SM32D-07 1730h

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

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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

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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

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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

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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

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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

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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

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The mesopause region (ca. 80-110 km) is a cold and curious place in the Earth's atmosphere. Temperatures therein are colder in summer and warmer in winter because gravity waves that propagate into the region from the lower atmosphere dissipate, depositing their energy and momentum and driving a residual circulation from the summer to winter hemispheres with upwelling and downwelling over the respective poles. Large and ubiquitous solar atmospheric tidal variations characterize the large-scale dynamics near the mesopause. These global waves also originate in the lower atmosphere and grow exponentially as they propagate upward. Solar geomagnetic disturbances can penetrate downward into the mesopause region and affect the dynamics and chemistry. This presentation will overview the penetration of solar storm effects into the Earth's atmosphere with an emphasis on the mesopause region effects during the April 2002 storm period. These effects include modifications to the quiescent circulation, neutral composition changes, and temperature variations.

SM41A-06 0940h

The role of solar wind dynamic pressure in driving geoeffectiveness: Global MHD simulation results

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The ionospheric energy deposition analysis carried out using a global MHD simulation has yielded a high-correlation power law between the solar wind parameters (density, velocity and IMF) and the total ionospheric power consumption. In particular, the energy budget analysis has demonstrated that the solar wind dynamic pressure has a role in the ionospheric Joule heating. The working hypothesis has been that since the Region 1 field-aligned currents close to the Chapman-Ferraro currents driven by the dynamic pressure variations, the Joule heating produced by the closure of Region 1 currents would be controlled by the solar wind dynamic pressure. Furthermore, the global MHD simulation results show that the energy content inside various volumes within the simulation magnetosphere appears to be driven by the solar wind dynamic pressure. Therefore we argue that the solar wind dynamic pressure has a strong contribution to the global energetics of the magnetosphere and ionosphere as determined from a global MHD simulation (GUMICS-4). We demonstrate quantitatively both the role of solar wind dynamic pressure on the Region 1 currents as well as its effect on the ionospheric Joule heating by using GUMCS-4. We discuss the role of weak Region 2 currents in GUMICS-4 in the interrelation of the solar wind dynamic pressure and the ionospheric Joule heating.

SM41B MCC: Level 1 Thursday 0830h

Dynamic and Global Aurora I Posters *(joint with SA, AE)*

Presiding: **P L Rothwell,** Air Force Research Laboratory/Space Vehicles Directorate**; R E Ergun,** University of Colorado

SM41B-0560 0830h POSTER

Kinetic Simulation of Nonlinear Interactions Mediated by Alfven Waves

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An electromagnetic particle-in-cell (PIC) code is used to identify key nonlinear interactions mediated by large amplitude shear Alfven waves that propagate between distant boundaries along the geomagnetic field, as may be of interest to I-M coupling studies. At the upper boundary waves are excited at frequencies below the ion gyrofrequency and with a transverse spatial structure having a scale length comparable to the ion gyroradius or the electron skin-depth. The waves propagate along and across the geomagnetic field and reflect from a lower ionospheric boundary. It is found that strong wave-particle interactions with electrons leads to the distortion of the propagation characteristics of the signals. The reflecting Alfven waves generate a self-consistent current system that flows along the edges of field-aligned density striations that are formed by the large plasma pressure resulting from heating by the Alfvenic electric fields. This work is sponsored by NSF.

SM41B-0561 0830h POSTER

Dynamic Planar Double Layers: Filamentary Substructures, Electron Holes and Ion Heating

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High-resolution measurements from FAST in the auroral return current plasma have revealed a wealth of information on the myriads of small-scale structures imbedded in large-scale ones. The fine structures appear in electric fields both parallel and perpendicular to the ambient Earth's magnetic field associated with the so-called diverging electrostatic shocks. The upward-accelerated electron flux and, therefore, the downward parallel current also show filamentary behavior. Using 2.5-D particle-in-cell (PIC) simulations, we study here the formation of a double layer (DL) and its stability. We find that the ion beam accelerated by the DL generates waves, which trigger fragmentation of the DL into substructures (DLSSs) like U- and V-shaped electrostatic shocks. The DL and DLSSs are seen to continually emit electron holes of varied shapes and sizes into the high-potential plasma above them, while below them in the low-potential plasma ions are transversely heated. Our simulation suggests important coupling between various auroral processes, namely, formation of DL, acceleration of electrons and ions, ion instabilities below the DL, filamentation of the DL by the waves generating DLSS, and continual emission of electron holes from them. In addition to revealing the coupling processes, simulations also bring out some of the quantitative features of return current plasma.

