[2]Jet Propulsion Laboratory, MS 169-327, Pasadena, CA 91109, United States

[3]NASA/Goddard Space Flight Center, Code 661, Greenbelt, MD 20771, United States

During this solar cycle we have found that solar energetic particle (SEP) isotopic composition in large gradual events can vary greatly from event to event. It is an open question how much of this fractionation is present in the source material and how much occurs during particle acceleration or propagation out of the corona. To first order, this mass fractionation seems to scale as a power law in the ionic charge to mass ratio, Q/M, similar to what is observed for SEP elemental fractionation. However, differences from power-law scaling seem to be required for most events to completely account for the observed abundances, for example in the case of Fe isotopes. Determining the actual fractionation patterns is necessary in order to use these data to better constrain the coronal source abundances and to understand the fractionation processes. In the >6 years since the launch of NASA's Advanced Composition Explorer (ACE), we have obtained SEP isotope measurements of abundant elements from C to Ni in >40 large SEP events. We find that the isotopic and elemental abundance enhancements are strongly correlated. By assuming isothermal conditions and using calculated equilibrium charge states, we attempt to characterize deviations in the fractionation patterns from simple power-law scaling. This work was supported by NASA at Caltech (under grants NAG5-6912 and NAG5-12929), JPL, and GSFC.

SH23B-04 1415h

Upper Limit on ^{3}He Fluences in Solar Energetic Particle Events

George C Ho[1] (240-228-7083; george.ho@jhuapl.edu)

Edmond C Roelof[1]

Glenn M Mason[2]

[1]Johns Hopkins University Applied Physics Laboratory, 11100 Johns Hopkins Road, Laurel, MD 20723, United States

[2]University of Maryland, Department of Physics, College Park, MD 20742, United States

We investigated 96 ^{3}He -rich (^{3}He/^{4}He > 0.004 at 0.2-2.0 MeV/nucleon) solar energetic particle (SEP) events from September 1997 through December 2002 using the ULEIS instrument on ACE. Both "impulsive" (flare-related) and "gradual" (CME-related) events are included. The ^{3}He fluences varied only by a factor of 100 above our sensitivity threshold while the ^{4}He fluences varied by factor of 100,000 above the same threshold. Moreover, we find no significant correlation between the ^{3}He and ^{4}He fluences. We find it striking that with more than 5 years of continuous SEP data, we could not found any SEP event that has a ^{3}He fluence higher than 10^5/cm^2-sr-MeV/nucleon, while the largest ^{4}He fluence observed was $1.6x10^7$/cm^2-sr-MeV/nucleon (two orders of magnitude larger than the ^{3}He upper limit). Since the event fluence should be same fraction of the particle net flux from the Sun at 1 AU, the observed upper limit for ^{3}He fluence indicates that there is a limit to the number of energetic ^{3}He ions that can be released from the Sun in a SEP event.

SH23B-05 1430h

The Q/M-Dependence of Spectral Breaks in the Large Solar-Particle Events of October 28 and 29, 2003

R. A. Mewaldt[1] (626-395-6612; RMewaldt@SRL.caltech.edu); G. M. Mason[2]; C. M. S. Cohen[1]; M. I. Desai[2]; A. L. Labrador[1]; M. D. Looper[3]; R. A. Leske[1]; J. E. Mazur[3]; E. C. Stone[1]; T. T. von Rosenvinge[4]; M. E. Wiedenbeck[5]

[1]Caltech, 220-47 Downs, Pasadena, CA 91125, United States

[2]University of Maryland, Department of Physics, College Park, MD 20742, United States

[3]Aerospace Corporation, 2350 E. El Segundo Blvd., El Segundo, CA 90245, United States

[4]Goddard Space Flight Center, Code 661, Greenbelt, MD 20771, United States

[5]Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91109, United States

We report measurements of the energy spectra of ions from H to Fe in the large solar energetic particle (SEP) events of October 28 and 29, 2003. The measurements extend from ∼0.1 to ∼100 MeV/nucleon and were made with the SIS and ULEIS instruments on ACE and the PET instrument on SAMPEX, supplemented by data from NOAA's GOES satellites. In both events the spectra of ten separate species all exhibit rather sharp spectral breaks during the hours just after the passage of the CME-driven shock that accelerated these SEPs. The locations of these breaks (in MeV/nucleon) are correlated with the charge-to-mass ratio (Q/M) of the ions, as measured by the MAST instrument on SAMPEX. The temporal evolution of the spectra and the interpretation of the Q/M-dependence of the observed spectral breaks will be discussed.

