SH21B CC: 518 C Tuesday 0830h

The February 2004 Ulysses Encounter With Jupiter I *(joint with SM)*

Presiding: **S T Suess,** NASA Marshall Space Flight Center**; R J Macdowall,** NASA Goddard Space Flight Center

SH21B-01 0830h

Ulysses Magnetic Field Observations During the Jupiter Distant Encounter

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November 2003 through March 2004 is the interval during which Ulysses encounters Jupiter for the second time. The spacecraft remains outside the Jovian magnetosphere at distances in excess of several thousand Jupiter radii. Nevertheless, the Ulysses observations are of interest because they provide an opportunity to study various emissions from Jupiter, including energetic particles, radio signals, dust and neutral atoms, over a wide range of Jovigraphic latitudes and local times. In addition, the observations identify the arrival at Jupiter of large -scale solar wind structures such as compression and rarefactions regions and the Heliospheric Current Sheet (HCS) which are of interest to the in-situ and any remote-sensing observations of Jupiter. The Ulysses magnetic field and solar wind measurements play a key role in identifying these structures throughout the encounter interval. The polarity and direction of the magnetic field allow testing of its effect on the escape of relativistic electrons, dust and other emissions from Jupiter's magnetosphere and their subsequent propagation in the solar wind. The data also contain information about solar wind shocks, waves, discontinuities, the HCS, etc. near 5AU and, in particular, those features impacting the Jovian magnetosphere.

SH21B-02 0845h INVITED

Simultaneous X-ray, Ultraviolet, and Radio Observations of Jupiter's Aurora

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Chandra observations of 40-minute periodicity in X-ray emissions from Jupiter's polar caps during the Cassini-Huygens 2000 Jupiter flyby are reminiscent of the correlation in a near-40-minute periodicity between quasi-periodic radio bursts and energetic field-aligned electron flows on Jupiter's dusk flank as measured by the Ulysses spacecraft in its initial Jupiter flyby. Follow-up observations using both Chandra and Ulysses are inconclusive, but simultaneous HST observations and X-ray spectral data provide tantalizing clues of a possible mechanism.

SH21B-03 0905h INVITED

Ulysses observations of jovian relativistic electrons in the interplanetary space: new results from distant encounter with Jupiter

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Since the first approach by Pioneer 10 in 1972, Jupiter is known to be the source of relativistic electrons that dominate the radiation environment of the entire inner heliosphere during solar quiet periods. Jets of relativistic electrons were observed when the spacecraft got within short distances of a fraction of 1 AU from the magnetosphere. Because it is a point source, one can use the spatial distribution of jovian electrons to figure out the properties of particle propagation such as the diffusion coefficient parallel or perpendicular to the magnetic field. Ulysses' unique out-of-ecliptic trajectory has made it possible to study particle propagation in the latitudinal direction. From the measurements during Ulysses first encounter with Jupiter in 1992 and subsequent polar orbits, it was found that the particle latitudinal transport should be enhanced at high heliographic latitudes relative to that near the solar equator. Twelve years later, Ulysses returns to Jupiter's orbit with a closest encounter with the planet in February 2004. Relativistic electron intensity has been increasing steadily towards Jupiter. In this paper, an analysis of electron measurements made by the HET of COSPIN experiment will be presented. The results will be compared with previous results to find out any solar cycle dependence of the jovian source and the particle propagation in the interplanetary magnetic field. Implication to the propagation of solar energetic particles and cosmic rays will be discussed.

