

²The Catholic University of America, 620 Michigan Ave. NE, Washington, DC 20064, United States

³Naval Research Laboratory, 4555 Overlook Ave. SW, Washington, DC 20375, United States

Fast coronal mass ejections (CMEs), X-class flares, solar energetic particles, and interplanetary shocks were abundantly observed during the solar eruptions of October-November 2003. The Large Angle and Spectrometric Coronagraph (LASCO) on board SOHO detected more than five dozen CMEs from three active regions (NOAA ARs 0484, 0486, and 0488). We compare the statistical properties of these super-storm CMEs with those of the general population observed during cycle 23. We find that (i) the super-storm CMEs are faster and wider than average, and hence possess enormous energy, (ii) nearly 20 percent of the ultra-fast CMEs (speed > 2000 km/s) occurred during the October-November interval, including the fastest CME of cycle 23 (2700 km/s), and (iii) the rate of full-halo CMEs was nearly four times the average rate during cycle 23. We discuss the implications of these extreme properties for the solar energy source. We also discuss the interplanetary consequences of these CMEs, such as shocks, radio bursts and solar energetic particles.

SH31B-04 0930h

Remote Sensing Observations of the late October 2003 Geoeffective Halo CMEs

David F. Webb¹ (781-377-3086; david.webb@hanscom.af.mil)

¹ The SMEI Team

¹ISR, Boston College, 140 Commonweath Ave., Chestnut Hill, MA 02467, United States

Eleven major (X-class) flares with accompanying coronal mass ejections (CMEs) occurred over the 2-week period in late October and early November. These were part of a series of major events centered around 3 huge sunspot groups. The largest geoeffective event occurred on October 28, had the third highest peak X-ray flux (X17) ever recorded, and was followed by another energetic event (X10) on October 29. At least 3 of the CMEs from this activity were Earth-directed ("halos"), which erupted when the sunspot regions were near Sun center, and caused geomagnetic storms. The 2 strongest storms, driven by the fast CMEs from the X17 and X10 events, occurred on October 28-30 yielding peak Dst values of -363 and -401, resp. The earliest halo CME was associated with M-class flares and at least two erupting filaments on October 22. It produced only minor storminess at Earth because its magnetic field was mostly northward. The Air Force Solar Mass Ejection Imager (SMEI) on the Coriolis satellite captured images of two of the 3 halo CMEs, on October 23 and 29. We compare the SMEI observations with SOHO LASCO coronagraph and EIT observations and Interplanetary Scintillation (IPS) observations of the events to study their structure and kinematics. SMEI observed these halo CMEs starting at angular distances of 28 and 21 deg. from the Sun, or about 1/3 of the way from the Sun to Earth. These observations demonstrate that SMEI can detect even fast, Earth-directed CMEs up to a day before their arrival.

SH31B-05 0945h

A High-Speed Erupting Prominence CME: A Bridge Between Types

Joan Feynman¹ (818-354-2881; joan.feynman@jpl.nasa.gov)

Alexander Ruzmaikin¹ (818-393-3953; alexander.ruzmaikin)

¹Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Dr., Pasadena, CA 91109, United States

Several studies have indicated that there may be two distinct types of Coronal Mass Ejections (CMEs): a high velocity bright energetic type associated with flares, and a smaller slower less impressive type associated with erupting prominences. How valid is this distinction? We analyze a CME combining attributes of both types, a high velocity bright CME associated with an erupting prominence. A study of this event and several others allows us to argue that the apparent differences separating the two types may be an observational effect. Our results are consistent with a single CME process for both flare associated and filament associated CMEs. This process consists of three stages. The initial stage is brought about by the emergence of new magnetic flux, which interacts with the pre-existing magnetic configuration and results in a slow rise of the magnetic structure, which later becomes the CME. The second stage is a fast reconnection phase with flaring and a sudden increase of the rise velocity of the magnetic structure. It also includes a rapidly increasing CME acceleration followed by a rapidly falling acceleration. The third stage or CME propagation stage shows only slow changes in the acceleration and finally the velocity becomes constant. LASCO observes only the third stage. The differences found between observed

flare-associated and prominence-associated CME velocity behavior appears to be primarily due to the relative heights in the corona at which the erupting structures form.