SH23B-06 1445h

Acceleration and Transport of Shock-accelerated Energetic Ions

Chee K Ng[1,2] (301-286-1504; CheeNg@milkyway.gsfc.nasa.gov)

Donald V Reames[1] (301-286-6454)

[1]Code 661, NASA Goddard Space Flight Center, Greenbelt, MD 20771

[2]Department of Astronomy, University of Maryland, College Park, MD 20742

Our model of the shock acceleration and interplanetary transport of energetic ions takes account of magnetic focusing, convection, adiabatic deceleration, pitch-angle diffusion due to resonant interaction with Alfvén waves, as well as self-consistent wave amplification and wave transport. We now include explicit frame transformation of particle distributions across the propagating shock discontinuity and wavenumber increase in wave transmission across the shock. We will present our calculations and discuss their implications on the observation of multi-species energetic ions at 1 AU.

SH24A CC: 518 C Tuesday 1530h

Acceleration, Release, and Propagation of Solar Energetic Ions and Electrons: When, Where, and How? III

Presiding: **S W Kahler,** Air Force Research Laboratory**; G M Simnett,** University of Birmingham

SH24A-01 1530h

Correlated Dispersionless Modulations in Suprathermal Electron and Impulsive Energetic Ion Events in the Solar Wind

John T. Gosling[1] (505-667-5389; jgosling@lanl.gov)

Ruth M. Skoug[1] (505-667-6594; rskoug@lanl.gov)

David J. McComas[2] (210-522-5983; dmccomas@swri.edu)

Joseph E. Mazur[3] (310-336-2389; Joseph.E. Mazur@aero.org)

[1]Los Alamos National Laboratory, MS D466, Los Alamos, NM 87545, United States

[2]Southwest Research Institute, Space Science and Engineering Division P.O. Drawer 28510, San Antonio, TX 78228-0510, United States

[3]The Aerospace Corporation, Space Sciences Department 2350 E. El Segundo Blvd., El Segundo, CA 90245-4691, United States

Large dispersionless modulations in particle intensity observed in impulsive solar energetic ion events have been interpreted in terms of spatially limited source regions and magnetic field line foot point motions during the 2-4 days it takes solar wind plasma and the embedded heliospheric magnetic field to travel from the Sun to 1 AU. Similar dispersionless modulations in particle intensity are observed within some low-energy (less than 1.4 keV) solar electron bursts at 1 AU. The latter commonly occur in direct association with discontinuous changes in the intensity of the solar wind electron strahl and can also largely be explained in terms of spatially limited burst source regions and magnetic field line foot point motions in the solar atmosphere. Concentrating on impulsive ion modulation events previously reported, we show that there is a close connection between dispersionless modulations in energetic ions and dispersionless modulations in low-energy solar electron bursts and in the electron strahl. This demonstrates that dispersionless modulations in both particle species have a common cause and generally occur on the same field lines. However, we find that a subset of the more dramatic ion modulations reported, which have corresponding dramatic changes in suprathermal electrons, appear to be more closely related to structural boundaries in the solar wind flow than to field line foot point motions.

SH24A-02 1545h

Spatial Structure of Solar Electron Bursts: Two-Point Observations using Genesis and ACE

John T Steinberg[1] (505-667-5308; jsteinberg@lanl.gov)

Curt A de Koning[1]

John T Gosling[1]

Ruth m Skoug[1]

Roger C Wiens[1]

[1]Los Alamos National Laboratory, Space and Atmospheric Sciences MS D466, Los Alamos, NM 87545, United States

Recent ACE studies have found that transient solar electron bursts associated with solar type III radio bursts are commonly observed at energies below 1.4 keV. At these energies the bursts appear as anti-sunward-directed electron beams superimposed on the suprathermal electron strahl and halo. Solar electron bursts are typified by their characteristic energy-time and pitch angle-time dispersion. Durations of burst events from onset to decay can vary from less than 1 hour to more than 30 hours, implying that the interplanetary magnetic filaments occupied by solar burst electrons are spatially broad. However, the true spatial extent and uniformity of a burst-carrying filament cannot be established from single spacecraft measurements. In order to explore the spatial characteristics of solar electron bursts, we have examined bursts detected at two spatially separated spacecraft: Genesis and ACE. The Genesis and ACE spacecraft both occupy L1 halo orbits and can be separated by up to 1 million km. We compared measurements from the nearly identical electron spectrometers on the two spacecraft. From November 2001 to May 2003 we found 136 solar electron bursts simultaneously detected by both spacecraft. More than two thirds of the burst events are strikingly similar at the two spacecraft, indicating that bursts are most often spatially uniform across ACE-Genesis separation distances. However, a number of burst events exhibit notable differences in the simultaneous Genesis and ACE observations, consistent with a non-uniform burst structure. Such structure indicates that the two spacecraft, though relatively near one another, are nonetheless found on interplanetary magnetic field lines mapping back to different solar source regions. We conclude that braided intermixing of interplanetary filaments is evident at 1 AU on separation scales of approximately one million km.

