electric field (shielding latitude θ). The local-time dependent proton differential fluxes assigned to the model boundary are a mixture of hot plasma from the mantle and cooler plasma from the low latitude boundary layer. We previously used this model to simulate the inner plasma sheet under weak convection corresponding to $\Delta\Phi$ and θ equal to 26 kV and 66°, and obtained two-dimensional quiet time equilibrium that agrees well with observations. In the current simulation, we start with the quiet time equilibrium and boundary particle sources and enhance convection by increasing $\Delta\Phi$ steadily from 26 to 146 kV and lowering θ from 66° to 52° in 5 hours while keeping the boundary sources time independent. The inner edge of the plasma sheet at midnight, mapped to the equatorial plane using the self-consistent magnetic field, moves from 10 R_E for $\Delta\Phi$ = 26 kV to 4 R_E for 146 kV. This earthward penetration to regions of dipole field results in strong plasma pressure increase, which significantly stretches the original dipole field lines. Proton pressure at r = 6.6 R_E increases from 1 to 6 nPa as $\Delta\Phi$ increases from 26 to 146 kV, while the magnetic field strength decreases from 80 to 10 nT. The simulated pressure and magnetic field strength, their radial variations at midnight, and their changes with convection strength in the inner plasma sheet in general agree with observations. Protons undergo enhanced earthward electric drift but are significantly diverted toward dusk by azimuthal magnetic drift around midnight. The enhanced magnetic drift, responding to enhanced particle energy, changes particles' trajectories and magnetic field configuration in a way that restrains particle energization, thus plays an important role in plasma sheet dynamics. Simulations are also run to a steady state under constant $\Delta\Phi$ = 98 kV and θ = 57.6°, which indicates the inner plasma sheet can remain steady under moderate and constant convection. A scale analysis of our results suggests that using the frozen-in condition E = -v$\times$B in MHD can lead to an inconsistency with Faraday's law in the inner plasma sheet because of neglect of the Hall term in the generalized term.

SM32D MCC: 2002-2004 Wednesday 1600h

Bow Shock, Magnetosheath, and Magnetopause I *(joint with SH)*

Presiding: **X Blanco-Cano,** Instituto de Geofisica, Universidada Nacional Autónoma de México**; S A Fuselier,** Lockheed Martin Advanced Technology Center

SM32D-01 1600h

Coupling of Solar Wind Energy to the Magnetosphere via ULF Waves

Harlan Spence[1] (spence@bu.edu)

John Lyon[1] (jlyon@bu.edu)

Larry Kepko[1] (lkepko@bu.edu)

Timothy Guild[1] (tguild@bu.edu)

Michael Wiltberger[2] (wiltbemj@ucar.edu)

[1]Boston University Center for Space Physics, 725 Commonwealth Avenue, Boston, MA 02215

[2]NCAR, HAO, Boulder, CO 80307

The solar wind flow ultimately provides energy to the magnetosphere through a variety of different processes. One of these energy transfer paths is via the excitation of magnetospheric ULF waves. Recent studies (Kepko et al., 2002; Kepko and Spence, 2003) have identified a subset of global ULF waves (multiple, discrete-frequency <3 mHz), driven directly by density structures in the solar wind. In this paper, we examine this mechanism through model-data comparison. We use the Lyon-Fedder-Mobarry MHD model to simulate the global magnetospheric response under a variety of solar wind ram pressure drivers (both idealized and as observed) and compare these results with observations to explore and quantify such characteristics as coupling efficiency and frequency response.

SM32D-02 1615h

Cluster Observations of Magnetic Structures at Quasi-Parallel bow Shocks

Elizabeth Lucek[1] (00442075947898; e.lucek@imperial.ac.uk)

Tim Horbury[1] (t.horbury@imperial.ac.uk)

Andre Balogh[1] (a.balogh@imperial.ac.uk)

Iannis Dandouras[2] (Iannis.Dandouras@cesr.fr)

Henri Reme[2] (Henri.Reme@cesr.fr)

[1]Imperial College London, The Blackett Laboratory, Prince Consort Road, London SW7 2BW, United Kingdom

[2]CESR, BP 4346, 31028 Toulouse Cedex 4, France

Collisionless quasi-parallel shocks are thought to be composed of a patchwork of short, large-amplitude magnetic structures (SLAMS) which act to thermalise the plasma, giving rise to a spatially extended and time varying shock transition. With the launch of Cluster, new observations of the three-dimensional shape and size of shock structures are available. We present SLAMS observations made when the spacecraft were separated by about 100 km. The SLAMS enhancement in $|B|$ is typically well correlated between spacecraft on this scale, consistent with previous observations showing that the overall SLAMS extent exceeded about 600 km, but small differences are still observed. The statistical characteristics of these differences contain information on the typical gradients of magnetic field changes within the SLAM structure which, in the cases studied here, occur on scales of 100-150 km.

