

## SH52C-05 1625h INVITED

## The Living with a Star Data Environment

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Living with a Star (LWS) is a program of applied scientific research geared towards understanding and predicting the effects of the Sun on human society. The LWS data environment is key to the success of the program. We will have to combine diverse data sets from a wide array of sources, including ones beyond the formal LWS missions. Data must be integrated with models and across disciplines. The size of some of the data sets will be unprecedented in our field, requiring innovations in data searching and selection techniques. We will have to work together as a community to develop easy data access, metadata standards, community software trees, and other essentials to the free sharing of data needed to attain LWS goals.

## SH52C-06 1655h INVITED

## Next Steps Toward an Integrated Solar-Terrestrial Data Environment: A Summary View

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The goal of solar-terrestrial research is to obtain information about the connected Sun-Earth system. However, the key to scientific success is to convert this information (data) into knowledge and, ultimately, to transform knowledge into wisdom. It has rightly been noted that research and development agencies such as NASA (as well as NSF, NOAA, and DOD) with new missions and new data collection platforms have been transformed into knowledge agencies. In order to make major new advances in solar-terrestrial research, it will be necessary to couple physical models from the Sun to the Earth and to assimilate vast data sets in a rapid and efficient way. As a summary of the preceding panel discussion and this session overall, this talk will attempt to identify our best consensus understanding of the next steps that should be taken to achieve a modern, well-integrated solar-terrestrial data environment.

## SH61A MCC: Hall D Saturday 0830h

## Particle Acceleration at Heliospheric Shocks: Observations, Theory, and Modeling I Posters

*Presiding:* G C Ho, Applied Physics Laboratory

## SH61A-0420 0830h POSTER

## Acceleration of Electrons by Interacting CMEs

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There is a growing observational evidence that interactions of coronal mass ejections (CMEs) near the Sun is a common phenomenon. Recently, we have performed 2-D MHD simulations of the interaction between two magnetic flux ropes. The aim was to provide some qualitative picture of the shock-cloud and cloud-cloud dynamic interactions that might be relevant to the interaction of CMEs. A fast CME generates a shock wave which penetrates a slower CME. Enhanced magnetic field in the flux rope and helical structure of field lines may favor acceleration of electrons at the shock by fast-Fermi process: multiple encounters are possible and nearly perpendicular parts of the shock are more abundant. Using results of our MHD simulations, we examine numerically efficiency of electron acceleration during the CME interaction.

## SH61A-0421 0830h POSTER

## Low Energy Ion Composition Variations in Large Solar Energetic Particle Event

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We have examined the temporal variations of low energy (~0.3 MeV/nucleon) hydrogen, helium and iron ions within thirty large SEP events using the ULEIS instrument on the ACE spacecraft (November 1997 to December 2002). We only selected clear and isolated events to study the variation in elemental abundances both during the event and averaged over the event. These events originated from different solar longitudes; hence we compare events that have similar magnetic connection to minimize the transport effects. All events exhibited an eventual decrease in the He/H ratio as is suggested by a recent theoretical model [Ng et al., 1999], but the degree of variation of He/H varies from event to event. However, we observed large temporal fluctuations in the Fe/O ratio in most of our events; these large fluctuations were not restricted just to the onset of the events. Even in events that have similar characteristics (magnetic connection, intensity), the Fe/O ratios can vary drastically from one event to another.

## SH61A-0422 0830h POSTER

## The Outer Source of Pickup Ions and Anomalous Cosmic Rays

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The traditionally accepted source of Anomalous Cosmic Rays (ACRs) is neutral atoms penetrating the heliosphere from the local interstellar cloud (LIC). The ACR composition should be depleted in easily ionized atoms such as C, Si, and Fe. However, significant fluxes of these ions are observed in ACRs and their source has not been previously identified. We show that there is an "outer source" of pickup ions, and hence ACRs, caused by sputtered atoms (subsequently ionized and picked up by the solar wind) from small grains generated via collisions of objects in the Edgeworth-Kuiper Belt. The outer source accounts for the abundance and composition of the additional population of ACRs. The discovery that ACRs are generated from material in the Edgeworth-Kuiper Belt provides an exciting new tool for understanding the mass distribution and composition of the Edgeworth-Kuiper Belt, and for probing the plasma-dust interactions in stellar environments.

