CDS/SUMER Joint Observations of High Velocity Events

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1 Scientific Justification

This program will study high velocity or explosive events *simultaneously* at temperatures ranging from the lower transition region to the corona.

The term *explosive event* has been used for a high velocity phenomenon mainly studied in the C IV lines at 1550 A with HRTS. Their properties are described by Dere (1994) and by Moses and Cook (1994) and more thoroughly in number of earlier papers (see references in Kjeldseth–Moe and Cheng 1994). Detailed knowledge is, however, limited to their appearance in the lower transition region around T $\approx 10^5$K. Similar high velocity events at higher temperatures extending into the corona was observed with the slitless spectrograph SO82A on Skylab in 1973–74. Quantitative measurements have been performed by Kjeldseth–Moe and Cheng (see Kjeldseth–Moe and Cheng 1994, and references therein. See also the table below.)

The main purpose of the proposed Joint Observing Program is to determine whether the energetic high velocity events seen in the corona and upper transition region is the same phenomenon as the explosive events at T $\approx 10^5$K. The observations may furthermore:

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

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.

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 are based on the known properties of explosive and high velocity events by HRTS and SO82A/Skylab, respectively listed in the table.

Properties of 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

Explosive events occur frequently in the lower transition region and typically one event are seen in the SUMER slit (l=120") every few minutes. We will therefore co-point CDS and SUMER to the best possible accuracy, i.e. 10-15". SUMER will then run its POP08 while CDS performs a small raster, 20" wide. The initial pointing will be selected and is most likely to be located at mid–latitude for initial runs of the JOP.

In order to test the SUMER and CDS co-pointing we may run a 4' $\times$ 4' raster of the region surrounding the target area. For mapping CDS uses the sequence TEST6-1 and a similar survey is run by by SUMER. From these images the relative pointing of the two instruments may be estimated and adjusted to the required accuracy. Results from this initial phase, the mapping phase, may be used to:

1. Adjust the relative pointing of SUMER and CDS in near real time before continuing the programme
2. Check the exact co-pointing after the observations
3. Identify the positions of the super granule cell boundaries

Regarding the last point it should be noted that explosive events tend to be most frequent in the supergranulation network or regions with activity. It is therefore advantageous to have high resolution MDI and EIT images of the target region as close as possible to the start of the JOP as well as ground based Ca II and H_α.

After the mapping the search and study phase will commence, either right away or after a pause to check and adjust the co-pointing from the mapping. The SUMER POP08 will be performed in one of two lines, O IV 790 A or Si IV 1393 A emitted at $1.7 \cdot 10^5$K and $0.7 \cdot 10^5$K, respectively. CDS observes lines formed throughout the transition region and corona. When SUMER discovers an event the used part of the slit is shortened and centred on the event, and a small raster is initiated. This ensures spatial mapping of the explosive event feature while maintaining reasonable information on the time history of the event.

3 Operational Sequences

The operational sequences described include the mapping sequences for both instruments. These, albeit necessary, are *not* part of the high velocity event study.

Furthermore, in setting SUMER parameters we have only included one of the two alternate lines for the JOP, i.e. the Si IV 1393 A line. Using the O IV 790 A line will require some modification to entries of reference pixel and image format.

SUMER Sequence Mapping Phase

INITIAL POINTING	To pre-selected location
SLIT	1" $\times$ 300"
SCAN AREA	300" $\times$ 300"
STEP SIZE	1.14"
SCAN LOCATIONS	263
DWELL TIME	7.5 s
DURATION OF SCAN	33 min
NUMBER OF SCANS	1
REPOINTING	None
TOTAL DURATION	33 min
LINE SELECTION	Si IV 1393.755 A (or O IV 790.199 A)
BINNING	Spatial: 1 px Spectral: 1 px
REFERENCE PIXEL	700
IMAGE FORMAT	85 px $\times$ 360"
COMPRESSION SCHEME	Log
ROTATIONAL COMPENSATION	Off
CO-OPERATION	CDS

SUMER Sequence Search Phase -
POP08 Pre Event Trigger

INITIAL POINTING	Middle of previous raster/adjusted
SLIT	1" × 120"
SCAN AREA	Stationary
DWELL TIME	2 s
REPOINTING	None
TOTAL DURATION	Until trigger
LINE SELECTION	Si IV 1393.755 A (or O IV 790.199 A)
BINNING	Spatial: 1 px Spectral: 1 px
REFERENCE PIXEL	700
IMAGE FORMAT	85 px × 360"
COMPRESSION SCHEME	Log
ROTATIONAL COMPENSATION	Off
CO-OPERATION	CDS

SUMER Sequence Study Phase -
POP08 Post Event Trigger

INITIAL POINTING	Location of High Velocity Event
SLIT	1" × 120"
SCAN AREA	7.6" × 24"
STEP SIZE	0.76"
SCAN LOCATIONS	10
DWELL TIME	1 s
DURATION OF SCAN	10 s
NUMBER OF SCANS	At least 12
REPOINTING	None
TOTAL DURATION	2 min or more
LINE SELECTION	Si IV 1393.755 A (or O IV 790.199 A)
BINNING	Spatial: 1 px Spectral: 1 px
REFERENCE PIXEL	700
IMAGE FORMAT	85 px × 360"
COMPRESSION SCHEME	Log
ROTATIONAL COMPENSATION	Off
CO-OPERATION	CDS

CDS Sequence Mapping Phase - Same as TEST6-1

INITIAL POINTING	To pre-selected location
SPECTROMETER	Normal Incidence
RASTER AREA	240" × 240"
SLIT	2" × 240"
RASTER LOCATIONS	120
STEP (DX, DY)	2", 0"
DWELL TIME	30 s
DURATION OF RASTER	63 min
NUMBER OF RASTERS	1
REPOINTING	None
TOTAL DURATION	63 min
LINE SELECTION	Si XII 520.67, He I 537.030, Fe XIV 334.17, Fe XVI 335.41, Ne VI 562.8, Mg VI 349.16, He I 584.33, O III 599.60, Mg IX 368.06, Mg X 624.94, O V 629.73
BINS ACROSS LINE	15
EST. COMPR. FACTOR	No compression
CO-OPERATION	SUMER

CDS: Search/Study Phase - Same as O-HIVEL2

INITIAL POINTING	Middle of previous raster/adjusted
SPECTROMETER	Normal Incidence
RASTER AREA	20" × 60"
SLIT	4" × 240"
RASTER LOCATIONS	5
MIRROR/SLIT STEP SIZE	4"
DWELL TIME	6 s
DURATION OF RASTER	46 s
NUMBER OF RASTERS	TBD
REPOINTING	None
TOTAL DURATION	TBD
LINE SELECTION	He I 584.33, O IV 554.52, O V 629.73, Mg IX 368.06, Mg X 624.94, Fe XI 352.68, Fe XII 352.10, Fe XII 364.47, Fe XIV 334.17, Fe XVI 335.40
BINS ACROSS LINE	15
EST. COMPR. FACTOR	16 bits to 12 bits
CO-OPERATION	SUMER