM inside and outside of the heliosphere, provide the best determination of cloud properties. We present recent models of the surrounding cloud based on in situ and astronomical observations of the ISM. These models imply n(HI) 0.21 /cc at the solar location and subsolar interstellar abundances for many common elements. The models also yield direct predictions of filtration in the heliosheath regions, yielding F(H) 0.4, F(O) 0.6, F(N) 0.7, and F(Ar) 0.6. The robustness of these models is tested against observations and models of pickup Ne and anomalous cosmic ray Ar in the heliosheath regions, which in turn constrains the ionization of the surrounding interstellar cloud.

SH21A MCC: 3006 Tuesday 0800h

Physics of Eruptions in the Low Solar Atmosphere I

Presiding: **G R Lawrence,** NASA Goddard Space Flight Center**; D Alexander,** Rice University

SH21A-01 0800h INVITED

The Acceleration of Coronal Mass Ejections

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To determine quantitative estimates of the net force acting on a CME requires knowledge of the CME acceleration as a function of distance from the solar surface. The CME acceleration is determined directly from the observed time-height trajectory of the event by two methods: (a) sucessive differentials and (b) the use of polynomial and exponential function curve fitting to the trajectory, followed by successive derivatives. We examine the acceleration of a set of Coronal Mass Ejections (CMEs) observed over a wide range of coronal scale heights by combining observations of the low corona from the Mauna Loa Solar Observatory and the Extreme ultraviolet Imaging Telescope (EIT) on the Solar and Heliospheric Observatory (SOHO) spacecraft with observations from the LASCO coronagraphs onboard SOHO. We apply both of the above techniques to the events and conclude that CME acceleration is greatest in the low corona despite the strong force of gravity in that region. (In addition, CME start times determined from outer coronal (LASCO) observations alone tend to be systematically later than the actual start times, most likely due to the fact that LASCO observations cannot observe CME acceleration in the low corona.)

SH21A-02 0820h INVITED

Acceleration of CMEs: A Diagnostic for Driving Mechanisms?

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Typical coronal mass ejections (CMEs) undergo the bulk of their acceleration low in the corona. Theoretical analysis based on a three-dimensional flux-rope geometry [1] shows that CME acceleration profiles exhibit a universal scaling law characterized by the critical scale height $Z_* \equiv S_f/2$, where S_f is the separation distance between the two stationary footpoints of the flux rope. Specifically, maximum acceleration is attained shortly after the apex of the flux rope reaches height Z_* from the solar surface, and the acceleration is subsequently reduced to about 1/4 of the peak value when the apex reaches height $Z_m \simeq 3Z_*$. This means that the observed acceleration profile in the low corona can directly yield information on the geometrical size of the flux rope, i.e., S_f. The S_f scaling is applicable regardless of the eruption speed so long as the pre-eruption structure is a flux rope or becomes one early enough in the eruption process. The scaling law has been tested against observed CMEs using TRACE, C1, C2, and C3 data, with good quantitative agreement, and is consistent with a recent simulation of a 3-D flux rope [2]. We discuss the observational implications of these results with respect to various proposed CME models and driving mechanisms. [1] Chen, J., and J. Krall, Acceleration of coronal mass ejections, *J. Geophys. Res.*, in press, 2003 [2] Roussev, I. I., et al., *Astrophys. J.*, *588*, L45, 2003. Work supported by ONR and NASA

SH21A-03 0840h

A 3D Line-Tied Model of Flux Rope Eruptions

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We consider the 3D force-free flux rope configuration which was proposed by Titov and Demoulin [Astron. Astrophys., 351, 707, 1999] as an approximation to the observed topology of coronal structures leading to eruptive flares. This configuration consists of a toroidal flux rope, oriented vertically, which intersects the photospheric surface at some distance above the center of the torus, along with several other photospheric sources which make up the potential background field in the corona. We extend the analysis of this configuration to correctly implement the effects of photospheric line-tying. We then investigate the equilibrium properties of this configuration and the conditions which yield an ideal loss of equilibrium. We follow the subsequent eruption of the flux rope under the assumption that the coronal portion retains a circular arc structure. Ultimately, this model will provide a semi-analytic 3D description of the evolution of coronal magnetic structures during an eruptive flare.