## SH61A-0423 0830h POSTER

ACE/SEPICA Observations of Energetic He<sup>+</sup> Associated With Interplanetary Disturbances at 1AU

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Solar Energetic Particle (SEP) events with unusually high abundance in He<sup>+</sup> that have been observed between 1998 and 2000 with ACE/SEPICA have been investigated in detail. Usually He<sup>+</sup>/He<sup>2+</sup> abundance ratio in the solar wind/corona is of the order of 10e<sup>-4</sup>. However during SEP events the He<sup>+</sup>/He<sup>2+</sup> ratio can be closer to one. This survey has shown that the increase of the He<sup>+</sup>/He<sup>2+</sup> abundance ratio coincides with the arrival of the shock (either driven by a CME or associated with a CIR) or a discontinuity. The analysis strongly suggests local acceleration of these ions and it is also shown that interstellar pickup ions are the main source for the He<sup>+</sup> enhancement. We have identified the types of discontinuities which are predominantly associated with an increase of the He<sup>+</sup>/He<sup>2+</sup> ratio. A representative sample of CMEs, CME-related disturbances as well as corotating/transient streams has been examined in detail. We have investigated the observed temporal and energy dependence of the He<sup>+</sup>/He<sup>2+</sup> ratio at the disturbances and we will describe the implications for the acceleration of He<sup>+</sup> pickup ions in the Heliosphere.

## SH61A-0424 0830h POSTER

## Electron Energization Process through the Electron-ion Coupling in the Shock Transition Region

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Collisionless shock waves convert ion inflow energy to the electron and ion thermal and non-thermal energy through electromagnetic field-particle interaction (shock dissipation process). In what way the ion inflow energy is transferred to the fields and electrons (or energy partition process) has been a long-standing problem. Recently, both of the observational and theoretical study indicate that electron scale (order of the electron inertia) coherent structure like electron phase holes and they play an important role to the electron energization process. Buneman instability between the inflow electron and the reflected ion is representative for the rapid electron-ion interaction through the electrostatic field which evolves nonlinear state of the formation of the large amplitude electrostatic structures (electron phase hole). Further, the electron phase hole couples with the inflow ion as well as the reflected ion on the branch of the ion-acoustic mode. Under some plasma conditions, we discuss this strong electron hole-ion coupling state from the point of view of the energy dynamics and exchange process between the electron and ion in the shock transition region by applying particle-in-cell simulation.

## SH61A-0425 0830h POSTER

## Cosmic-ray Spectra at Spherical Shocks

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We discuss the nature of the spectra of particles accelerated at spherical shocks, such as the solar wind termination shock. We show that, in addition to the two well-known spectral regions characterized by a power-law momentum dependence and an exponential high-energy cutoff caused by the spherical geometry, a new region can be identified. This consists of an enhancement of the cosmic-ray intensity ("bump") just below the cutoff. Similar features have been seen previously in multi-dimensional models and cosmic-ray modified shocks, where they were explained by acceleration in the latitudinal direction along the shock face and decreasing effective shock compression ratio, respectively. We show that a similar "bump" may be obtained in a purely spherically-symmetric geometry with no drifts. We attribute this effect to increased shock acceleration efficiency at certain energies. We also demonstrate that a one-dimensional planar shock with a reflecting wall upstream can give a similar effect.

## SH61A-0426 0830h POSTER

## Statistical Study of Solar Impulsive Electron Events

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This study with the WIND 3DP instrument of 380 solar impulsive electron events shows many different temporal delays with respect to the correlated radio type III bursts. The majority of events have a delayed electron injection time with respect to the radio type III bursts of about 14 minutes. This is similar to other published findings, but with more events and better statistics. To try and determine why some events showed on-time arrivals of electrons while most were delayed we analyzed their peak flux spectra and the frequency distribution of events. The frequency distribution for all events is a power law with a slope of  $1.35 \pm 0.05$  for energies 30 keV to 300 keV. The peak flux spectra for individual events usually shows a double power law dependence with a steepening at 50 keV. The two slopes have average indices of -3.5 and -2, and are slightly correlated. However there was no difference in these distributions between on-time events and delayed events. It is also found that there is a strong tendency for events with in-situ detected Langmuir waves at 1 AU to be delayed less (12 minutes on average) than those without visible waves (17 minutes on average). An interesting finding is that electron events occurring during a radio type II burst show significantly harder spectra, indicating that shocks with type II bursts might be more efficient at accelerating higher energy particles.