SH24A-03 1600h

Propagation of Energetic particles to High Heliographic Latitudes

Trevor R Sanderson[1] (trevor.sanderson@esa.int); Richard G Marsden[1] (richard.marsden@esa.int); Cecil Tranquille[1] (cecil.tranquille@esa.int); Robert J Forsyth[2] (r.forsyth@imperial.ac.uk); John T Gosling[3] (jgosling@lanl.gov); R Bruce McKibben[4] (bruce.mckibben@unh.edu)

[1]Research and Scientific Support Department of ESA, Estec, Keplerlaan 1, Noordwijk 2200 AG, Netherlands

[2]Imperial College of Science, Technology and Medicine, Prince Consort Road, London, United Kingdom

[3]DS 466, Los Alamos National Laboratory, Los Alamos, United States

[4]Department of Physics and Space Science Center, University of New Hampshire, Durham, United States

The Ulysses spacecraft has now almost completed its second orbit, passing for the second time over the southern and then the northern pole of the Sun. Energetic particles associated with CMEs were observed at the highest latitudes over both poles of the Sun, quite unlike the first polar pass when, at the very highest latitudes, neither CME nor CIR accelerated particles were observed. The particle events observed over the two poles were completely different. Ulysses never left the slow solar wind as it passed over the southern pole, and events observed there tended to be similar to events observed at lower latitudes. Over the northern pole Ulysses was in the fast solar wind for several solar rotations. Events observed there differed substantially from events observed over the southern pole. Onsets were slow, particle angular distributions were almost isotropic, and increases were observed when the CME arrived. We discuss these differences in the context of the configuration of the heliosphere at the time.

SH24A-04 1615h

Transverse Anisotropies of 40-90 MeV Solar Energetic Protons: A Re-interpretation

Edmond C Roelof[1] (+1-240-228-5411; edmond.roelof@jhuapl.edu)

David Lario[1] (+1-240-228-4745; david.lario@jhuapl.edu)

[1]Johns Hopkins University/Applied Physics Laboratory, 11100 Johns Hopkins Road, Laurel, MD 20723-6099, United States

Zhang *et al.*, [*Astrophys. J.*, **595**, 493-499, 2003; *J. Geophys. Res.*, **108**, A4, 1154, SSH 4-1, 4-13, 2003] report strong anisotropies of 40-90 MeV protons transverse to the local magnetic field in two solar energetic particle events (2000:196 and 2000:256) observed by Ulysses/COSPIN/HET. They interpret their results in the context of diffusive transport and consequently conclude these events constitute strong evidence for the existence of transverse diffusion in the helisosphere. We see three difficulties with this interpretation. 1) The magnetic field was unusually well ordered during the periods of transverse anisotropies. Theories of transverse diffusion require the presence of irregularities in the magnetic field. 2) Fourier analysis of the angular distribution reveals a second harmonic whose amplitude is comparable to that of the first harmonic. This is inconsistent with diffusive transport (Fick's law) that predicts a dominant first harmonic. 3) Only two such intervals have been identified in a search of the mission-long Ulysses COSPIN data set. The paucity of such intervals is inconsistent with this being a pervasive mode of transport. We have independently analyzed the COSPIN/HET channel H45 data and we confirm the data analysis of Zhang *et al.* for both events. However, we find that the data are much more consistent with a quantitative interpretation in terms of weak scattering with an evolving field-aligned streaming and a bi-directional anisotropy component in the presence of a gradient anisotropy. The scale of the gradient extracted from the pitch-angle distributions is comparable to that of the flux-rope-like magnetic structures in which it occurs. The above-mentioned three points are thus explained as follows. 1) Weak-scattering is expected in regions of quiet fields. 2) The pitch-angle distribution in both events eventually becomes predominantly bi-directional, indicating a mirroring within the structure. Consequently the significant second harmonic is immediately explained. 3) The conditions for observing a strong gradient anisotropy at these energies is restricted to a special class of structures, and hence should be a relatively rare occurrence.