SH21A-04 0855h

Magnetic Reconnection Rate and Mass Acceleration in Flare-CME Events

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To understand the role of magnetic reconnection in the early stage of coronal mass ejections (CMEs), an observational relationship is yet to be established between magnetic reconnection and the dynamical evolution of the mass acceleration. We present measurements of the magnetic reconnection rate, in terms of the electric field inside the reconnecting current sheet and the rate of magnetic flux convected into the diffusion region, in two well observed two-ribbon flares, which are compared with the dynamical evolution of filament eruption and CMEs associated with the flares. We find that there is a good temporal correlation between the magnetic reconnection rate, represented by E_{rec}, and the mass acceleration a in both events studied in this paper. With the given temporal resolution, E_{rec} and a rise and decay together, and reach the maxima coincidently. The time profile of E_{rec} also correlates well with the flare non-thermal emission, both peaking during the rise of soft X-ray emission. We also discuss the magnitude and time scales of magnetic reconnection and mass acceleration revealed in the observations, and explore the structure of the evolving flux rope with available observations.

SH21A-05 0910h

Flux Rope Acceleration and Enhanced Magnetic Reconnection

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Recent flare and CME observations have shown that flux ropes are accelerated in the low corona in the form of coronal mass ejections or filament eruptions or soft X-ray plasma ejecta. The conclusion from these observations is that the most intense peak in the flare hard X-ray emissions and the maximum rate of increase in soft X-ray emission occur at the time of maximum acceleration of the flux rope's rising motion. To understand these observations we present results of our 2-1/2D MHD simulations of arcade field evolutions by employing a nonuniform anomalous resistivity. The simulation results relate the flux rope's accelerated rising motion with an enhanced magnetic reconnection rate and thus an enhanced reconnection electric field in the current sheet during the flare rise phase. The simulation results provide good quantitative agreement with observations of the acceleration of flux ropes (CMEs) for several CME-flare events. For the X-class flare events the peak reconnection electric field is $\sim O(10^3$ V/m) or larger, enough to accelerate electrons to over 100 keV in a field-aligned distance of 0.1 km and produce impulsive hard X-ray emission observed during the flare rise phase, consistent with the estimated reconnection rate obtained from the magnetogram data and two-ribbon emissions. Comparisons of the flux rope height, velocity and acceleration between our simulation results and observed CME-flare events will be presented.

SH21A-06 0925h

Radio Observations of Rapid Acceleration in a Slow Filament Eruption/Fast CME Event

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We discuss a filament eruption/coronal mass ejection (CME) associated flare event of GOES class M2.8 that occurred on November 17, 2001. This event was observed simultaneously by Nobeyama RadioHeliograph (NoRH) at 17 and 34 GHz and by the Giant Meterwave Radio Telescope (GMRT) in India at 1060 MHz. The flare occurred in active region 9704 at S18E41. NoRH observes the filament during its eruption both as a dark feature against the solar disk and a bright feature above the solar limb. The filament eruption shows a very gradual onset and then a rapid acceleration phase coincident with the launch of a fast halo CME. The flare on the disk in microwaves has a gradual rise, a broad maximum and a gradual decay. At 1060 MHz, its time profile had three impulsive peaks. The NoRH height–time plot of the filament shows a roughly constant gradual acceleration for an hour, followed by a very abrupt acceleration coincident with the impulsive phase of the associated flare. Soft X–ray images show heating in a long loop underneath the filament prior to the flare. The impulsive behavior of 1060 MHz emission combined with high brightness temperatures indicated the existence of nonthermal electrons in loops that clearly are not the same as the loops containing the microwave-emitting electrons. The latter are dominated by thermal bremsstrahlung and agree well with the EUV and soft X–ray loops. This study is consistent with recent findings that the rapid acceleration of flare–associated CMEs is closely tied to the impulsive phase of the flare. A trigger is required to cause the rapid acceleration to occur at the same time as the flare even though the two events are spatially well separated. We speculate that this trigger is provided by some kind of reconnection in the multiple flux systems that exist between the flaring active region and the erupting filament.