## SH61A-0427 0830h POSTER

## Case Study of a Shock Observed by Voyager 2 in October 2001

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We present a detailed case study of a shock observed by Voyager 2 in October 2001, when the spacecraft was at a distance of 56.7 AU from the Sun. This shock was the strongest observed since 1991 and resulted in significant acceleration of energetic particles. Signatures of this shock were observed by the plasma (PLS), Cosmic Ray (CRS), plasma wave (PWS), Magnetometer (MAG) and Low Energy Charged Particle (LECP) instruments. At these large heliospheric distances substantial alteration of the shock by pickup ions is expected to occur. We look for pickup ion effects by comparing the 2001 event with two large shocks observed by Voyager 2 at similar points in solar cycles 21 and 22. We also compare the October 2001 data from Voyager 2 to measurements from other spacecraft (such as Voyager 1, Ulysses, IMP8) to look at radial evolution of the shock.

## SH61A-0428 0830h POSTER

## Acceleration of Coronal Mass Ejections

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Observations show that coronal mass ejections (CMEs) typically exhibit nearly constant speeds or only gradual acceleration beyond 2-3 solar radii ( $R_s$ ) from Sun center, indicating that the most significant acceleration of CMEs occurs below these heights. This paper examines the physics of CME acceleration with the emphasis on three physical issues raised by these observations: (1) why the "main" acceleration of CMEs is localized close to the Sun, (2) what determines the height beyond which no rapid acceleration is observed, and (3) whether distinct mechanisms are required to explain the apparent bi-modal distributions of speed-height profiles with nearly constant speeds and gradual acceleration. These questions are investigated using a theoretical model based on a three-dimensional magnetic flux rope that has been demonstrated to reproduce observed CME dynamics. It is shown that for a given flux rope, there exists a critical height  $Z_*$  such that when the centroid of the apex of the flux rope expands beyond  $Z_*$ , the acceleration decreases as

$(R \ln R)^{-2}$ , where  $R(t)$  is the major radius of the expanding flux rope. This result is traced to the toroidal geometry and the inductive properties of the Lorentz self-force. For the simple toroidal flux rope geometry, the critical height is shown to be  $Z_* = S_f/2$ , where  $S_f$  is the distance between the two footprints of the flux rope. This implies that unless  $S_f \gg 1R_s$ , the main acceleration peaks at  $Z_* < R_s/2$ . The theory is tested against CMEs showing significant acceleration beyond 2-3  $R_s$ . By examining an ensemble of flux ropes corresponding to varying amounts and durations of poloidal flux injection, it is shown that a bi-modal distribution of speed-height profiles is obtained if an upper limit to the amount of injected flux is imposed. One mechanism is sufficient to account for the range of observed CME acceleration. It is suggested that the early-time acceleration can provide a diagnostic of driving mechanisms.

Work supported by ONR and NASA.

## SH61A-0429 0830h POSTER

## Small-Scale Plasma Hole in a Corotating Interaction Region (CIR)

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In a statistical study of 28 geomagnetic negative sudden impulses (SI-s), Takeuchi et al. [2002] showed that interplanetary causes of SI-s can be classified into 4 types. Almost all the SI-s were caused by tangential discontinuities at (1) high-low speed stream interfaces within corotating interaction region (CIR), (2) front boundaries of magnetic clouds, and (3) rear boundaries of non-compressive density enhancement (NCDE). However, only one SI- occurred on February 11, 1999 was caused by an unusual structure in the solar wind. It was observed by ACE (X:243, Y:9 Re), IMP 8 (X:16, Y:28 Re), and WIND (X:-30, Y:-72 Re). The structure had low proton density and temperature and high magnetic field strength, and was embedded in a CIR. The duration was about 100 minutes. That's why I call it "small-scale plasma hole". A geomagnetic negative-positive sudden impulse (SI-/SI+) pair was observed at low-latitudes. The structure was close to a heliospheric current sheet. By examining the time-lag of the convection from ACE to IMP8, the Earth, and WIND, we found the plasma hole aligned with the CIR. This has to be some transient structure because similar structures could not be found within the CIR one solar rotation before or after. Although it had some properties similar to magnetic clouds or small-scale flux ropes [Moldwin et al., 2000], the field direction inside it was almost constant with no rotation. Small-scale structures in the solar wind have come to attract the interest of scientists in both space physics and astrophysics in recent times [e.g., Wang et al., 1998]. Not only large structures such as magnetic clouds or coronal mass ejections (CMEs) but also small-scale structures should be investigated in detail by making good use of recent multi-satellite solar wind observations. In the paper, we show the characteristics of the plasma hole and discuss its probable source.