SM32D-03 1630h

Time and Length Scales of Magnetic Field Variations in the Quasi-Perpendicular Terrestrial Bowshock

Tim Horbury[1] (00 44 20 7594 7676; t.horbury@imperial.ac.uk)

Elizabeth Lucek[1]

Andre Balogh[1]

Iannis Dandouras[2]

Henri Reme[2]

[1]Imperial College London, The Blackett Laboratory Prince Consort Road, London SW7 2BW, United Kingdom

[2]CESR, 9, avenue du Colonel Roche 31028, Toulouse Cedex 4, France

The terrestrial bowshock is an example of a moderate Mach number collisionless shock which can be studied in detail. Despite decades of study of the quasi-perpendicular shock, several questions remain, such as the scales of various parts of the shock transition and in particular the time and length scales of its variability. Recent measurements using the four Cluster spacecraft make it possible to measure the orientation and motion of the quasi-perpendicular bowshock surface and also, by comparing profiles measured by different spacecraft, its variability. We present estimates of the variation with Mach number of the ramp, overshoot and undershoot scales and compare these with earlier work. We also discuss the variability of shock structures, such as the peak magnetic field and the ramp itself, and demonstrate that the shock ramp varies on scales of a few seconds, but appears to be stable over scales of hundreds of km.

SM32D-04 1645h

Energetic Ion Observations at the Cusp and Bow Shock

Shen-Wu Chang[1] (256-9617679; changs@cspar.uah.edu)

Karel Kudela[2] (kkudela@kosice.upjs.sk)

Joseph F Fennell[3] (foseph.f.fennell@aero.org)

Harlan E Spence[4] (spence@bu.edu)

[1]Center of Space Plasma and Aeronomic Research, University of Alabama in Huntsville, SD50, 320 Sparkman Dr., Huntsville, AL 35805, United States

[2]Institute of Experimental PHysics, Slovak Academy Sciences, Kosice 04353, Slovakia (Slovak Republic)

[3]The Aerospace Corporation, Mail Stop M2-259, Los Angeles, CA 90009, United States

[4]Boston University, Department of Astronomy and Space Physics, 725 Commonwealth Ave, Boston, MA 02215, United States

Previous studies have shown that solar wind ions are accelerated up to $\sim$150 keV/e at the quasi-parallel bow shock via the first order Fermi mechanism. It has been suggested that shock accelerated ions can directly enter the cusp when cusp and quasi-parallel shock are magnetically connected through the merging of IMF and geomagnetic field lines. Results from global hybrid simulations for a northward and antisunward IMF are consistent with the ion acceleration and transport processes. We present simultaneous observations of energetic ions from Interball and Polar in the foreshock and cusp region, respectively. Ion fluxes at the quasi-parallel bow shock agree with those in the cusp. Furthermore, energetic ions at both places demonstrate similar spectral characteristics. These results are consistent with the shock acceleration and ion transport processes.

SM32D-05 1700h

Cluster Observations of the Flank Boundary Layer Under Northward IMF Conditions

Donald H Fairfield[1] (301-286-7472; Donald.H.Fairfield@nasa.gov); A. Balogh[3]; M W Dunlop[4]; C J Farrugia[2]; A N Fazakerley[5]; F T Gratton[6]; L M Kistler[2]; C Mouikis[2]; C J Owen[5]; H Reme[7]

[1]Laboratory for Extratresstrial Physics, NASA/GSFC, Code 695 NASA/GSFC, Greenbelt, MD 20771, United States

[2]Space Science Center, University of New Hampshire, Durham, NH 03824, United States

[3]The Blacket Laboratory, Imperial College, London SW7 2BZ, United Kingdom

[4]Space Sciences Division, SSTD , Rutherford Appleton Laboratory, Oxfordshire OX11 0QX, United Kingdom

[5]Mullard Space Science Laboratory, University College London, Holmbury St. Mary, Dorking, Surrey RH5 6NT, United Kingdom

[6]Instituto de Fisica del Plasma,CONICET and FCEyN, University of Buenos Aires, Buenos Aires 1428, Argentina