SH32A CC: 518 A Wednesday 1030h

Violent Sun-Earth Connection Events of October-November 2003: Solar Plasmas (joint with SA, SM)

Presiding: D Ruffolo, Mahidol University; J C Kasper, Massachusetts Institute of Technology

SH32A-01 1030h

The Suns Halloween Scare and the Media Frenzy

Paal Brekke (301 286 6983; pbrekke@esa.nascom.nasa.gov)

European Space Agency, NASA/Goddard Space Flight Center, Mailcode 682.3, Bld. 26, Room G-1, Greenbelt, MD 20771, United States

SOHO appeared to be in everyone's focus this fall as the Sun turned from an almost spotless orb into an ominously scarred source of mighty fireworks in just a few days. Over two weeks, it featured three unusually large sunspot groups (including the largest one of this solar cycle), 11 X-class flares (including the strongest ever recorded), numerous halo CMEs (two with near-record speeds) and two significant proton storms which lasted for a combined five days. Satellites, power grids, radio communication and navigation systems were significantly affected in this period. The events caused unprecedented attention from the media and the public. Images from SOHO as well as quotes from SOHO scientists appeared in nearly every major news outlet (CNN, BBC, Associated Press, Reuters, to mention a few). Stories including SOHO images made the front page of newspapers and were featured prominently on including USA Today and The Washington Post. NASA estimated that the story reached "all" US newspapers and 2000 US TV channels. Media coverage in Europe was also impressive. The attention wiped out all existing SOHO web traffic records

URL: <http://sohowww.nascom.nasa.gov/hotshots/pastshots.html#Halloween2003>

SH32A-02 1045h INVITED

Fast, Hot and Furious: The October/November CMEs observed by ACE and WIND

Thomas H Zurbuchen¹ (thomasz@umich.edu); Adam Szabo² (Adam.Szabo-1@nasa.gov); Ruth Skoug³ (rskoug@lanl.gov); Charles Smith⁴ (Charles.Smith@unh.edu); Keith Ogilvie² (Keith.Ogilvie@gscf.nasa.gov); Alan Lazarus⁵ (ajl@mit.edu); Justin Kaspar⁵ (jck@mit.edu)

¹University of Michigan, Ann Arbor, MI, United States

²NASA Goddard Space Flight Center, Greenbelt, MD

³Los Alamos National Laboratory, Los Alamos, NM

⁴University of New Hampshire, Durham, NH

⁵Massachusetts Institute of Technology, Center for Space Research, MA

We discuss, using the ACE and WIND data, the solar activity during a period of approximately 10 days starting in late October 2003. The solar events of interest were associated with a very large cluster of highly complex active regions and resulted in coronal mass ejections causing a number of the most spectacular events ever observed in situ. This time-period includes the fastest CME ever directly observed, the hottest charge states observed to our knowledge, and the largest shock velocity jump observed in the solar wind to date. ACE observed the events from L1, and WIND observed them from the magnetospheric tail, successively emerging into the far magnetosheath during times of high dynamic pressure. We will also discuss electron data from both, WIND and ACE. In addition to excellent solar wind data, WIND also provided a unique measure of the time-variability of magnetosphere. We will use ACE and WIND data to discuss these events, as well as the interactions between various ejections.

SH32A-03 1105h

Extremely fast solar wind observations during October-November, 2003

Ruth M Skoug¹ (505-667-6594; rskoug@lanl.gov); John T Steinberg¹ (jsteinberg@lanl.gov); John T Gosling¹ (jgosling@lanl.gov); David J McComas² (dmccomas@swri.edu); Charles W Smith³ (Charles.Smith@unh.edu); Norman F Ness⁴ (nfness@bxclu.bartol.udel.edu); Qiang Hu⁵ (qiang.hu@ucr.edu); Leonard F Burlaga⁶ (Leonard.F.Burlaga@nasa.gov)

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

²Southwest Research Institute, Space Science and Engineering Division, San Antonio, TX 78228, United States

³University of New Hampshire, Institute for Earth, Oceans and Space, Durham, NH 03824, United States

⁴University of Delaware, Bartol Research Institute, Newark, DE 19711, United States

⁵University of California, Riverside, IGPP, Riverside, CA 92521, United States

⁶NASA, Goddard Space Flight Center, Greenbelt, MD 20771, United States

On October 29 and October 30, 2003, the SWEPAM instrument on the ACE spacecraft measured solar wind speeds in excess of 1850 km/s (best estimate of 2100 km/s) and 1710 km/s, some of the highest speeds ever directly measured in the solar wind. These speeds were observed following two large coronal mass ejection (CME) driven shocks. Surprisingly, despite the unusually high speeds, many of the other solar wind parameters were not particularly unusual in comparison with other large transient events. The magnetic field Bz reached -68 nT, large but not unprecedented values. Although the proton temperatures were higher than typical for a CME in the solar wind at 1 AU, the proton densities were moderate, leading to low to moderate plasma beta and dynamic pressure. The solar wind dynamic pressure reached 50 nPa, again not unusual for large events, but, when coupled with the large negative Bz, sufficient to cause intense geomagnetic disturbances at the Earth. The solar wind observations presented here provide the solar wind input to the magnetosphere during these events. We will present an analysis of the October-November 2003 shocks and CMEs using magnetometer observations from the ACE/MAG instrument and ion and electron observations from ACE/SWEPAM.