SH21B-04 0925h INVITED

Radio Jupiter Observed From High Northern Latitudes

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Radio observations of Jupiter during the Voyager fly-bys in 1979 and the Ulysses fly-by in 1992 revealed that dramatic changes in morphology occurred in conjunction with seemingly small changes in observer's Jovicentric latitude. Indeed, at sub-observer latitudes outside the nominal equatorial band observable from Earth, several new Jovian radio components were observed. During the later half of 2003 and most of 2004, the Ulysses spacecraft is performing another fly-by of Jupiter, but at a much greater distance (0.8 to 2.0 AU) than during the 1992 fly-by (6 Jovian radii). However, even at these distances, Jupiter is the dominant radio source, permitting synoptic intensity and (occasionally) polarization observations to be made by the Ulysses radio and plasma wave instrument. During this distant fly-by, the Jovicentric latitude excursion is very large, covering the range from about +75 degrees down to -15 degrees while closer than 2 AU to Jupiter. Here we describe low frequency (< 1 MHz) observations made during the northern phase of this fly-by, covering latitudes from +75 degrees to almost the equator, including some intervals at the same latitude but dramatically different local times. Perhaps the most persistent emissions observed at high latitudes are the so-called QP (quasi-periodic) bursts, although their appearance is much more complex than during the first Ulysses fly-by in 1992. Also evident are some broad band features that may be triggered by co-rotating solar wind structures. Coronal mass ejections (CMEs) are another contributor to the variability of Jovian radio emissions and we will show examples of enhanced Jovian emissions correlated with impact of CMEs with the Jovian magnetosphere during the extremely active solar storms of Oct-Nov 2003.

SH21B-05 0945h

Jovian Dust Streams Measurements During Ulysses' 2004 Distant Jupiter Encounter

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Collimated burst-like streams of dust particles were discovered with Ulysses during approach to Jupiter in 1992 and later confirmed with Galileo and Cassini. The streams occurred at approximately monthly intervals (28 +- 3 days) which was explained by the particle interaction with the interplanetary magnetic field. Maximum impact rates were above 1000 per day, impact speeds exceeded 200 km/sec and grain radii were approximately 10 nm. Later Galileo measurements showed that the particles strongly interact with Jupiter's magnetosphere and that they originated from Io. More than ten years after their discovery, Ulysses measured the dust streams again during approach to Jupiter in 2003. Eight dust streams were detected by January 2004, confirming the grain properties, impact rates and monthly periodicity recognized in 1992. The measured impact directions are compatible with a grain origin from the jovian system, and the most distant stream recognized in the latest data occurred at 3.3 AU jovicentric distance. Taken all measurements together - the streams were detected at various jovigraphic latitudes between -35 deg and +75 deg.

SH22A CC: 518 C Tuesday 1030h

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

Presiding: **R A Mewaldt,** California Institute of Technology**; J T Steinberg,** Los Alamos National Laboratory

SH22A-01 1030h

A Survey of Multi-MeV Electrons in Solar Energetic Particle Events Over a Complete Solar Cycle

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The Proton/Electron Telescope (PET) aboard the Solar, Anomalous, and Magnetospheric Particles Explorer (SAMPEX) satellite has measured light ions and electrons in low Earth orbit, both in the radiation belts and over the polar caps, since launch in July 1992. The instrument includes several channels that sense multi-MeV electrons with strong rejection of background; this enables us to observe these particles even during strong proton-dominated solar energetic particle (SEP) events. During a few events over the last solar activity cycle, notably the October/November 2003 events, we detect electrons with energies above 10 MeV. We will present a survey of SEP electron observations over the SAMPEX mission to date, including fluxes and spectral shapes.

SH22A-02 1045h

Comparing Solar Hard X-ray Emissions and Impulsive Electron Events seen at 1AU

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The Sun frequently accelerates electrons in solar flares and type III radio bursts. Some of the accelerated electrons lose their energy by collisions in the denser, lower solar atmosphere producing hard X-ray (HXR) emissions, while others escape into interplanetary space. Whether the HXR producing and the escaping electrons are accelerated by the same mechanism is not known. We present a combined study of RHESSI

X-ray observations and WIND/3dp in situ electron observations taken near 1 AU. Electron events with a solar release time in close temporal agreement with the HXR peak time are selected. For these events, the electron spectrum measured at 1 AU is compared with the electron spectrum derived from the HXR observations. We find the derived and the observed electron spectrum do not agree with a simple model of electron acceleration high in the corona with downward moving electrons producing HXRs in the lower, denser corona (thick target model) and upwards moving electrons escaping into interplanetary space without energy changes; the observed electron spectrum at 1 AU would predict a much harder HXR spectrum than what is observed. More complicated models including the effects of how particle escape from the acceleration cite are need. That a high coronal acceleration can be excluded makes it hard to explain how the low energy electrons, down to a few hundred eV, can escape to ∼1 AU. This suggests that two different mechanisms may be accelerating electrons and that the HXR emission is not related to the electrons seen at 1 AU despite the close temporal correlation.

