SOHO Joint Observing Programme 03

CME ONSET STUDY

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Progress:

Draft Scheme	February 15, June 6 1994
Discussion at SPWG	June 14 1994
Detailed Plan	June 22 1994
Distributed to PI Teams	June 22 1994
Minor Revisions	Nov 4, Nov 24 1994
Revision	February 5, June 23 1995
Revision	February 21, March 13, August 5 1996
First Run	October 5-13 1996
Update	October 16 1996

Objective: To study the onset phase of coronal mass ejections

Conditions Necessary to Run: Occurance of a suitable target region crossing W40 and involvement of at minimum CDS or SUMER and a coronagraph.

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 the limb, i.e. CMEs which are unlikely to be Earth- directed and, therefore, undetected by the SOHO particle instruments. Thus, in parallel, a CME study should be made for disc eruptions.

Scheme: The basic method is for CDS, SUMER and EIT to monitor specific structures as they approach and cross the west limb of the Sun. Meanwhile, LASCO and UVCS provide supporting data by concentrating on observations in the corona above. 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 5-10 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: Ideally, a target should be chosen, such as a prominence or active region, which is at about W40. 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 the limb. In the event that no target can be followed in this way, a suitable alternative would be a target such as a filament or prominence near or on the limb. 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.

Spectreometer: Normal incidence

Slit: 4x240 arcsecond, 4x4 arcmin field of view - i.e. 60 location raster 10 Sec exposure at each location

Line Selection -

Ion	Wavelength(Å)	LogTe	Comment
He I	584.33	4.3	cool, granulation, depleted in holes
O V	629.73	5.2	transition region
Si X	356.04	6.0	density sensitive with 347Å
Si X	347.40	6.0	density sensitive with 356Å
Mg IX	368.06	6.0	good for hole boundary/structure
Fe XVI	360.76	6.3	

Data Compression: To 12 bits. Note: The data can be supplemented with occasional runs of POBS1_2 to provide a greater spectral coverage of a region of the target area.

CDS Study ID: EJECT_V3

- **SUMER**

SUMER will run POP 25 - Principal operation is 234x300 arcsec raster using 1x300 arcsec slit covering Fe XII 1242, N V 1238 and C I 1266 A, taking about 3 min per raster.

This operation will be interspersed with smaller rasters as defined in the SUMER Red Book. ** SUMER Operation details to be confirmed. **

- **LASCO**

The LASCO synoptic operations should suffice for this operation, providing 360 degree images in C1,2,3 and full-Sun EIT data. Any extra opportunities should be used to slot in extra images ofthe corona overlying the target region.

- **EIT**

EIT 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.

- **UVCS**

The UVCS observation plan for JOP 03 is divided into three phases:

Phase I: Characterization of the corona above the selected prominence.

Field of view extending into corona above CDS/SUMER target area. 11 slit locations - between 1.5 and 5.0 solar radii - 1.5, 1.7, 1.9, 2.1, 2.3, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0. For the range 1.5 - 2.5R, line intensities and profiles of major lines are obtained, dwell time at each slit location = 1 hour. Above 2.5 R, profiles of H I Ly-alpha and intensities of other lines are obtained. The scientific aim of the observation is to derive outflow velocity from Doppler dimming of H I and O VI and to measure proton and OVI velocity distributions, electron temperature and density above the prominence or other target selected for the JOP. vskip 0.25cm Field of view - 14 arcsec x 40 arcmin slit (14 x 28 arcsec pixels)

Observed spectral lines OVI 1032/1037 Å, Fe XII 1242 Å, Mg X 610 Å, Ly-beta 1025 Å, Si XII 521/499 Å, N V 1238/1242 Å, Si III 1206 Å, S X 1196 Å, Ly-alpha 1216 Å and 4500-6000 Å polarized radiance.

Phase II: Near limb observation above the selected prominence.

Solar limb to 1.5 R. UVCS instrument is configured to observe at 1.5 R and then offset pointed towards the disc in 0.05 R increments to a height of 1.25 R. An exposure is taken at each height. Following completion, the OVI detector is turned off and offpointing of the instrument continues in 0.05 R increments until the solar limb is reached. This provides an image of the prominence in Ly-alpha.

Field of view - Ly-alpha - 7 arcsec x 40 arcmin slit (14 x 56 arcsec pixels) OVI - 7 arcsec x 40 arcmin slit (14 x 28 arcsec pixels)

Observed spectral lines - Si III 1206 Å, C II 1037 Å, Ly-alpha 1216 Å, Fe XII 1242 Å, N V 1238/1242 Å, OVI 1032/1037 Å, Mg X 610 Å, Si XII 499/521 Å, H I Ly-beta 1025 Å, polarized radiance 4500-6000 Å.

