

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 bursts 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 continuously to the few-MeV electron intensities. During it's recent descent 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.

## SH23A-02 1330h POSTER

### Recurring Episodes of Jovian Radio Emission Driven by Magnetospheric Interaction with Corotating Solar Wind Density Structures and Sector Boundaries

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In 2003 and early 2004, the Ulysses spacecraft descended from high heliographic latitudes towards perihelion, bringing it relatively close to Jupiter. The geometry of this distant flyby (0.8 AU closest approach) caused Ulysses to spend more than 6 months above a jovian latitude of 50 deg at a range of less than 2 AU, while the spacecraft traversed a considerable range of Jovian local time (9 hrs to 17 hrs). During much of this time interval, Jupiter was intercepted each solar rotation by two corotating high density structures and sector boundaries. From the perspective of Ulysses, the radio response of the magnetosphere to a given corotating structure was the intensification of either Jovian broad-band kilometric (bKOM) emission or of a combination of emissions, including bKOM and Jovian narrow-band kilometric (nKOM) emission. Such enhancements have been studied previously with Voyager, Ulysses, Galileo, and Cassini radio data. For Ulysses observations in 1991 and 1992, in particular, the typical scenario was brightening in the Jovian bKOM emission, followed by a sudden cessation of the bKOM emission and an onset of an nKOM "event" that lasted for some 120 hours (Reiner et al., 2000). For the sequences of events in 2003-2004, the two episodes per solar rotation clearly have different morphologies. These differences provide a unique opportunity to study solar wind and interplanetary magnetic field interaction with the Jovian magnetosphere over a period of 6 months, with upstream data provided by the Ulysses solar wind and magnetic field instruments. The goal is to determine which inputs to the magnetosphere are the most influential, resulting in different magnetospheric and, consequently, radio emission responses.

## SH23A-03 1330h POSTER

### Jovian BHL Emissions Observed During the Ulysses-Jupiter Distant Encounter

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During the Ulysses-Jupiter near-encounter in 1992 several new components of Jovian radio emissions were discovered. One new component, called Bursty High-Latitude (BHL), was observed during Ulysses' brief excursion to high Jovian magnetic latitudes. This radiation component was characterized by its burstiness and its unique elliptical polarization. The northern BHL emissions, which were observed only briefly by Ulysses in 1992, were observed from high magnetic latitudes ( $> 40^\circ$ ) and in the CML range from  $135^\circ$  to  $240^\circ$ . Since the recent 2003/2004 Ulysses-Jupiter distant encounter views Jupiter from high northern magnetic latitudes for an extended time period, it was anticipated that Ulysses might observe many episodes of BHL emission, which would help to further characterize this unique Jovian radiation and establish its possible relationship to other Jovian radio components. However, the relative paucity of these BHL emissions observed during the distant encounter suggests that they may require some triggering agent. Indeed, it is very interesting that the observed episodes of BHL emissions are often found to immediately precede major long-duration nKOM events, which are known to be triggered by interactions of the Jovian magnetosphere with the interplanetary sector structure. During the entire nKOM event there appears to be no further episodes of the BHL emissions. These results are reminiscent of our

previous findings that Jovian bKOM emissions abruptly ceased just prior to long-duration nKOM events associated with the passage of sector boundaries.

## SH23A-04 1330h POSTER

### Jovian Modulation of Ulysses HISCALE low-energy Electrons

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Estimates of the power spectrum computed from the various low-energy ( $\sim 40 - 300$  keV) electron detectors of the Ulysses HISCALE instrument were computed on overlapping data segments starting in Jan. 2003 as Ulysses approached Jupiter (closest approach in Feb. 2004) towards the end of Ulysses' second orbit. In addition to the usual low-frequency solar modes expected in this data, a peak at 27.99 MHz, corresponding to Jupiter's rotational period of 9h 55m, becomes evident in mid 2003 and, in the last data segment computed in 2003, was about  $3.4\sigma$  above the background spectrum. Because relative long,  $\sim 170$ -day, data blocks were necessary for both sensitivity and to resolve Jovian rotation from the nearby 27.435 MHz solar mode, it is not possible to give a precise range for the initial detection. It appears that Jovian modulation of the electron fluxes must extend somewhat more than one AU from the planet, further than observed during Ulysses 1992 initial Jupiter pass.

