CDS/SUMER Joint Observations of High Velocity Events

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1 Scientific Justification

This program proposes to study high velocity or explosive events *simultaneously* at temperatures ranging from the lower transition region to the corona. It has been hypothesised that such high velocity events are caused by magnetic reconnection in the solar atmosphere. Whether or not this is the case, they may be important for the energy and momentum input to the upper solar atmosphere. Their unusual properties may furthermore give important clues to understanding the structures and processes in the upper solar atmosphere.

Explosive event is the term used for a high velocity phenomenon observed in the solar transition region, around T $\approx 10^5$K, using the C VI lines at 1550 A. Their known detailed properties are thus limited to their appearance in the lower transition region. Their properties are described by Moses and Cook (1994) and by Dere (1994) and more thoroughly in number of earlier papers (see references in Kjeldseth–Moe and Cheng 1994)

Similar high velocity events in the transition region and corona was observed with the slitless spectrograph SO82A on Skylab in 1973–74, in lines ranging in temperature from 10^4K (He I and He II lines) to the corona (i.e. the Fe XVI lines emitted at T $\approx$ 2.5 MK). Recent quantitative measurements have been performed by Kjeldseth–Moe and Cheng (see Kjeldseth–Moe and Cheng 1994, and references therein).

The main purpose of the proposed Joint Observing Program is to determine whether the energetic high velocity events observed in the corona and throughout the transition region constitute the same phenomenon as the explosive events, mainly observed in the C IV lines at 1550 A with the High Resolution Telescope and Spectrograph, HRTS.

The observations may furthermore:

- Map the energy and momentum release for high velocity events as functions of location, temperature and time, and
- Show whether the high velocity events may be explained by flows from a reconnecting region in a short magnetic loop.

References

Dere, K. P. 1994, *Space Science Reviews*, **70**, 21.

Kjeldseth–Moe, O. and Cheng, C.-C. 1994, *Space Science Reviews*, **70**, 85.

Moses, D. and Cook, J.W. 1994, *Space Science Reviews*, **70**, 81.

2 Operational Considerations

The observing sequences for CDS and SUMER are based on the observed properties of explosive and high velocity events as observed by HRTS and SO82A/Skylab. These are summarised in Table 1 below.

Table 1 Explosive Events and Coronal High Velocity Events

Properties	Explosive events	Coronal HVE
Average extent	$\approx$ 1500 km	$\approx$ 2500 km
Range in extent	$\approx$ 1000–3000 km	$\approx$ 2000–5000 km
Velocity dispersion average	$\approx$ 200 km s^{-1}	$\approx$ 400 km s^{-1}
Velocity dispersion range	$\approx$ 100–400 km s^{-1}	$\approx$ 200–1350 km s^{-1}
Average lifetime	$\tau \approx 40$ s	Uncertain, $\tau \approx 1$ min
Range in lifetime	$\tau < 20$ s to minutes	Not known
Lateral motion	$v_{Lat} < 20$ km s^{-1}	$v_{Lat} < 25$ km s^{-1}
Temperature range	$5{\cdot}10^4$K<T<$2{\cdot}10^5$K	$1{\cdot}10^5$K<T<$2.5{\cdot}10^6$K
Location in latitude	Extended, mid latitudes	Up to 60^o
Location rel. to features	Edges of magnetic regions	Both Q.R. and A.R

The operations consist of two phases both for CDS and SUMER: A *search* phase and a *study* phase. The initial pointing will be selected before the JOP is run, but it is most likely to be located at mid–latitude for initial runs of the program. The explosive events tend to be most frequent in regions with opposite magnetic fields, i.e in supergranulation network or regions with activity. Images from EIT, magnetograms from MDI and ground based observatories, and Ca II and H_α images may be used in selecting the area. It is thus important to have MDI and EIT images taken of a region of interest as close as possible to the start of the JOP.

In the *search* phase Both CDS and SUMER will start by scanning the same wide region to establish conditions prior to events. SUMER is asked to detect the high velocity event and send a flag with coordinates to be picked up by CDS. Both instruments will then initiate a *study* phase of a limited region including the high velocity event, with good time resolution to cover the time evolution. This study will run long enough to determine post–event conditions.

The SUMER study is limited to the strongest of the O VI resonance lines, the line at 1032 A, formed at $3{\cdot}10^5$K, while CDS observes lines formed throughout the transition region and corona. In the *study* phase the SUMER region is made small to get high time resolution, repeating the measurements every 22 seconds. CDS region is somewhat larger than the SUMER region to ensure co–pointing.