SH22A-03 1100h

Solar Origin of Interplanetary Impulsive Electron Events

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Many solar impulsive electron events have been traditionally associated with type III radio emissions. Several recent studies however showed that, in the majority of the events, the solar release of electrons at high energies can present delays of up-to-half an hour with respect of the onset of type III bursts. We have revisited the origin of a large number of events using multiwave-length observations. For each event, we investigated the coronal restructuring using EUV, white-light, radio imaging and spectral observations in a wide frequency range that allows us to follow the evolution of the corona from a few tenths above the solar limb up to a few solar radii. Radio observations revealed direct energetic electron signatures, close in time with the electron release. The release time for the delayed events always coincides with the onset or major changes in the complex of radio emissions. This close association indicates that the coronal processes involved in the radio emissions are at the origin of the electron acceleration. We illustrate our results by presenting, more particularly, one recent event for which the observations were also coupled with imaging spectroscopy measurements obtained by the RHESSI mission (from 3 keV to 17 MeV). RHESSI observed a hard X-ray emission, which lasted for more than fifteen minutes. This emission was closely associated in time and space with the radio emission imaged by the Nançay Radioheliograph. The results suggest that, for this event, both electrons detected in the corona and those injected in the interplanetary medium are due to a similar process involving coronal magnetic field interactions. Their respective sites of acceleration/injection are however distinct in space and time. The energetic electrons detected in the interplanetary medium are not released during the X-ray burst.

SH22A-04 1115h

The Source of Short (<1 hour) Beams of Near-relativistic Electrons Seen by ACE

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The EPAM instrument on the ACE spacecraft has detected ∼170 highly anisotropic near-relativistic electron events since launch in 1997. Most of these are associated with coronal mass ejections (CME) off the western hemisphere of the Sun, and the release altitude is typically around 3-4 solar radii (Sun centered). About half (82) of the beamed events are short-lived "pulses" (<1 hour full width at 1/3 maximum at ∼60 keV). 11 had decays from maximum intensity of <15 minutes to 1/20 of maximum. Some events have a strong pulse at the onset, followed by a long-lived increase, such as occurred after the GOES X-ray class X17 flare on 28 October, 2003. We suggest that the short pulses are electrons accelerated by a CME-driven shock onto magnetic field lines directly linked to the spacecraft. That the pulse is short lived indicates that the coronal environment, rather than the shock, is more important for electron acceleration, as the shock strength is unlikely to change significantly over 15 minutes, whereas a fast CME (eg 2000 km/s) moves around 3 solar radii in this time. Near the ecliptic plane, this will take the CME from a region of largely closed magnetic field into a region of open magnetic field. As the electron injection for the pulsed events has ceased by this time, this strongly suggests that both the shock and the closed magnetic field of the corona are needed for efficient acceleration. For longer lived events, the electrons observed, which are only moderately anisotropic or isotropic, are those gradually released from within the CME, (probably originating from the associated flare), which populate the inner heliosphere.

SH22A-05 1130h

Effective drift velocity and initiation times of interplanetary type-III radio bursts

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We derive an "effective drift velocity" (EDV) from dynamic WIND/WAVES spectrograms of interplanetary type-III fast-drift radio bursts associated with 171 (1997-2003) near-relativistic electron events observed at 1 AU. The EDV should be regarded as a phenomenological parameter that characterizes the burst drift. It is a weighted spatial average of the exciter front velocities within the extended burst. A frequency-time contour at a constant observed intensity is a sample of emission from an irregular volume where the extended exciter region encounters the density corresponding to the frequency. Therefore the contour of the spectrogram that defines the "leading edge" of the emission is produced by the earliest exciter electrons to reach regions with that particular plasma frequency in sufficient numbers to produce type-III emission at the WIND spacecraft. The weighting involves not only the spatial distribution of the exciter electrons, but also the intrinsic brightness and radiation pattern of the type-III emission (as well as possible refraction effects). Nonetheless, even with all these caveats, the EDV derived from the "leading edge" will be among the fastest exciter velocities sampled from the entire burst pattern. The "leading edge" is established by a best fit of multiple time-frequency points obtained from different frequency cuts. The onset point for each given frequency is determined when the intensity curve rises above background. The same analysis technique also yields an estimate of the time at which the interplanetary type-III radio burst was initiated in the low corona. In this sense, the EDV and initiation times derived from the "leading edge" as well as the "peak" and "trailing edge" of the type-III burst are useful phenomenological parameters for the characterization of burst propagation. It is certainly a more robust a parameter than the ill-defined "transit time", when a contour of the emission pattern reaches the local plasma frequency. We examine the EDVs and initiation times with respect to the delayed injection of near-relativistic electrons and plasma density, measured at ACE, to determine whether the EDVs are correlated with the observed delays. No statistically significant correlations have been found.