## SH23A-05 1330h POSTER

### Superfine Structure of Jovian Millisecond Radio Bursts

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Jupiter decameter (DAM) radio emission mainly consists of wide-band radio storms with time scales in seconds (L-bursts) and milliseconds (S-bursts), the latter comprising a series of short pulses with duration of a few to tens of milliseconds, and strongly controlled by the satellite Io. First in-depth analysis of the subpulse structure was made by Carr and Reyes (1999) with the discovery of successive deep envelope modulations, with time resolution better than 30 microseconds, and during these subpulse periods the discovery of phase coherence. Recent observations by means of the newly developed waveform receiver (at present unsurpassed in spectral resolution) and connected to the decameter world-largest radio telescope UTR-2 (Kharkov) yielded waveform measurements of Jovian S-bursts which have been analyzed by the wavelet analysis method. Main outcome of the present investigation is the detection of clear signatures of microsecond modulations, providing evidence of a superfine burst structure with the following parameters: a) instantaneous frequency band of one separated microsecond pulse of 100 to 300 kHz, b) time duration of one separated micropulse of 6 to 15 microseconds, and c) time interval between closest subsequent microsecond pulses of 5 to 25 microseconds. The apparent frequency drift of a millisecond burst evidently results from sequentially decreasing frequencies of subsequent subpulses, each representing an island of phase coherent gyrating electron bunches.

## SH23B CC: 518 C Tuesday 1330h

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

*Presiding:* S Krucker, University of California, Berkeley; W H Matthaeus, Bartol Research Institute, University of Delaware

## SH23B-01 1330h

### Time Scales of Solar Energetic Particle Events and Speeds of Source CMEs

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Solar Energetic Particle (SEP) events are characterized primarily by their peak intensities or fluences. Event temporal characteristics and their associations with solar phenomena are less frequently considered. We measure the times to SEP event onsets, rise times and event durations of  $E = 20$  MeV solar proton events observed with the NASA/GSFC Epack instrument on the Wind spacecraft. The approximately 140 SEP events, observed from 1998 through 2002, were accompanied by associated coronal mass ejections (CMEs) observed with the Lasco coronagraph on the SOHO spacecraft. The timing characteristics of the SEP events are compared with the speeds and widths of the associated CMEs to determine whether any of the characteristics of the SEP intensity-time profiles can be related to CME properties. The longitude dependence of the temporal profiles is considered separately to determine the geometric extents of the shocks producing the SEP events at 1 AU.

## SH23B-02 1345h

### Investigation of the Acceleration Sites for Types II and III Radio Bursts during Solar Eruptions

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Energetic properties of fast coronal mass ejections (CMEs) and the correlation of CMEs with flares suggest the production of high energy particles and CME-driven fast shocks in major solar eruptive processes. It is generally believed that the high energy particles, especially the energetic electron beams, are responsible for type III radio bursts, and that CME-driven shocks produce type II radio bursts. Observations show that type II bursts do not appear below a certain height. On the other hand, type III burst may be observed at both high and low altitudes. This indicates that acceleration sites of the electron beams may exist at both the CME-driven shock surface and the current sheet in the wake of CME, according to the catastrophe model of CMEs. The former could account for type III bursts at higher altitudes and the latter for those at lower altitudes. Both observations and theory show that the main acceleration phase of CMEs occurs in the lower corona, where the local Alfvén speed (or the magnetosonic speed) is large, so that the CME-driven shocks may not develop until the CME reaches higher altitudes. On the basis of the catastrophe model of CMEs, we estimate that the highest frequency of type II burst is around 300 MHz, which corresponds to an altitude of  $\sim 1.5 \times 10^5$  km. This result is consistent with similar estimates based on observations that bring the corresponding frequency to a few hundred MHz.

## SH23B-03 1400h

### The Isotopic Composition of Solar Energetic Particles in Large Events of Solar Cycle 23

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