The SUMER raster i sufficiently brief to observe most high velocity events several times. The CDS raster is longer, 46 seconds. Together with the interval between reading of the flag, i.e. 16 seconds, and the time required to switch to the study phase, CDS should in most cases make at least *one* observation of each high velocity event during its life time ($\tau \approx 60$ seconds).

At the end of the JOP there may remain up to 27 minutes of SUMER data to be downlinked. It may not be necessary to transfer all these data, but the 3 last full *search* phase rasters should either be downlinked right away or stored for later downlink.

It should be possible to repeat the JOP several times, by re–starting the *search* phase after the end of the *study* phase until the end of a given total time for the program.

3 Study assumptions

The following explicit assumptions have been made for the JOP:

- Co-pointing of CDS and SUMER is possible to 10–15". Less accurate co–pointing may not render the program impossible, but it will have to be re–written.
- SUMER has on board software to detect the EE and may set a flag with coordinates to be read by CDS.
- CDS may read out its detector at positions that are differently centered along the slit in the *search* and *study* phases, respectively.
- It will not cause any difficulties to leave out registering reference areas on the CDS detector

4 Operational Sequences

SUMER Sequence for Search Phase

INITIAL POINTING	To pre-selected location
SLIT	1” $\times$ 120”
SCAN AREA	60” $\times$ 120”
STEP SIZE	1.14”
SCAN LOCATIONS	53
DWELL TIME	2 s
DURATION OF SCAN	106 s
NUMBER OF SCANS	Maximum 10
REPOINTING	None
TOTAL DURATION	Maximum 19 min + 27 min or less of data transmission from memory
LINE SELECTION	O VI (1031.912 A)
BINNING	Spatial: 1 px Spectral: 1 px
REFERENCE PIXEL	512
IMAGE FORMAT	50 px $\times$ 120”
COMPRESSION SCHEME	Bytescale: 16 bits to 8 bits
CO-OPERATION	CDS (IIF)

SUMER Sequence for Study Phase

INITIAL POINTING	At High Velocity Event from Search Phase
SLIT	1” $\times$ 120”
SCAN AREA	12.5” $\times$ 24”
STEP SIZE	1.14”
SCAN LOCATIONS	11
DWELL TIME	2 s
DURATION OF SCAN	22 s
NUMBER OF SCANS	15
REPOINTING	None
TOTAL DURATION	6 min
LINE SELECTION	O VI (1031.912 A)
BINNING	Spatial: 1 px Spectral 1 px
REFERENCE PIXEL	512
IMAGE FORMAT	50 px $\times$ 24”
COMPRESSION SCHEME	None
CO-OPERATION	CDS (IIF)

CDS Sequence for Search Phase

INITIAL POINTING	To pre-selected location
SPECTROMETER	Normal Incidence
RASTER AREA	60” $\times$ 120”
SLIT	2” $\times$ 240”
RASTER LOCATIONS	30
MIRROR/SLIT STEP SIZE	2”
DWELL TIME	15 s
DURATION OF RASTER	540 s or less
NUMBER OF RASTERS	2 or less
REPOINTING	None
TOTAL DURATION	1080 s or less
LINE SELECTION	O IV 554, Ne VI 562, He I 522, O III 599, O V 629, Mg VIII 315, Fe XIV 334, Fe XVI 360, Mg IX 368
BINS ACROSS LINE	21
EST. COMPR. FACTOR	16 bits to 12 bits
CO-OPERATION	SUMER (IIF)

CDS Sequence for Study Phase

INITIAL POINTING	To coordinates of IIF from SUMER
SPECTROMETER	Normal Incidence
RASTER AREA	20” $\times$ 30”
SLIT	2” $\times$ 240”
RASTER LOCATIONS	10
MIRROR/SLIT STEP SIZE	2”
DWELL TIME	3 s
DURATION OF RASTER	58 s
NUMBER OF RASTERS	6
REPOINTING	None
TOTAL DURATION	348 s
LINE SELECTION	O IV 554, Ne VI 562, He I 522, O III 599, O V 629, Mg VIII 315, Fe XIV 334, Fe XVI 360, Mg IX 368
BINS ACROSS LINE	21
EST. COMPR. FACTOR	16 bits to 12 bits
CO-OPERATION	SUMER (IIF)