SH21A-07 0940h

Acceleration of Fast CME: A Parametric Study

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The analysis of LASCO/SOHO, Skylab and Solar Maximum Mission (SMM) observations show that there are many CMEs initiated with streamer and flux-rope magnetic topology (Dere et al. 1999; St. Cyr et al., 1999; Plunkett et al., 2000). Two types of CMEs have been distinguished with different kinematic characteristics (MacQueen and Fisher, 1983; Andrews and Howard, 2001). These are fast CMEs with high initial speeds (i.e. constant speed) and slow CMEs with low initial speeds but gradual acceleration (i.e. accelerated CMEs). Efforts have been made to probe the underlying physics responsible for these dual characteristics. Low and Zhang (2002) proposed that fast and slow CMEs result from initial topology of the magnetic field characterized by normal and inverse quiescent prominences, respectively. Liu et al. have successfully performed a numerical MHD simulation for this scenario. In this presentation, we explore other possible processes using a 2.5D, time-dependent streamer and flux-rope MHD model (Wu and Guo, 1997) to investigate the dual kinematic properties of the CMEs by specifying the different initiation processes with a particular magnetic topology (i.e. inverse quiescent prominence magnetic topology). Two typical initiation processes are tested; (1) injection of the magnetic flux into the flux-rope causes additional Lorentz force to destabilize the streamer launching a CME (Wu et al., 1997) resulting in a category slow CME and (2) draining the plasma from the flux-rope together with flux injection leads to a balloon instability due to the magnetic buoyancy force which results in a impulsive eruption and launches a fast CME. References Andrews, M.D. and Howard, R.A., Space Sci. Rev., 95, 147, 2001 Dere, K.P. et al., Ap. J., 529, 575, 1999 Lin, et al., Proceedings of ICSC 2003: Solar Variability as an Input to the Earth's Environemnt, ESA-SP-535, 2003 (in press). Low, B.C. and Zhang, M., Ap. J., 564, L53, 2002. MacQueen, R.M. and Fisher, R.R., Solar Phys. 89, 89, 1983. Plunket, S., et al., Solar Phys. 194, 321, 2000. St. Cry., O.C. et al., J. Geophys. Res., 104, 12493, 1999. Wu, S.T. and Guo, W.P. in Coronal Mass Ejection, Geophys. Monogr. Ser. 99, (N. Crooker, et al. eds.), AGU Washington, DC 1997. Wu, S.T. et al., Solar Phys., 175, 719, 1997.

SH21B MCC: Level 1 Tuesday 0830h

Interplanetary Physics II Posters

Presiding: **S P Gary,** Los Alamos National Laboratory**; M Velli,** University of Firenze

SH21B-0106 0830h POSTER

Bow Shock's Geometry at the Magnetospheric Flanks

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During almost three decades of operation, the IMP-8 satellite collected an extensive amount of both plasma and magnetic field measurements. The entire dataset has been searched for all Earth's bow shock crossings observed by IMP-8 and more then 11,000 crossings were found. Due to the IMP-8's orbital trajectory, most of the bow shock crossings were observed at the magnetospheric flanks where the Xgse position was between 0 and -20 Re while the Zgse positions between -20 and 20 Re. About 5000 individual bow shock crossings were used in this study to investigate the bow shock's cross-section: deviations from the circular profile, IMF orientation and Mach number effects on its shape.

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SH21B-0107 0830h POSTER

Bow Shock in Interaction of Solar Wind with Dusty Cometary Coma

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