SH24A-05 1630h

Trapping of Solar Energetic Particles by Small-Scale Topology of Solar Wind Turbulence

David Ruffolo[1] (david_ruffolo@yahoo.com)

William H. Matthaeus[2] (yswhm@bartol.udel.edu)

Piyanate Chuychai[1] (piyanate@corona.phys.sc.chula.ac.th)

[1]Chulalongkorn University, Department of Physics, Faculty of Science, Bangkok 10330, Thailand

[2]University of Delaware, Bartol Research Institute, Newark, DE 19716, United States

The transport of energetic particles perpendicular to the mean magnetic field in space plasmas long has been viewed as a diffusive process. However, there is an apparent conflict between recent observations of solar energetic particles (SEP): 1) impulsive solar flares can exhibit "dropouts" in which SEP intensity near Earth repeatedly disappears and reappears, indicating a filamentary distribution of SEPs and little diffusion across these boundaries. 2) Observations by the *IMP-8* and *Ulysses* spacecraft, while they were on opposite sides of the Sun, showed similar time-intensity profiles for many SEP events, indicating rapid lateral diffusion of particles throughout the inner solar system within a few days. We explain these seemingly contradictory observations using a theoretical model, supported by computer simulations, in which many particles are temporarily trapped within topological structures in statistically homogeneous magnetic turbulence, and ultimately escape to diffuse at a much faster rate. This work was supported by the Thailand Research Fund, the Rachadapisek Sompoj Fund of Chulalongkorn University, and the NASA Sun-Earth Connections Theory Program (grant NAG5-8134).

SH24A-06 1645h

Nonlinear theories of parallel and perpendicular scattering of energetic particles

A Shalchi[1] (302-831-8118; shalchi@bartol.udel.edu)

J W Bieber[1] (302-831-2240; john@bartol.udel.edu)

Gang Qin[2] (gqin@fit.edu)

W H Matthaeus[1] (302-831-2780; whm@udel.edu)

[1]Bartol Research Institute, University of Delaware, Newark, DE 19716, United States

[2]Physics and Space Sciences Department, Florida Institute of Technology, Melbourne, FL 32901, United States

Recently the nonlinear guiding center (NLGC) theory [1,2] of perpendicular diffusion of charged test particles has shown promise in providing a needed improvement in the correpondence of scattering theory to numerical results from computation of charged particle orbits in model magnetic turbulence. This has motivated a search for extensions of particle diffusion theory in which the parallel and perpendicular diffusion are simultaneously computed, and each is an implicit function of the other. Here we report on two such approaches. In the first, self-consistency is obtained as a nonlinear extension of quasilinear theory, in the context of a Fokker Planck approach. The second approach seeks to develop a theory that is approriate to strong turbulence, in which decorrelation from unperturbed orbits occurs rapidly. Here we derive the coupled integral equations that are solved for the diffusion coefficients in each case, and the results are compared with numerical simulations.This research supported in part by NSF grant ATM-0000315 and NASA grant NAG5-11603. [1] W H. Matthaeus, G. Qin, J. W. Bieber and G. P. Zank, Astrophys. J., 590, L53 (2003) [2] A. Shalchi, J. W. Bieber and W. H. Matthaeus, Astrophys. J., in press (April 2004)

SH31A CC: 220 C-E Wednesday 0830h

Acceleration, Release, and Propagation of Solar Energetic Ions and Electrons: When, Where, and How? IV Posters

Presiding: **E C Roelof,** Applied Physics Laboratory, Johns Hopkins University**; G C Ho,** Applied Physics Laboratory, Johns Hopkins University

SH31A-01 0830h POSTER

A study of the injection of electrons in solar impulsive events observed from $\leq$0.4 to $\geq$200 keV

Linghua Wang[1,2] (windsound@ssl.berkeley.edu)

Robert P. Lin[1,2] (rlin@ssl.berkeley.edu)

Sam Krucker[2] (krucker@ssl.berkeley.edu)

John T. Gosling[3] (jgosling@lanl.gov)

[1]Space Science Laboratory, UC Berkeley

[2]Physics Department, UC Berkeley

[3]Los Alamos National Laboratory, Los Alamos, New Mexico

We present a detailed analysis of several solar impulsive electron events detected from a few hundred eV to >200 keV by the WIND 3D Plasma and Energetic Particle experiment. For the event beginning at ~17:20UT on August 7, 1999, the electron flux profiles show sharp peaks (~5 to 10s of minutes FWHM at energies > 20 keV) and a path length derived from the peak times of ~1.16±0.09 AU, indicating that the electron propagation is essentially scatter free. Under the scatter-free assumption and correcting for the contamination by higher energy electrons on onsets observed in lower energy channels, we find that for the higher energy $\geq$40 keV, electrons appear to be released 10±3 minutes after the start of type III radio burst at the Sun. The event durations at energies below ~5-10 keV are substantially larger,suggesting a different behavior at those energies.

