SOHO Joint Observing Programme 08

EARTH DIRECTED CME STUDY

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Progress:

Draft Scheme	June 7 1994
Discussion at SPWG	June 14 1994
Detailed Plan	June 22 1994
Distributed to PI Teams	June 22 1994
Minor Revisions	November 4 1994
Revision	February 5, June 23 1995

Objective: To study the onset phase of coronal mass ejections on the disc, i.e. Earth-directed, and their signatures at L1.

Conditions Necessary to Run: Run when specifed target feature crosses E20. Minimum required instrumentation is CDS or SUMER and particle instruments.

Scientific Case: A Coronal Mass Ejection (CME) represents a significant restructuring of the solar corona. Some 10^{12}-10^{13} kg of matter can be expelled from the corona as a magnetic loop system, some tens of degrees across, expands into interplanetary space at speeds of several hundred km/s. Such events often involve prominence eruption and even flares, though the relationships are unclear. Also, soft X-ray brightenings within huge coronal loops have been associated with such events. Numerous models have been presented to explain the CME onset but we have very little information on the properties of the source magnetic structures, on the plasma within them and on the precise sequence of events leading to eruption. Studies of such structures as they erupt will not only allow us to predict the onsets of CMEs and understand their relationship to flare/prominence activity, they will pave the way to predicting geomagnetic activity since such activity is generated by CME- magnetospheric interaction.

Since mass ejection involves the eruption of hot (million degree) coronal plasma and cool (ten thousand degree) prominence material, with activity in the high corona, low corona and chromosphere, observations of this kind require a multidisciplinary approach, with large fields of view and a large temperature range.

This study is designed as a "first look" exercise, to be refined as we learn to view and study CME onsets. It homes in on events near disc centre, i.e. CMEs which are likely to be Earth- directed and, therefore, detected by the SOHO particle instruments and the Wind and Cluster particle and field detectors. Complementray to this study is the study for CME onsets using limb observations. The disadvantage of disc observations is that we are forced to use proxi data, such as a prominence disappearance, to identify the onset of a CME. Coronagraph observations will, in general, be unable to detect the CMEs in question.

Scheme: The basic method is for CDS, SUMER and EIT to monitor specific structures as they cross central meridian. In particular, we suggest that large, active prominences are suitable targets. Meanwhile, LASCO can provide 360 degree coverage in the hope that any ejection is seen as a halo event. The following points are taken into account:

- CMEs are huge - on average 45 heliographic degrees across at the solar limb. Thus, we need large fields of view.
- There are clear associations between CMEs and prominences and active regions. Such regions should be among our initial targets.
- Past studies suggest that temporal resolutions of order 5 arc minutes are appropriate.
- Since this is a sit-and-wait programme, the observing schemes are chosen to provide useful data in the event of no eruption.

Pointing and Target Selection:

A target should be chosen, such as a prominence or active region, which is at about E20. The programme should be run on that target for as much time as possible, i.e. about 6 or more hours per day, for the following 5-6 days until it is well beyond about W60. This range covers the events most likely connected to the Earth. Prime targets should be (i) large prominences (which can be identified in ground based H-alpha data), (ii) active regions which have recent history of activity (again, identified using ground based H-alpha data), (iii) prominences associated with regions of emerging magnetic flux (identified using H-alpha and magnetogram data), (iv) large active region interconnecting loops (identified using X-ray images - e.g. Yohkoh).

Operating Details:

- **CDS**

This scheme involves the largest field of view with a selection of lines appropriate for a wide temperature range. This should provide temperature, density, abundance, flow and morphological information over a large area in the CME source region. Note: Since we are summing across lines, lines are selected which are appropriately separated from surrounding lines. Mg and Fe ranges are used to cover the temperature range, with some density coverage.

Spectreometer: Normal incidence

Slit: 4x240 arcsecond, 4x4 arcmin field of view - i.e. 60 location raster 3 Sec exposure at each location Total duration = 357 sec (5.95 min) incl. overheads

Line Selection - Synoptic Line Selection [NIS]

Ion	Wavelength(Å)	LogTe	Comment
He I	584.33	4.3	cool, granulation, depleted in holes
Mg VI	349.13	5.6	
Mg VIII	313.73	5.9	
Mg IX	368.06	6.0	good for hole boundary/structure
Mg X	624.94	6.1	
Fe XI	369.16	6.1	
Fe XII	364.47	6.2	
Fe XII	338.26	6.2	density sensitive ratio w. 364.47
Fe XIII	320.80	6.2	
Fe XIII	318.14	6.2	density sensitive ratio w. 320.80
Fe XIV	334.17	6.3	
Fe XV	327.02	6.3	

Data Compression: Sum 11 pixels across each line. Telemetry = 12 lines x 120 pixels x 16 bits / 10000 = 2.3 Sec. No bottleneck.

CDS Study ID: EDCME

- **SUMER**

The SUMER operation includes one wavelength selection with a wide range of lines which complements the CDS selection. Particularly useful for flow and morphological study.

Slit: 1x300 arcsec slit

Raster area: 300x300 arcsec - centred on CDS field. 0.76 arcsec steps - 4 steps over 2 Sec - accumulate simultaneously. Total duration = 395 steps = 197.5 Sec per raster (3.3 min)

Line Selection - 1204-1244Å (Covers: H I Ly-alpha 1216Å, N V 1238Å, Fe XII 1242Å.)

- **EIT**

The EIT images will provide an overview of the CME source area and surrounding structures with images in each of four bands covering the target area.

Extract 8.32 x 8.32 arcmin field (6 x 6 blocks of 32 x 32 2.6 arcsec pixels) - centred on CDS field. 10:1 compression (2.5 arcsec) with all four bands Frequency - about 6 per hour.

- **LASCO**

The LASCO coronagraphs should concentrate on monitoring the 360 degree corona, looking for halo events, i.e. Earth-directed CMEs. The specific operational details are listed below:

C1 - Fe 5303Å green line. Images every 10 minutes.

C2 - White light images every 20 minutes.

C3 - White light images every 2 hours.

- **MDI**

MDI will provide magnetogram support during the operation. Standard resolution magnetograms of the limb area produced about 10 per day.

- **SWAN**

SWAN has the potential for detecting cooler material crossing the inner heliosphere, possibly the reminder of prominence eruptions.

The heliosphere near to the Sun should be monitored.

- **CELIAS, CEPAC**

This programme is geared toward Earth directed CMEs. Some events will interact with the Earth. Particle data should be monitored for such events, though this does not involve changes in the mode of operation of CELIAS or CEPAC.

Monitor solar wind for correlations with CME events.

- **Ground Based Instrumentation**

Ground based instrumentation is essential for identifying prominences, magnetic structure and, possibly the ejecta themselves.

The following data are required:

- H-alpha images of the full Sun and target region (e.g. Big Bear, the SOON network etc)
- H-alpha limb observations (e.g. Mauna Loa Solar Observatory, Wroclow Observatory)

- Coronal white light images (from Mauna Loa Solar Observatory, Hawaii)
- Magnetogram images (e.g. Marshall SFC, Beijing, the SOON network etc)

Notes:

- It is recognised that instruments on SOHO will be operating synoptic programmes which should not be interrupted and other pressures from target of opportunity operations will exist. Thus, although a single operation will last for 5-6 days, we may expect between 25 and 75% of the time dedicated to the CME Onset effort in that time.

- This programme should be run on a number of occasions to ensure reasonable observations of CME onsets.

- The programme described above is an initial attempt to detect and investigate CME onsets. Thus, the programme should develop with time. For example, at this time we cannot sensibly build in inter-instrument flags though their use could be envisaged at a latter time.