[7]CESR, BP4346 31028, Toulouse Cedex 4, France

The four Cluster spacecraft made observations near the dusk flank boundary layer during a north-to-south passage at a location near X=-5 Re on November 20-21, 2001. The IMF remained quite steady and northward while a decreasing solar wind kinetic pressure moved the boundary outward and kept it near Cluster for almost 20 hours. Magnetic field and plasma measurements revealed repeated traversals between a higher-density tailward-flowing magnetosheath plasma with cool isotropic 30 eV electrons and a lower density, lower-tailward-velocity boundary layer plasma with anisotropic field aligned electrons nearer 80 eV. Transitions from the boundary layer to the magnetosheath were characterized by rotations to a more northward external magnetic field. These outbound crossings were invariably better defined than those in the opposite direction. For these outbound crossings, boundary normals were determined from a minimum variance analysis on the magnetic field; these normals generally agreed within 5 degrees at the 4 spacecraft and showed tilting of the normal toward the sunward direction as is typical for waves on the boundary. Individual transitions were seen successively at the four spacecraft with 5-20 s delays at spacecraft separation distances up to 2000 km. The transitions back to the boundary layer occurred gradually over a period of several minutes until the next abrupt entry to the magnetosheath. This recurrence periodicity of a few minutes is that often seen for Kelvin-Helmholtz waves in this boundary region. Determinations of Kelvin-Helmholtz instability criteria will be compared with these observations.

SM32D-06 1715h

Low Frequency Waves in the Magnetosheath as Seen by Cluster

Michael A. Balikhin[1] (+44-1142225628; m.balikhin@sheffield.ac.uk); Malcolm Dunlop[2]; Michael E. Gedalin[3]; Simon N. Walker[1]; Oleg A. Pokhotelov[1]; A. Balogh[4]; E. Amata[5]

[1]ACSE, The University of Sheffield, Mappin Srteet, Sheffield S1 3JD, United Kingdom

[2]RAL, RAL, Didcot OX11 0QX, United Kingdom

[3]Department of Physics,Ben-Gurion University, BGU, Beer-Sheva 84105, Israel

[4]The Blackett Laboratory, The Blaccket Imperial College, London SW7 2BZ, United Kingdom

[5]CNR-IFSI, Via Del Fosso del Cavaliere, 100, Rome 00133, Italy

The distribution of plasma waves encountered during one complete traversal of the magnetosheath from the bow shock to the magnetopause is studied using data from the four Cluster satellites . It is shown that in the region adjacent to the magnetopause mirror waves dominate plasma turbulence. As the Cluster spacecraft move away from the magnetopause other plasma modes replace the mirror waves.

SM32D-07 1730h

Filamentation of Langmuir waves and the role of absolute decay instability in the electron foreshock: comparison of CLUSTER observations and theory

Jan Soucek[1,2] (soucek@ufa.cas.cz); Vladimir Krasnoselskikh[1] (vkrasnos@cnrs-orleans.fr); Thierry Dudok de Wit[1] (ddwit@cnrs-orleans.fr); Jolene Pickett[3] (pickett@uiowa.edu); Craig Kletzing[3] (cak@delta.physics.uiowa.edu); Simon Walker[5] (simon.walker@sheffield.ac.uk); Kristine Sigsbee[3] (kristine-sigsbee@uiowa.edu); Ondrej Santolik[4] (santolik@mff.cuni.cz)

[1]LPCE/CNRS, 3A, Av. de la recherche scientifique, Orleans 45071, France

[2]UFA AV CR, Bocni II/1401, Prague 4 14131, Czech Republic

[3]Department of Physics and Astonomy, University of Iowa, Iowa City, IA 52242, United States

[4]Faculty of Mathematics and Physics, Charles University, V Holesovickach 2, Prague 18000, Czech Republic

[5]ACSE, University of Sheffield, Mappin Street, Sheffield S1 3JD, United Kingdom

Statistical analysis of HF electric field observed by WBD instrument on CLUSTER in the electron foreshock region show that the distribution of wave amplitudes depends on the scale of their modulation. In many cases the HF spectrum has two distinct narrow peaks near the plasma frequency. In some of those cases, when the difference of frequencies can be resolved by the instrument and is above the lower limit of frequency response, a wave with frequency corresponding to this difference is also observed. These observations indicate the presence of decay instability. The energy distribution has log-normal form for small amplitudes and manifests strong deviations from gaussian form for amplitudes larger than 1 mV/m. This suggests that the properties of small and large amplitude waves are determined by different physical processes. Conventional theory of parametric instabilities in a homogeneous medium gives results independent on scale, that disagrees with these experimental results. We propose a theoretical model based on the hypothesis that the wave activity for relatively intense electric fields is concentrated in filaments directed along the magnetic field lines. In this case the absolute parametric instability can develop. This results in the formation of profiles of the electric field of secondary Langmuir wave and density perturbations associated with ion-sound waves that correspond to eigenmodes generated by this instability. The threshold is shown to be inversely proportional to the characteristic modulation scale. This is due to the effect of the leakage of the energy of secondary waves through the filament boundaries. Taking into account this additional damping we evaluated the dependencies of wave amplitudes on characteristic scale of the modulation in a stationary state. The analytical results are shown to be in a good agreement with statistical analysis of intense Langmuir waves observed by WBD instrument in the electron foreshock region.