SM41B-0562 0830h POSTER

Determination of the Short- and Long-Range Parallel Potential in the Downward Auroral-Current Region From FAST Satellite Data and Theory

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Over the years, satellite observations have suggested the following characteristics of the downward auroral-current region: diverging electrostatic shocks and a downward pointing parallel E-field; upflowing low energy (less than a few kilovolts) field-aligned electrons; intense transverse ion heating; small-scale density cavities; intense ELF and VLF electric-field turbulence; and sometimes rapidly moving bipolar solitary structures. We give a multimoment fluid theory for the auroral return-current region that is based on the Vlasov-Maxwell equations for the particle dynamics and a Fokker-Planck model for the wave-particle interactions. Using FAST particle and wave data as a boundary condition, these equations may be integrated from the satellite altitude down to the shock- and transition-region altitude and up to several earth radii in order to determine both the short- and long-range, self-consistent parallel potential. For a particular winter satellite pass near local midnight, this model finds that typical voltage distributions are: a 240 volt increase from the bottom of the shock region to the top of the transition region (2800 km); a 30 volt increase from the top of the transition region to the satellite altitude (4130 km); and a 330 volt increase from the satellite altitude to 3 earth radii for a total potential increase from the topside ionosphere to 3 earth radii of about 600 volts.

SM41B-0563 0830h POSTER

Particle simulation of electromagnetic field signature associated with electrostatic solitary waves

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We present particle simulations of electrostatic solitary waves (ESW) observed by the GEOTAIL spacecraft and recent spacecraft in the Earth's magnetosphere. Recent particle simulations have demonstrated that ESW correspond to Bernstein-Greene-Kruskal electron holes formed through nonlinear evolution of electron beam instabilities. Since an electron hole is a coherent electrostatic potential structure, electron beam instabilities were conventionally studied by electrostatic particle simulations. However, the POLAR spacecraft and FAST spacecraft observed electromagnetic field signatures associated with ESW. To study interaction between coherent electrostatic potentials and electromagnetic waves, we extend the previous electrostatic particle model to an electromagnetic particle model. In the present two-dimensional simulations of an electron beam instability, electromagnetic field components are enhanced around two-dimensional electron holes. We found that the enhancement of electromagnetic fields is due to a current formed by electrons undergoing the $E \times B_0$ drift, where the electric field is a perpendicular electrostatic field at the edge of a two-dimensional electron hole. An electromagnetic beam mode is excited by the current due to the drifting electrons moving with the electron hole. The amplitude ratio of the electric field to the magnetic field is estimated based on the present simulation result, and it is in agreement with those of the POLAR and FAST observations.

SM41B-0564 0830h POSTER

Kinetic Simulations of Shear Alfvén waves: Electron Dynamics in uniform and nonuniform magnetic fields

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Standing and travelling shear Alfvén waves contribute to electron acceleration and parallel electric field formation on auroral field lines in Earth's magnetosphere. We model the shear Alfvén waves in one dimension and use a self-consistent kinetic simulation code to study the parallel electron dynamics in the presence of shear Alfvén waves in the inertial regime. We study both travelling shear Alfvén wave pulses as well as standing shear Alfvén waves which represent field line resonances. We compare results from simulation runs with uniform and non-uniform magnetic fields in order to demonstrate the effect of including the magnetic mirror force term. We also show results from simulation runs with non-uniform density profiles, to investigate the effect of varying the Alfvén speed and electron inertial length along the field line.

SM41B-0565 0830h POSTER

Generation of Alfven waves by upper hybrid waves

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There is a great interest in ionospheric heating and modification as evidenced by the HAARP facility in Alaska and a large effort in Norway, and long time effort at Arecibo. In a series of laboratory experiments at the upgraded **LA**rge **P**lasma **D**evice (LAPD) at UCLA we are simulating these interactions. We launch high power microwave pulses into a strongly magnetized plasma ($n \leq 10^{12}\mathrm{cm}^{-3}$, $B_0 = 1 - 2.5$ kG, He,Ne, Dia= 50 cm, Length 17m). The microwaves (f $\simeq$ 9 GHz) are beamed either along the magnetic field into

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