## SH61A-0430 0830h POSTER

## Energetic particle transport at CME-driven shocks

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Interplanetary shocks, and in particular, CME-driven shocks, are effective particle accelerators and can often accelerate particles to 10's MeV and sometimes even  $\sim$  GeV. As a CME-driven shock propagates, expands and weakens, particles accelerated diffusively at the shock can escape upstream and downstream into the interplanetary medium. These escaping energized particles then propagate along the interplanetary magnetic field, experiencing only weak scattering from fluctuations in the interplanetary magnetic field (IMF). Here, we study the transport of energetic particles escaping upstream from a CME-driven shock using a Monte-Carlo approach. One advantage of this approach is that it allows us to follow single particle trajectory after the particle escapes from the shock front. Thus, we can easily investigate the characteristics (intensity profiles, spectra, angular distribution) of high-energy particles arriving at Earth. Results of the Monte-Carlo simulation for two reference shocks (a strong and a weak) will be presented. This work, together with our previous work on particle acceleration at shocks, will likely provide a basis for interpreting observations of high-energy particles made at 1 AU by ACE and WIND.

## SH61A-0431 0830h POSTER

## The Acceleration of Coronal Mass Ejections in the Low Corona

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Coronal Mass Ejection (CME) speeds and accelerations have been measured in the low corona, down to 1.12 solar radii, using data from the Mauna Loa MK3 and MKIV telescopes, and out to 30 solar radii, using data from the LASCO telescopes. Most of the CME accelerations occur within the Mauna Loa field of view. The average CME acceleration determined from the MK3 and MKIV data is significantly higher than the average acceleration derived for the same CMEs using the LASCO data only. The Mauna Loa and LASCO data are combined to estimate the rate of change of the acceleration, when possible, and to determine CME start times. The CMEs with the highest accelerations and speeds tend to be associated with erupting active regions and the start times of these highly accelerated CMEs is usually within 3 minutes of the flare onset, which is the time resolution of the Mauna Loa data. These results are consistent with previous studies of CME trajectories.

## SH61A-0432 0830h POSTER

## Predicting the Properties of Coronal Mass Ejections at 1AU.

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Remote observations of CMEs at the Sun are combined with in-situ observations of their associated ICMEs at 1AU. The feasibility of space weather prediction on the basis of coronal measurements is investigated. Current models of CME arrival times (Gopalswamy et al., 2000) assume a constant deceleration of the ejecta from the corona to 1AU, and do not explicitly include the effect of the ambient solar wind speed. Furthermore, the estimation of the speed of a CME along the Earth-Sun line is subject to severe projection effects. A comparison of the effect of these factors on the predicted 1AU arrival times is made, and the importance of the speed of an ICME in the solar wind frame is highlighted for prediction of the magnetic properties of an ICME.

## SH61A-0433 0830h POSTER

## CME Evolution in the Corona and Solar Wind

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Coronal mass ejections (CMEs), immense eruptions of plasma and magnetic fields with velocities as high as 2000 km/s, are a major transient input of mass and energy into the solar wind. We are using time-dependent 2D and 3D MHD computations to study the evolution of CMEs. A simulated CME is initiated by flux cancellation at the photosphere. The calculation follows the eruption and the subsequent propagation of a magnetic flux rope to 1 AU. We discuss the evolutionary properties of the CME, both near the Sun and beyond the Alfvén and sonic points. We also examine the properties likely to be inferred about the flux rope from simulated time series data obtained when the flux rope passes over hypothetical spacecraft at different positions.