SM32D-08 1745h

Statistical Studies of Foreshock Langmuir Wave Amplitudes

Kristine Sigsbee[1] (319-335-1221; kms@beta.physics.uiowa.edu); C. A. Kletzing[1] (cak@delta.physics.uiowa.edu); D. A. Gurnett[1] (donald-gurnett@uiowa.edu); J. S. Pickett[1] (pickett@uiowa.edu); A. Balogh[2] (a.balogh@ic.ac.uk); E. Lucek[2] (e.lucek@ic.ac.uk)

[1]Department of Physics and Astronomy, 203 Van Allen Hall, University of Iowa, Iowa City, IA 52242, United States

[2]Space and Atmospheric Physics Group, The Blackett Laboratory, Imperial College, Prince Consort Road, London SW7 2BW, United Kingdom

Between February 2001 and May 2002, more than 200 hours of data were recorded by the Cluster Wideband Data (WBD) Plasma Wave Receiver in the vicinity of Earth's foreshock. We will discuss the statistics of the amplitudes of Langmuir waves observed by the Cluster WBD Plasma Wave Receiver in the foreshock region. The largest amplitude Langmuir waves were observed by Cluster near the boundary between the foreshock and solar wind in a region approximately 1 R_E wide, in agreement with earlier studies. The electric field amplitude probability distributions often follow a combination of the log-normal statistics predicted by stochastic growth theory and power law statistics when sorted by the distance from the foreshock boundary. Deviations from stochastic growth theory occur for large amplitude waves near the edge of the foreshock, where the probability distributions resemble a power law. Corrections to the probability distributions for non-optimal auto-ranging due to rapid waveform amplitude variations will be discussed.

SM41A MCC: 2008 Thursday 0800h

Sun-to-Earth Elements and Linkages That Drive Geoeffectiveness III *(joint with SA, SH, NG)*

Presiding: **E R Talaat,** Applied Physics Laboratory, Johns Hopkins University**;** **P C Anderson,** The Aerospace Corporation

SM41A-01 0800h INVITED

Update on the Sun-Earth Connection Chains Observed during the Solar Storm Events of April 2002: New Science & Outreach Aspects

Nicola J. Fox[1] (240 228 3529; nicola.fox@jhuapl.edu)

Janet U. Kozyra[2] (734-647-3550; jukozyra@engin.umich.edu)

[1]JHU/Applied Physics Lab, Space Department 11100 Johns Hopkins Road, Laurel, MD 20723, United States

[2]The University of Michigan, Department of Atmospheric, Oceanic and Space Sciences 2455 Hayward Street, Ann Arbor, MI 48109, United States

The interaction between the Earth and the Sun is complex and presents multi-faceted effects that vary from event to event. Observations from more than 20 satellites and a large number of ground-based sites during the April 14-24, 2002 series of solar storms allowed us to trace, in detail, the chain of events from the Sun to the Earth. These events were organized into four major sun-Earth chains that each span space physics disciplines and grouped under: solar particles, magnetospheric drivers, solar radiance, and energy balance. In a major and still ongoing community campaign, these linked chains of events were followed from their origins on the Sun as active regions, flares and coronal mass ejections, through the interplanetary medium until they impinged upon the magnetosphere and interacted with Earth's upper atmosphere. Such chains of events provide scientists not only with a wealth of scientific data to investigate the complicated couplings and feedbacks which abound in the Sun-Earth system, but also with a way to excite students and the general public. In this presentation we will summarize the progress that has been made in the understanding of these four chains, and describe how these data and results can be used for public outreach through a variety of programs implemented within the USA.

SM41A-02 0820h INVITED

Key Issues Related to Solar Sources and Interplanetary Propagation of the April 2002 Events

Nat Gopalswamy (3012865885; gopals@fugee.gsfc.nasa.gov)

NASA/GSFC, Bldg 21, Rm 260, code 695 NASA/GSFC, Greenbelt, MD 20771, United States

A summary of the solar events such as coronal mass ejections (CMEs) and flares associated with the April 2002 storms will be provided. In particular events from the primary active region, AR9906 and the underlying magnetic configuration will be discussed. The connection of these CMEs to the interplanetary shocks and the solar energetic particles events will be explored. Based on the arrival times of the interplanetary CMEs and shocks, the evolution of these disturbances as they propagated between the Sun and Earth will be described. Finally, a comparison of the April 2002 events with other geoeffective events will be made.