Phase III: Sit and Stare above the selected prominence.

One slit location above the prominence at 2.5 R. Dwell time up to 10 hours. The scientific aim to to observe a wide range of ionisation stages and to look for cool material and study its evolution in the corona. 100 sec. exposure time to have temporal resolution. Recorded lines are identical to the sit and stare observation.

Field of view - Ly-alpha - 14 arcsec x 40 arcmin slit (14 x 56 arcsec pixels) OVI - 84 arcsec x 40 arcmin slit (42 x 56 arcsec pixels)

Observed spectral lines - Fe XII 1242 Å, NV 1242/1238 Å, H I Ly-alpha 1216 Å, Si III 1206 Å, He I 537 Å, S IV 1062 Å, Si XII 499/521 Å, OVI 1032/1037, H I Ly β 1025 Å, C II 1037 Å, polarized radiance 4500-6000 Å.

- **MDI**

MDI will provide magnetogram support during the operation. Standard resolution magnetograms of the limb area produced about 10 per day so the basic synoptic programme should suffice.

- **SWAN**

SWAN has the potential for detecting cooler material crossing the inner heliosphere, possibly the reminder of prominence eruptions. Events should be examined in hindsight.

- **CELIAS, CEPAC**

Although this programme is geared toward non-Earth directed CMEs, some events will interact with the Earth, due to orientation, CME expansion or non-radial motion. Particle data should be monitored for such 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.

Inter Agency Consultative Group:

The IACG campaign on CMEs, their structure, development and evolution has discussed collaborative efforts which are centred on the above operation. The IACG plan complements the scheme by building in the following collaborations:

Yohkoh (launch 1991): The Soft X-ray Telescope (SXT) instrument should be used for the identification of potential CME source regions - e.g. large X-ray emitting loops. Also, Yohkoh should be included in the programme for the study of large scale X-ray structure and its evolution before during and after the CME onset. This extends on the spatial coverage available to SOHO. The Bent Crystal Spectrometer instrument, as well as the SXT and the Hard X-ray Telescope can be used also for the identification of flares associated with ejecta. Target selection will most likely be done in discussion with both the SOHO and Yohkoh teams.

Coronas (launch 1994/5): EUV and X-ray imagers and spectrometers are available on Coronas I/F which could complement the SOHO and Yohkoh operations. The launch dates and durations are not clear at this time.

TRACE (launch 1997): The Transition Region and Coronal Experiment is an Explorer class, small mission, designed to produce EUV/UV images in a variety of wavelengths. This would be very complementary to the SOHO spectroscopic observations in the same wavelengnth range. The launch date may be 1997.

GOES (on going series): The GOES X-ray integrated Sun devices will be used to study the global X-ray response and to identify flares. If the planned GOES X-ray imager becomes available, it can be used to identify and study large scale structure and its evolution as events progress.

GRO: The BATSE device on the Gamma Ray Observatory can be used to identify flare signatures which may be associated with CME onsets.

Other Space Borne Instruments: As with the GRO and GOES instruments, supplementary information on associated flares can be given by the Interball mission. Since the mission lifetime and launch date is uncertain, the collaboration must be driven on the basis of opportunity at the time of the programme. Further, the SWATH mission may have relevant instrumentation, though this is to be confirmed.

Other Ground Based Instruments: Beyond the devices mentioned above, the IACG concluded that our understanding of radio signatures of mass ejections is far from understood. Thus, it was suggested that a comprehensive radio campaign be included. This should include many observatories covering a wide range of wavelengths, particularly for the observation of prominences, type II and type IV events, as well as flare signatures.e.g.
Nobyama - cm wavelength imaging - especially relevant for prominence observations
Potsdam - 40-800 MHz sweeps plus single frequency obs: for type II, IV observations
Nancay - multifrequency radioheliograph
Owens Valley - microwave images of flare/CME sites.

The communication between the ground based and space based groups should be coordinated through the GSFC SOHO EOF/EAF.

Since the planned SOHO launch date is November 1995 and there is a 4 month cruise phase, followed by a month long period of commissioning, if we allow 2 months for familiarisation, the first chance for a campaign of this kind is about May/June 1996. To maximize the chance of Yohkoh being in operation at the time, we must start the campaigns as near to this time as possible.