SH32A-04 1120h

An Unusually Fast CME Observed by Ulysses at 5 AU on November 15, 2003

Curt A de Koning¹ (505-667-3700;

dekoning@lanl.gov); John T Steinberg¹ (jsteinberg@lanl.gov); John T Gosling¹ (jgosling@lanl.gov); Daniel B Reisenfeld¹ (dreisen@lanl.gov); Ruth M Skoug¹ (rskoug@lanl.gov); O C St. Cyr² (Chris.StCyr@nasa.gov); M L Malayeri⁵ (leila@cme.gscf.nasa.gov); David J McComas³ (DMcComas@swri.edu); André Balogh⁴ (a.balogh@ic.ac.uk)

¹Los Alamos National Laboratory, Space and Atmospheric Sciences MS D466, Los Alamos, NM 87544, United States

²NASA Goddard Space Flight Center, NASA Goddard Space Flight Center Code 682, Greenbelt, MD 20771, United States

³Southwest Research Institute, Southwest Research Institute Space Science and Engineering Division, San Antonio, TX 78228, United States

⁴The Blackett Laboratory, Imperial College, London SW7 2BW, United Kingdom

⁵University of Maryland, Department of Physics, College Park, MD

On November 15, 2003, Ulysses was 5.2 AU from the sun and observed a large coronal mass ejection (CME) with a peak solar wind flow speed of 993 km/s and an average flow speed of 832 km/s. This is the fastest solar wind speed recorded by Ulysses SWOOPS at this distance since a similar event in November 1992. We believe this CME originated in the same group of active regions responsible for the extremely fast CMEs that impacted the Earth on October 29 and 30, 2003. The CME took 4.4 days to propagate past Ulysses, and thus had a radial width of ~ 2.1 AU. Using sunward ballistic projection of the CME, we infer a width of ~ 1 AU at a radial distance of 1 AU, which is well above the average size observed at this distance. The structure of the CME resembles a magnetic cloud, with a depressed

proton plasma beta of ~ 0.01 and a smooth rotation of the magnetic field polar angle from 43° to -62° . In addition, SWOOPS also observed bidirectional electron streaming throughout the CME, indicating that even at this distance it contained closed field lines. Assuming the CME lift-off speed was greater than or equal to the speed measured by Ulysses, this CME left the Sun on November 6, or later. We are undertaking a study to identify a unique SOHO/LASCO counterpart on the western limb of the Sun, which corresponds to the Ulysses position of 5° north of the ecliptic and 100° west of the Earth. In the days preceding the CME Ulysses observed disturbed solar wind conditions, including six shocks from November 6 to November 15 and a small CME on November 7, indicating a high degree of solar activity.

SH32A-05 1135h

Shock Events at Cassini Associated With the October-November 2003 Solar Flares

Douglas C Hamilton¹ (1-301-405-6207; dh7@umail.umd.edu)

Norbert Krupp² (krupp@linmpi.mpg.de)

Donald G Mitchell³ (Donald.G.Mitchell@jhuapl.edu)

Stamatios M Krimigis³ (Tom.Krimigis@jhuapl.edu)

¹Department of Physics, University of Maryland, College Park, MD 20742, United States

²Max Planck Institute for Aeronomy, 37191 Katlenburg-Lindau, Germany

³Applied Physics Laboratory, The Johns Hopkins University, Laurel, MD 20723, United States

The huge solar events of late October and early November 2003, which had such a large impact on the Earth, produced interplanetary shocks that were also observed at 8.7 AU by Cassini some 10-15 days later. At least two shock-associated particle events were observed by the MIMI particle instruments with shocks arriving on Nov. 10 and Nov. 16, 2003. Cassini was about 65 degrees west of the sun-earth line, making the Nov. 2, X8.3, W56 flare closest to the Cassini sub-solar point. This presentation will emphasize the ion composition and energy spectra of these events, especially in the suprathermal 3-220 keV/e range measured by the MIMI/CHEMS spectrometer. The ion composition differs from that typically observed in events at 1 AU in that the heavier ions are dominated by accelerated interstellar pickup ions; namely, He⁺ and O⁺. We will use composition variations to assess the relative importance of solar and interstellar pickup seeded particles. The Cassini spacecraft generally is oriented so that the solar wind cannot be detected directly. Therefore, away from the shocks, we will use the He⁺ cutoff energy to obtain an indirect measurement of the solar wind speed and thereby evaluate the degree of deceleration from 1 AU.