SH22A-06 1145h

Implications for Near-Relativistic Solar Electron Transport from the Propagation Characteristics of Type-III Solar Radio Bursts

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A companion paper by Haggerty and Roelof [this Session] sets out the characteristics of fast-drift radio bursts from 0.05AU to 0.5AU. The radial exciter velocities that define the leading edge of the bursts commonly are in the range 0.1c to 0.4c. The near-relativistic electrons observed by ACE/EPAM have velocities 0.4c-0.8c. We consider the possibility that the near-relativistic electrons are also generating radio emission in the type-III radio bursts, albeit below the sensitivity threshold of the WIND/WAVES receivers. If so, the energy spectrum of the electron unidirectional differential intensity during the rise of the near-relativistic electron events should exhibit a plateau. A positive slope in the reduced phase space density (PSD) would be quenched to a plateau, because otherwise it would drive the growth of Langmuir waves (which can then couple to electromagnetic modes to produce type-III radio emission). For strongly anisotropic PSDs, the reduced PSD is proportional to the peak intensity in the beam. However, such a plateau in the beam intensity would be partially obscured by an instrumental effect, namely the scattering of electrons within the EPAM solid-state detector (SSD). This would deposit energy in the lower energy channels from the early-arriving higher energy electrons, thus producing counts in the lower energy channels before electrons of that energy had actually arrived (thus tending to flatten the measured spectrum). We have developed a tool for evaluating this instrumental effect in the SSD during the rise phase of the EPAM electron events [Haggerty and Roelof, *Adv. Space Res.*, **32**(3), 423-428, 2003] using the GEANT simulation package. We are now adapting it to beam intensity spectra with the expected plateau at lower energies. The measured (uncorrected) EPAM spectra do indeed exhibit a plateau during the rise phase of beam-like events. If the instrumental effect proves to be negligible, the plateau implies that the electrons have lost energy by transferring parallel momentum to the Langmuir waves throughout their transit from the Sun. Then the measured electron injection delays ∼10 minutes that we have reported [Haggerty and Roelof, *Adv. Space Res.*, **32**(12), 2673-2678, 2003] would have to be increased, because we had assumed that the electrons traveled to 1 AU at the measured energy without energy loss.

SH23A CC: 220 C-E Tuesday 1330h

The February 2004 Ulysses Encounter With Jupiter II Posters *(joint with SM)*

Presiding: **R J Macdowall,** NASA Goddard Space Flight Center**; M Zhang,** Florida Institute of Technology

SH23A-01 1330h POSTER

Ulysses COSPIN/KET Observations of Jovian Electron Bursts During the Distant Jupiter Encounter

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The COSPIN/KET experiment on-board Ulysses has been monitoring the flux of 3-20 MeV electrons in interplanetary space since launch in October 1990. Between 1 and 10 AU Jovian and galactic particles contribute continously to the few-MeV electron intensities. During it's recent descend to low latitudes the Ulysses spacecraft approached Jupiter to less than 1 AU. However, in addition to the average intensity level well accounted for by diffusion, we report in this contribution very short duration electron events, which are called Jovian electron jets, characterized by: (i) a sharp increase and decrease of flux: (ii) a spectrum identical to the electron spectrum in the Jovian magnetosphere; and iii) a strong anisotropy. The results are compared with similar events observed during the Jovian close flyby in 1992.