THE SOLAR FLARE AND COSMIC GAMMA-RAY BURST EXPERIMENT ABOARD THE ULYSSES SPACECRAFT

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Abstract

The HUS-Ulysses team has prepared an instrument for the Ulysses spacecraft consisting of 2 Csi detectors and 2 Si surface barrier detectors for measuring X-rays in the range 5-200 keV with up to 8 ms time resolution. The prime objectives of the experiment are the study of solar flares and cosmic gamma-ray bursts. The Ulysses mission will leave the ecliptic during the forthcoming solar maximum. The total time above ecliptic latitudes +-70 degrees is expected to be 230 days. The solar data can be used in conjunction with other experiment to measure the directivity of the emission and for correlative studies.

The Cosmic Gamma-Ray Burst Experiment

The HUS X-ray flare and cosmic gamma-ray burst detector aboard the Ulysses spacecraft was designed by 3 european institutes, namely the Centre d'Etude Spatiale des Rayonnements,Toulouse (France), the Max Planck Institute fuer Extraterrestrische Physik, Garching bei Muenchen (West Germany), and the Astronomical Institute of Utrecht (The Netherlands). The launch is planned for october 1990. the primary objectives are the study of solar X-ray flares and of cosmic gamma-ray bursts.

The experiment consists of 2 detectors: 2 Si sensors operating in the range 5 to 20 keV with a field of view of 75 degrees (half cone, centered on the earth) and two CsI(Tl) scintillators for the range 15-200 keV with an all-sky field of view. The bit rate allowed in the Ulysses telemetry for HUS is 40 bit/second and the time resolution is up to 4 seconds for the Si sensors and up to 8ms for the scintillators.

The HUS 2B sensors are surface barrier detectors each 500 microns thick and 0.5 cm2 in area with a Be front window to reject low energy X-rays. The energy band channels are shown in the following table:

ENERGY BAND CHANNELS OF THE SOFT X-RAY DETECTORS

Channel	D0	D1	D2	D3	D4	D5
Energy limits (keV)	>3.5	5-7.1	7.1-10	10-14	14-20	>20

The count rates from the six channels D0 to D5 from the sum of the two sensors are accumulated over times which depends on the spacecraft telemetry as shown in the next table

ACCUMULATION TIMES FOR THE SOFT X-RAY DETECTORS

Channel	D0	D1	D2	D3	D4	D5
Accumulation times (sec.)						
Tracking mode	8	8	4	4	16	16
Storage mode 1	16	16	8	8	32	32

The HUS 2A sensor consists of 2 hemispherical CsI(Tl) scintillator cristals 3mm thick, optically coupled to 2 PM tubes. The effective area is about 20 cm2. In the absence of a flare, HUS2A has two waiting modes selectable by command. In mode 1, the Integral Count Rates (ICR sum of the two CsI detectors in the range 15-200 keV) are transmitted every 0.25 sec, in tracking mode (twice this value in storage mode 1). In mode two, the nominal mode for the mission, ICR are transmitted every 0.5s in tracking mode and, in addition, 4 channel energy spectra are transmitted everyach 8s (16s). The instrument switches automatically into burst mode when the count rate between 30 and 200 keV exceed a preset value during time intervals selectable by command between 0.125 and 2s. In this mode the time history of the flare is recorded with an integration time of about 8ms during 16s. These 16s begin 2 seconds prior to the trigger instant in order to keep the onset of the flare or a possible precursor. Energy spectra in 16 channels are also stored with 1s time resolution for 16s, 2s time resolution for 32s, and 16s time resolution for 448 seconds (total 8mn 16s). After the 32 kbit memory has been filled, the contents are sent to the telemetry. This burst readout mode lasts 34 mn in tracking mode. During this time count rates are transmitted every 0.5s in tracking mode. Then the experiment goes into a calibration mode. In this mode 32 spectra analysed in 32 channels are transmitted for each of the 2 CsI detectors

The two sensors (Si and CsI) are located on the radial boom of the spacecraft, in order to reduce the RTG background. After a launch in 1990, Ulysses will encounter Jupiter in 1992 and after a gravity assist maneuver will go out of the ecliptic to make 2 solar passes in 94 and 95 The total time spent at ecliptic latitudes more than +-70 degrees will be on the order of 230 days. As there is a shift in time between the maximum number of X-ray and optical flares, it is expected that Ulysses will record a large number of flares during its flight out of the ecliptic. Note that the overall mission takes place during the forthcoming solar maximum and that the experiment will work with almost 100

In addition of the normal data treatment of the experiment telemetry the PIs will have access to quick look data from selected data sets using a remote connection to JPL.

To conclude we mention (not exhaustively) two items for which the Ulysses contribution may be useful:

1. Multispacecraft observations: Ulysses (out of the ecliptic or far from the earth) may record a flare with an in-ecliptic spacecraft (e.g. GRO/BATSE or SOLAR A). This allows the determination of the direct of the emission or the height of the emitting region.
2. Ulysses data may be compared with data taken at other wavelengths from the earth, leading to useful correlations.

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