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## SH61A-0434 0830h POSTER

## SEP Onset Variability Near Earth

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We investigate the spatial-temporal variability of near-to-several-MeV energy proton flux onsets in a number of impulsive Solar Energetic Particle (SEP) events in interplanetary space near Earth using instruments on the ACE, IMP-8, Geotail, and GOES spacecraft. At some times and locations, a portion of the approaching SEP particle population is propagating along the average interplanetary magnetic field, and at other times and locations, a portion is transported with escaping solar plasma. ACE is stationed at L1, about 230 Re upstream of Earth in the solar wind. ACE presently serves as the primary early warning monitor of approaching interplanetary disturbance flux, both at solar wind and SEP energies. The GOES geosynchronous orbit (6.6 Re) satellites serve as our indicators of geoeffective SEP events, defined in this study as those events that produce hard energy spectrum proton flux enhancements at geosynchronous orbit. IMP-8 and Geotail orbit Earth at 25-44 and 10-30 Re geocentric, respectively, providing a diverse array of spatial configurations for measuring spatial-temporal variability in the near-Earth interplanetary medium. It is of considerable practical interest to determine the effectiveness of a single spacecraft monitor at L1 in detecting deleterious particle fluxes before they reach the Earth (as in the Living With A Star Program, for example) and of general scientific interest to determine the spatial and temporal variability of SEP onsets. At the leading edges of SEP populations, one might not necessarily anticipate a locally uniform structure, but rather a structured, variable, and anisotropic structure. Both might occur simultaneously, but at different locations. This study is a first step in determining how variable those structures are. The purpose of an early warning from L1 is to anticipate danger and help protect assets at geosynchronous orbit, such as communications satellites, and at lower altitudes, such as at the International Space Station and polar flying aircraft, for example. We present several examples of onsets in which the local spatial structure appears to be variable.

## SH61A-0435 0830h POSTER

## Spectral Properties of Heavy Ions Accelerated by Interplanetary Shocks Near 1 AU

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Energetic ions above  $\sim 0.05$  MeV nucleon<sup>-1</sup> are accelerated routinely at interplanetary (IP) shocks driven by fast coronal mass ejections (CMEs). Theoretically, these observations have been interpreted in terms of diffusive shock acceleration of ions originating from either the bulk solar wind or a suprathermal tail consisting predominantly of solar wind ions. Recently, however, composition measurements from ACE have provided new insights into the question of the origin and injection of the source population for such IP shocks. In particular, observations from the Ultra-Low Energy Isotope Spectrometer on board the Advanced Composition Explorer have unexpectedly shown large enrichments of the rare isotope <sup>3</sup>He over the solar wind value in a number of CME-driven IP shock events. The acceleration of tracer ions like <sup>3</sup>He in such events with enhancements several times above the solar wind values is clear evidence that solar wind is not the exclusive source of material that is accelerated at interplanetary shocks. Indeed, a detailed survey of the heavy ion composition measurements has shown that solar wind ions may not even be the dominant source of material in such IP shocks. In this talk, we will

present spectral properties of heavy ions in the 0.05-10.0 MeV nucleon<sup>-1</sup> energy range accelerated in over 70 IP shock events, and compare the spectral indices with key predictions of shock acceleration theory. We will discuss these new results in terms of seed populations and currently known rigidity-dependent shock acceleration theories.

## SH61A-0436 0830h POSTER

## An Observational Study of the Relationship between CMEs and Flares

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We present an observational study of the relationship between coronal mass ejections (CMEs) and flares occurred in NOAA Active Region 9236 on November 24-25, 2000. For this work, we consider following two approaches. First, we have examined the relationship between CME kinematics and flare strength for four homologous CME-flare events which can produce a good statistical sample since these homologous events have almost the same projection effect and probably involve similar magnetic field structures. Second, we have directly estimated the initial eruption speeds of a filament associated with the X1.8 flare using two sequences of H $\alpha$  images (high-resolution blue wing and full-disk centerline) with a 1-minute time cadence and then compared them with GOES X-ray fluxes. As a result, we have found that: (1) there is a conspicuous correlation between the ejection speeds of CMEs in LASCO C2/C3 field of view and the peak fluxes of the associated flares and (2) the start of the filament eruption is timed about 10 min before the onset of the associated X1.8 flare. In this case, therefore, the flare cannot be a cause of the CME despite the kinematic correlation.