SH31A-02 0830h POSTER

Low Energy SEP Events of October/November 2003 at 1 and 5 AU

Carol G Maclennan[1] (cgm@lucent.com)

Louis J Lanzerotti[1,2] (ljl@lucent.com)

C Denker[2]

[1]Bell Laboratories, Lucent Technologies, 600 Mountain Avenue, Murray Hill, NJ 07974, United States

[2]Center for Solar-Terrestrial Research, NJ Institute of Technology, 333 King Blvd., Newark, NJ 07102, United States

The late October-early November solar energetic particle (SEP) events during the declining stage of solar cycle 23 provide an outstanding opportunity to investigate the propagation of solar-produced ions and electrons in the inner (< 5 AU) heliosphere. The EPAM instrument on the ACE spacecraft (1 AU) and the HISCALE instrument on the Ulysses spacecraft (essentially in the ecliptic plane at 5.2 AU and about 117° east of the Earth-Sun line) were ideally situated to measure the in-ecliptic interplanetary particles produced by the series of large solar eents. Of particular interest is the particle event on 28 October 2003 (day 301) following the exceptionally large X17 flare in Active Region 486. Particles were observed at both ACE and Ulysses; quite rapid onsets of the intensities of ions were measured at both spacecraft. Indeed, this event may have the most rapid onset of any SEP event ever measured at 5 AU. This presentation will concentrate on an examination of the intensities, time dependence, and radial gradients of protons and heavy ions (Z$\geq$2) that were measured during the series of SEPs in this time interval.

SH31A-03 0830h POSTER

The effect of adiabatic energy loss during interplanetary propagation of solar energetic particles

Gang Qin[1] (gqin@fit.edu)

Ming Zhang[1] (mzhang@pss.fit.edu)

[1]Florida Institute of Technology, Florida Institute of Technology, Melbourne, FL 32901, United States

Because of the divergence of the solar wind flows, energetic particles should experience adiabatic energy loss almost everywhere in the interplanetary space. The energy loss of particles gyrating in magnetic fields is a pitch-angle dependent process and it is present with or without particle scattering by magnetic turbulences. The energy loss is much faster close to sun than at large radial distances. Our particle simulations show that adiabatic energy loss is significant even in a short period of less than one day. The result indicates that adiabatic energy loss cannot be completely neglected in the modeling of solar particle events. This is particularly true for gradual events that can last as long as one solar rotation. Even the initial phase, adiabatic energy loss may be important, because it takes a few hours to a day for a solar particle event to reach its maximum intensity at 1 AU. In this paper, we will show how the inclusion of the adiabatic energy loss into the focus transport equation will affect the spatial distribution, time profile and dissipation of solar energy particles in large gradual events.

SH31A-04 0830h POSTER

Relativistic Solar Particles on 1989 October 22: Injection along Both Legs of a Closed Interplanetary Magnetic Field Loop

David Ruffolo[1,2] (david_ruffolo@yahoo.com); Paisan Tooprakai[2] (paisan@astro.phys.sc.chula.ac.th); Manit Rujiwarodom[2] (rmanit@sc.chula.ac.th); Thiranee Khumlumlert[3] (thiraneek@hotmail.com); John W. Bieber[4] (john@bartol.udel.edu); Paul Evenson[4] (penguin@bartol.udel.edu); Roger Pyle[4] (pyle@bartol.udel.edu)

[1]Mahidol University, Department of Physics, Faculty of Science, Rama 6 Road, Bangkok 10400, Thailand

[2]Chulalongkorn University, Department of Physics, Faculty of Science, Bangkok 10330, Thailand

[3]Naresuan University, Department of Physics, Faculty of Science, Phitsanulok 65000, Thailand

[4]University of Delaware, Bartol Research Institute, 217 Sharp Lab, Newark, DE 19716, United States

Worldwide neutron monitor observations of relativistic solar particles on 1989 October 22 have proven puzzling, with an initial spike sometimes followed by a

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