SH32A-06 1150h

The Propagation of the October/November 2003 Events to the Outer Heliosphere

John D. Richardson¹ (617-253-6112; jdr@space.mit.edu)

Chi Wang^{1,2} (cw@space.mit.edu)

Justin C Kasper¹

¹M.I.T., MIT 37-655, Cambridge, MA 02139, United States

²Laboratory for Space Weather, Chinese Academy of Science, Beijing, China

The October/November 2003 events were the most intense of this solar cycle. Since many CMEs were observed across the solar surface, these events may create a GMIR, a shell of material moving outward through the heliosphere. We use the Wind, ACE, and IMP 8 data from 1 AU as input to an MHD model of the solar wind which includes pickup ions. This model will be used to predict the propagation times and evolution of the ICMEs as they move outward. Comparison of the model results to observations will be made when possible. In particular, we will predict the arrival time and structure of these events at the Voyager spacecraft and compare these predictions with observations. The large series of ICMEs in 1991 are thought to be responsible for an intense episode of heliospheric radio emission; we will predict when the current events should reach the heliosphere and thus when we would expect a future intensification of the radio emission.

SH33A CC: 518 A Wednesday 1330h

Violent Sun-Earth Connection Events of October-November 2003: Energetic Particles (joint with SA, SM)

Presiding: R Lin, University of California, Berkeley; C M Cohen, California Institute of Technology

SH33A-01 1330h INVITED

An Overview of SEPs During the October-November 2003 Storms

C. M. S. Cohen¹ (626 395-6614;

cohen@srsl.caltech.edu); R. A. Mewaldt¹; G. M. Mason²; M. I. Desai²; A. C. Cummings¹; R. A. Leske³; E. C. Stone¹; T. T. von Rosenfing³; M. E. Wiedenbeck⁴

¹California Institute of Technology, MC 220-47, Pasadena, CA 91125, United States

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

³NASA/Goddard Space Flight Center, Code 660, Greenbelt, MD 20771, United States

⁴Jet Propulsion Laboratory, 4800 Oak Grove Dr., Pasadena, CA 91109, United States

The October-November 2003 solar energetic particle (SEP) events were some of the largest in solar cycle 23. Measurements of the heavy ion composition and spectra were made throughout the events from energies of 0.1 to 100 MeV/nucleon by the Solar Isotope Spectrometer and the Ultra Low Energy Isotope Spectrometer on ACE, yielding valuable information regarding the energy and time dependence of the composition. We will present these measurements and compare them to similar ones made in other large SEP events from this cycle, such as the Bastille Day event and the April 2002 storms period. In addition, we will examine characteristics of the locally accelerated energetic particles (e.g., the maximum energy and flux increase) at the time of the shock passage for these and other big events.

SH33A-02 1350h

Unusual Features of the October 28, 2003 Ground Level Enhancement

John W Bieber¹ (302-831-2240; john@bartol.udel.edu)

Paul Evenson¹ (penguin@bartol.udel.edu)

Roger Pyle¹ (pyle@bartol.udel.edu)

David Ruffolo² (david_ruffolo@yahoo.com)

Alejandro Sáiz^{2,3} (alex@astro.phys.sc.chula.ac.th)

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

²Mahidol University, Department of Physics, Faculty of Science, Rama 6 Rd., Bangkok 10400, Thailand

³Chulalongkorn University, Department of Physics, Faculty of Science., Bangkok 10330, Thailand

The ground level enhancement (GLE) of October 28, 2003 was unusual in a number of respects. Instead of a single, anisotropic peak from the Sunward field direction followed by an isotropic decay in intensity, this event exhibited two highly anisotropic spikes from very different directions. The earliest onset was seen by Norilsk, Russia, which is surprising because this station at the time was viewing approximately anti-Sunward along the nominal Parker spiral direction. While that spike rapidly declined, another spike was observed by several neutron monitor stations, lasting about 60 minutes. This spike was also not from the Sunward field direction, but rather from a far South latitude. The decay of the event, on the other hand, was unusually slow. In fact, the particle intensity remained at elevated levels until the CME associated with the GLE arrived at Earth and swept the solar particles away. In addition, this event had an unusually hard energy spectrum compared to other GLE. We report on observations of the event made by the SpaceShip Earth neutron monitor network, together with preliminary modeling of the event based on the Boltzmann equation. This work was supported by NSF grant ATM-0000315, the Thailand Research Fund, and the Rachadapisek Sompoj Fund of Chulalongkorn University.