SM41A-03 0840h INVITED

Role of CME-associated magnetic field increases in the Solar Particle Chain

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

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

Dennis K Haggerty[1] (240-228-7886; dennis.haggerty@jhuapl.edu)

[1]Johns Hopkins U./Applied Physics Lab., 11100 Johns Hopkins Rd., Laurel, MD 20723, United States

Large increases (DB) in the interplanetary magnetic field associated with coronal mass ejections (CMEs) play a major role in controlling the intensity histories of solar energetic particles (SEPs) at 1 AU. While a large increase (DB) is en route to Earth, it can attenuate the intensity of the higher energy SEPs that are injected after the CME is launched, while possibly shock-accelerating the lower energy SEPs at the same time. When no significant increase (DB) is between the Sun and the Earth and we are magnetically well connected to the SEP injection site, we observe a beam-like impulsive event whose back-scatter depends upon the structure of the interplanetary field beyond 1 AU. When a large increase (DB) is beyond the Earth at the time of an SEP injection, it can enhance the SEP intensity by forming a reflecting barrier that impedes the escape of the SEPs into the outer heliosphere. The Storms 2002 period (14-24 April) provides examples of all three configurations because of the interleaved sequences of CME launches and SEP events. The different configurations are readily identifiable by their distinctive signatures in the ACE/EPAM electron and ion intensity/anisotropy histories in the half-dozen individual SEP events during the period. The implication for the Solar Particle Chain is that the fluence at Earth from SEP events will vary widely depending upon the configuration of the large increases (DBs) in the interplanetary field (inside and/or outside 1AU) produced by the transits of CMEs.

SM41A-04 0900h INVITED

Magnetospheric and Auroral Activity during Sawtooth Events: Energy Flow Through the MIA system During Periodic Magnetospheric Disturbances

Michael G Henderson[1] (505 665-7425; mghenderson@lanl.gov); Ruth Skoug[1] (rskoug@lanl.gov); Michelle F Thomsen[1] (mthomsen@lanl.gov); Joe Borovsky[1] (jborovsky.lanl.gov); Geoff D Reeves[1] (reeves@lanl.gov); Thomas J Immel[2] (immel@ssl.berkeley.edu); Stephen B Mende[2] (mende@ssl.berkeley.edu); Anthony TY Lui[3] (Tony.Lui@jhuapl.edu)

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

[2]Space Sciences Laboratory, University of California, Berkeley, CA 94720-7450

[3]Johns Hopkins University Applied Physics Laboratory, 11100 JOHNS HOPKINS RD, Laurel, MD 20723-6099, United States

During intervals of prolonged moderate but steady southward IMF Bz, the magnetosphere frequently enters a state in which quasi-periodic, large-amplitude, global oscillations are observed in the geosynchronous energetic particle fluxes. These oscillations have been termed "sawtooth events" because their shape – a series of slow flux decreases followed by rapid increases – resemble the teeth of a saw blade. Recent studies of sawtooth events have shown that each of the flux increases are associated with characteristic substorm onset signatures including field dipolarization, injection of energetic particles, ground magnetic perturbations, and embedded auroral onsets. Thus, it has been shown that sawtooth events are actually a sequence of recurrent quasi-periodic substorms. In addition, the level of solar wind driving necessary to induce sawtooth behavior appears to be transitional between driving levels that give rise to SMC (steady magnetospheric convection) and full-blown storm type behavior. Sawtooth events can therefore be viewed as a magnetospheric mode similar to SMCs except that for sawtooth events, the flow of energy from the solar wind into the magnetosphere becomes too large to dissipate without the (literally) periodic occurrence of substorms. I.e., the magnetosphere is continuously "driven" toward substorm-like reconfigurations in order to "reset" itself at periodic intervals. In this presentation we examine the possibility that during such long-lived, predominantly driven events, the energy input to the ionosphere/atmosphere system is greatly enhanced by the continuously driven auroral disturbances that occur.

SM41A-05 0920h INVITED

The Penetration of Solar Storm Effects Into the Earth's Atmosphere

Maura E Hagan[1] (303-497-1537; hagan@ucar.edu)

Raymond G Roble[1] (303-497-1562; roble@ucar.edu)

[1]NCAR, HAO P.O. Box 3000, Boulder, CO 80307-3000, United States