## SH61A-0437 0830h POSTER

## Intense Flares Without Solar Energetic Particle Events

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We study favorably located (western hemisphere) X-class flares that were not associated with solar energetic particle (SEP) events. Three of the four such flares that occurred during the present cycle lacked coronal mass ejections (CMEs), consistent with the current paradigm. Soft X-ray data for these three events show either outward moving loops above the main flare loop or a much slower rise of the flare loop itself, as predicted in bipolar reconnection models. However, unlike fully eruptive events, the outward moving loops appear to stop at a certain distance. We speculate that they are held back by overlying magnetic field, as implied in soft X-ray images. The flare that was associated with a CME (but not an SEP event) produced metric and decametric type III bursts, but those without CMEs did not. Other characteristics for the flares not associated with SEP events include relatively short decay times of hard X-ray emission at 30-50 keV. We are extending our study to include additional (somewhat smaller) events to try to identify key parameters that keep intense flares from erupting and accompanying SEP events.

## SH61A-0438 0830h POSTER

## Extreme Mass Fractionation Patterns in Solar Particle Events

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Studies of the isotopic composition of solar energetic particles (SEPs) have been made with the Solar Isotope Spectrometer (SIS) on board the Advanced Composition Explorer (ACE) spacecraft for numerous large SEP events in this solar cycle. Rather large mass fractionation effects have been observed, with the <sup>22</sup>Ne/<sup>20</sup>Ne ratio varying by as much as a factor of 5 from event to event. In many cases, this mass fractionation seems well organized as a power law in the ionic charge to mass ratio,  $Q/M$ . Recently, SIS has detected a number of much smaller, <sup>3</sup>He-rich events that had sufficient fluxes of heavy ions at high energies ( $>10$  MeV/nucleon) to allow measurements of their elemental and isotopic composition. Enormous enhancements of heavy isotopes are found, with in some cases both the <sup>22</sup>Ne/<sup>20</sup>Ne and <sup>26</sup>Mg/<sup>24</sup>Mg ratios approaching 1, as opposed to their solar wind values of 0.073 and 0.14 respectively. The small event on 20 August 2002 is especially interesting, as there were enough heavy ions to allow statistically significant measurements of a wide variety of isotopes from <sup>13</sup>C to <sup>54</sup>Fe. We present isotopic abundance measurements of moderate-sized <sup>3</sup>He-rich SEP events, particularly those in the 3-6 August and the 19-21 August 2002 time periods, and examine whether the fractionation patterns observed for these events agree with those found for large SEP events in an effort to determine whether the underlying physical causes of mass fractionation are the same in the two classes of events.

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## SH61A-0439 0830h POSTER

Observations of Exceptional Elemental and Isotopic Composition Patterns in <sup>3</sup>He-Rich Solar Energetic Particle EventsM. E. Wiedenbeck<sup>1</sup> (818-354-7168;mark.e.wiedenbeck@jpl.nasa.gov); R. A. Leske<sup>2</sup>,G. M. Mason<sup>3</sup>; W. R. Binns<sup>4</sup>; C. M. S. Cohen<sup>2</sup>;A. C. Cummings<sup>2</sup>; G. A. de Nolfo<sup>5</sup>; J. R. Dwyer<sup>6</sup>;J. S. George<sup>2</sup>; R. E. Gold<sup>7</sup>; S. M. Krimigis<sup>7</sup>; J.E. Mazur<sup>8</sup>; R. A. Mewaldt<sup>2</sup>; P. L. Slocum<sup>8</sup>; E. C.Stone<sup>2</sup>; T. T. von Rosenvinge<sup>5</sup><sup>1</sup>JPL/Caltech, MS 169-327 4800 Oak Grove Dr., Pasadena, CA 91109, United States<sup>2</sup>Caltech, M.S. 220-47, Pasadena, CA 91125, United States<sup>3</sup>U. Maryland, Dept. of Physics, College Park, MD 20742, United States<sup>4</sup>Washington U., Dept. of Physics Campus Box 1105, St. Louis, MO 63130, United States<sup>5</sup>NASA/GSFC, Code 661.0, Greenbelt, MD 20771, United States<sup>6</sup>Florida Tech., Dept. Physics and Space Sci. 150 W. University Blvd., Melbourne, FL 32901, United States<sup>7</sup>JHU/APL, 11100 Johns Hopkins Rd., Laurel, MD 20723, United States<sup>8</sup>Aerospace Corp., P.O. Box 92957, Los Angeles, CA 90009, United States