URL: <http://www.bartol.udel.edu/~neutronm/>

SH33A-03 1405h INVITED

Heliospheric energetic particle observations during the October-November 2003 superstorm events

D. Lario¹ (david.lario@jhuapl.edu); S. Livi¹ (stefano.livi@jhuapl.edu); S. M. Krimigis¹ (tom.krimigis@jhuapl.edu); R. B. McKibben² (bruce.mckibben@unh.edu); C. G. MacLennan³ (cgm@lucent.com); D. B. Reisenfeld⁴ (dreisen@lanl.gov); C. de Koning⁴ (dekonig@lanl.gov); C. T. Russell⁵ (ctrussell@igpp.ucla.edu); M. K. Dougherty⁶ (m.dougherty@imperial.ac.uk)

¹Applied Physics Laboratory, The Johns Hopkins University, 11100 Johns Hopkins Rd., Laurel, MD 20723, United States

²Department of Physics and Space Science Center, University of New Hampshire, 39 College Road, Durham, NH 03824, United States

³Bell Laboratories, Lucent Technologies, 600 Mountain Avenue, Murray Hill, NJ 07974, United States

⁴Space and Atmospheric Sciences, Los Alamos National Laboratory, Los Alamos National Laboratory, Los Alamos, NM 87545, United States

⁵University of California Los Angeles, Institute of Geophysics and Planetary Physics, 3845 Slichter Hall, MS 156704, Los Angeles, CA 90095, United States

⁶The Blackett Laboratory, Imperial College, London, SW7 2BW, United Kingdom

We present a multi-spacecraft analysis of the energetic particle observations during the October-November 2003 "superstorms" period. We use energetic particle measurements from the following instruments: (1) the Low-Energy Magnetospheric Measurement System (LEMMS) on board the Cassini spacecraft, (2) the Heliosphere Instrument for Spectra, Composition and Anisotropy at Low-Energies (HI-SCALE) and the Cosmic Ray and Solar Particle Investigation (COSPIN) telescopes on board Ulysses, (3) the Electron, Proton and Alpha Monitor (EPAM) on board ACE and (4) the Energetic Particle Sensor (EPS) on board the GOES spacecraft. We combine energetic particle data with solar wind and magnetic field observations from the magnetometers and plasma instruments on board the respective spacecraft. The Cassini spacecraft was en route to Saturn, close to the ecliptic plane, at 8.7 AU from the Sun and less than 70 degrees west in longitude with respect to the Sun-Earth line. The Ulysses spacecraft was at 5.2 AU from the Sun, very close to the ecliptic plane, and 54 degrees to the west with respect to the Sun-Cassini line. Prior to the occurrence of these series of events, the structure of the inner heliosphere was well-organized by recurrent corotating high-speed streams. The intense solar events of October-November 2003 disturbed this stable structure, filling the inner heliosphere with energetic particles and sending a sequence of fast CMEs past the three spacecraft. In this paper we characterize the particle intensity enhancements seen at the three spacecraft and associate them with the solar wind disturbances traveling between the Sun and the spacecraft.

SH33A-04 1425h

Solar Energetic Particles Near the Orbit of Jupiter From the Oct/Nov. 2003 Solar Events: Observations From the Ulysses COSPIN Instruments

Robert Bruce McKibben¹ (603-862-5087; bruce.mckibben@unh.edu); John D. Anglin² (613-990-0752; dave.anglin@nrc.ca); Silvia Dalla³ ((44) 161 200 8771; s.dalla@umist.ac.uk); Bernd Heber⁴ ((49) 170 9606119; bheber@uni-osnabrueck.de); Horst W Kunow⁵ ((49) 431 880-2487; hkunow@kernphysik.uni-kiel.de); Richard E Marsden⁶ ((31) 71 565-3583; richard.marsden@esa.int); Trevor R Sanderson⁶ ((31) 71 565 3577; trevor.sanderson@esa.int); Ming Zhang⁷ (321 674-8098; mzhang@pss.fit.edu)

¹Space Science Center, U. of New Hampshire, Morse Hall 39 College Rd, Durham, NH 03824, United States

²Herzberg Institute for Astrophysics, National Research Council of Canada 100 Sussex Drive, Ottawa, ON K1A 0R6, Canada

³UMIST, P.O. Box 88, Manchester M60 1Qd, United Kingdom

⁴University of Osnabrueck, Barbarastrasse 7, Osnabrueck 49069, Germany

⁵Christian Albrechts Universitaet, Leibnizstr. 1, Kiel 24118, Germany