Large enhancements of <sup>3</sup>He and Fe abundances in impulsive solar energetic particle events are commonly thought to result from resonant heating by plasma waves occurring at the solar flare site. To test and discriminate among models for these processes it would be of great interest to observe additional abundance enhancement patterns which are not simply smooth functions of the particle charge-to-mass ratios. Using three instruments on the Advanced Composition Explorer (ACE) spacecraft we have observed several <sup>3</sup>He-rich SEP events in August 2002 that had unusually hard energy spectra. In addition to obtaining spectral measurements over two decades in energy, we also derive elemental abundances of more than 20 elements between C and Ni as well as isotopic composition for 10 of these. Significant abundances of elements heavier than Ni are also observed in some of these events. Our measurements provide, for the first time, a detailed picture of the isotopic as well as the elemental composition

in individual  $^3\text{He}$ -rich events. We find large enhancements of a number of neutron-rich isotopes. For example,  $^{22}\text{Ne}/^{20}\text{Ne}$  and  $^{26}\text{Mg}/^{24}\text{Mg}$  are each  $>0.5$ , significantly in excess of the solar wind values of 0.07 and 0.14, respectively. We report the ACE spectra and composition observations and compare with the elemental composition in "average"  $^3\text{He}$ -rich events as well as in several recently-reported events with unusual enrichment patterns (Mason et al. 2002). We discuss these new observations in the context of models of particle acceleration in  $^3\text{He}$ -rich events.

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**SH61A-0440 0830h POSTER**

**A Comparison of SEP Ionic Charge States in Local Shock and Impulsive Events**

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The SEPICA instrument on the Advanced Composition Explorer (ACE) spacecraft has measured ionic charge states of solar energetic particles (SEPs) from late 1997 through 2000. Charge state measurements provide insights about the acceleration and propagation history of SEPs. In impulsive events, SEP charge states provide information about the flare environment, where source heating and collisions are important. In interplanetary shock events, SEP charge states are diagnostics of the rigidity-dependent acceleration process and particle seed populations. For example,  $^3\text{He}$  enrichment has been observed in some events with a local shock passage (Desai et al., 2001). An enhancement in high charge state Fe has also been observed in these events (Popecki et al., 2001). This suggests that the seed population for the interplanetary shock contained ions previously accelerated in flares.

SEP charge states from impulsive events will be compared to those from events with a local shock passage (ESP events). In addition, the ESP events will be separated into those with and without  $^3\text{He}$  enrichment. Results will be presented in the context of mission-integrated ionic charge state distributions for each species.

**SH61A-0441 0830h POSTER**

**On the Heliospheric He+ Pickup Ion Acceleration by CME Driven Shocks**

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We present the results from the study of local acceleration in the vicinity of CME-driven shocks using ACE/SWICS He+ pickup ion data at 1 AU. The pickup ions are injected for acceleration and develop a power-law spectrum at energies above 30 keV. These power-law tails are compared with theoretical predictions of shock-accelerated particles. We find that, generally, the acceleration process is less efficient than anticipated from the shock acceleration theory. We attribute this to the efficiency of these physical processes that lead to injection into shock acceleration. We discuss the scenario that the source of injection may not be associated directly with the shocks, but with statistical acceleration processes due to the compressed shock turbulence.

**SH61A-0442 0830h POSTER**

**Coronal Mass Ejections (CMEs) Induced Shock Formation and Properties**

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It has been recognized that solar energetic particles (SEPs) are accelerated at interplanetary shocks from the point of their formation in the lower corona to 1 A.U. and beyond. In this study, we will investigate the formation and propagation of induced shocks from the inner corona to 1 A.U. using a CME three-dimensional, axisymmetric (i.e. 2.5-D) magnetohydrodynamic (MHD) code. A well-studied CME event (1997 January Sun-Earth Connection Event) is used as a baseline to match the solar wind conditions measured at 1 AU (WIND data) to model CME driven shocks. The properties of the shock as a function of distance and latitude from the Sun up to 1 A.U. will be presented. Also, the geoeffective parameters are computed using disturbed solar wind properties.

**SH62A MCC: 124 Saturday 1330h**

**Particle Acceleration at Heliospheric Shocks: Observations, Theory, and Modeling II**

Presiding: T Zurbuchen, University of Michigan; G Li, University of California, Riverside

**SH62A-01 1330h INVITED**

**Identifying the Real Seed Population for Shock Accelerated Energetic Particles: Recent Observational Progress**

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Gradual solar energetic particle events, traveling interplanetary shocks, and corotating interaction regions are examples of shock acceleration of particles in the heliosphere. Although shock acceleration of particles has long been the subject of theoretical investigation, nevertheless key energetic particle properties such as intensity and spectral index are only roughly correlated with predictions of the theories. This may be due to limitations of the theories, but it may also be due to a lack of understanding of properties of the seed population. Recent measurements have shown that trace elements in the thermal plasma (e.g. singly ionized He, and  $^3\text{He}$ ) often show dramatic enhancements in the energetic particle population. Although the observational picture is far from complete, it appears that the injection threshold in these events is about 1.5-2 times the solar wind speed. In this range, multiple particle sources are present, including solar wind suprathermals, pickup ions, and remnant material from prior shocks and impulsive events. Thus, the enhancements are not due to properties of the shock acceleration, but rather are primarily due to the properties of the seed population. This points to new opportunities for theoretical and experimental investigations to quantitatively model shock accelerated particle populations using realistic seed populations.

**SH62A-02 1350h**

**Solar Energetic Particles and Interacting CMEs: Cause or Coincidence?**

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A recent study by Gopalswamy et al. has determined that more than 80 percent of the largest solar energetic particle (SEP) events during solar cycle 23 were associated with interacting coronal mass ejections (CMEs), suggesting that such interactions somehow facilitate SEP acceleration processes. Using data for 44 large SEP events from the Solar Isotope Spectrometer on ACE, we examine this hypothesis by searching for compositional and spectral signatures of possible CME interactions and by measuring the time-of-acceleration of high-energy protons and heavier ions near the Sun. For heavy ions we illustrate an approach that makes use of the measured mass and kinetic energy to compute particle velocity to an accuracy of 0.1 percent. By comparing the inferred particle acceleration times near the Sun with CME trajectories measured by SOHO, and assuming that it is a shock driven by the fastest CME that accelerates the particles, we find that in many events the acceleration of high energy protons and heavy ions begins within a few solar radii of the Sun. By comparing the time and location where acceleration begins in a sample of magnetically well-connected events with the time and location of possible CME interactions in the same event, we find that in most cases particle acceleration begins well before the primary CME has had an opportunity to interact with preceding CMEs. We conclude that CME interactions are not a necessary condition or cause of particle acceleration in most large SEP events.

**SH62A-03 1405h INVITED**

**Challenges for Modeling Acceleration and Transport in Solar Energetic Particle Events**

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Shocks, driven by fast coronal mass ejections (CMEs), are believed to be the primary accelerator of energetic particles in large, so-called gradual solar particle events. Thus far in Cycle 23, instruments on ACE, Wind, SOHO, and IMP8 have provided detailed observations of the energy spectra, composition, and temporal evolution of nearly 50 large events in which the differential proton intensity at  $\sim 20$  MeV exceeded galactic cosmic ray levels by a factor of more than  $10^4$ . These events exhibit a large range of variability in all of their characteristics. Some of this variability is reasonably well understood in terms of familiar notions about shock acceleration, source-plasma composition, and particle transport. For other aspects we appear to have a qualitative understanding that is not yet bolstered by detailed quantitative modeling. However, many observed characteristics, such as spectral variability among elemental species, clearly challenge our present understanding. We will review these new challenges and speculate about the physics issues that must be addressed in future modeling efforts.

**SH62A-04 1425h INVITED**

**Particle Acceleration by Interplanetary Shocks**

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Interplanetary shocks can accelerate both solar wind ions and flare-released high-energy particles to high energies. The acceleration process is generally thought to be diffusive shock acceleration although almost entirely based on a highly simplified steady-state description. The importance of the evolving shock and the time constraints for accelerating particles diffusively at a shock, coupled to the inhomogeneous magnetic field and the expanding solar wind have not been widely recognized. We have developed recently a fully time-dependent model to describe particle acceleration at an expanding interplanetary shock wave, including the self-consistent calculation of the spatial diffusion coefficient in the vicinity of the shock, particle escape and transport into the upstream wind. We review results for strong and weak interplanetary shocks, showing intensity profiles, escaping particle spectra at 1 AU, spectra at and behind the shock, particle distributions,