JOP053: SUMER, CDS, EIT, MDI

Size & Brightness of Features in the Upper Solar Atmosphere

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Scientific Justification

In the solar photosphere magnetic and thermal structures show substantial power at small scales ($< 1''$). In the upper chromosphere the magnetic field is considerably more homogeneous (e.g., Harvey and Hall 1971, Rüedi et al. 1995) and covers the complete solar surface (e.g., Giovanelli 1980, Solanki & Steiner 1990). The size of features and their brightness does not scale correspondingly, with considerable small-scale structure seen at all but possibly the highest transition-region temperatures. For example, SUMER has already observed features with sizes lying at the limit of its resolution (Lemaire et al. 1996). In addition, there is strong if indirect evidence for even much smaller scale structure (well below the spatial resolution of SUMER) in the transition region (e.g. Kjeldseth–Moe 1989). We propose to record the size, location and brightness of individual features at different temperatures and to reconstruct their geometry as far as possible therefrom. Although it is possible to determine filling factors of the radiating plasma using other means, the spatial distribution of emission can be mapped only by direct imaging. This geometry should provide constraints on the heating mechanism. Also, by observing at different distances from the limb a more accurate estimate of the centre-to-limb variation of the intensity in small-scale features is to be obtained.

In the absence of seeing the MTF of the telescope and the pixel size (or the composite of slit width and scan step in the direction perpendicular to the slit) set the main limitations on the achievable spatial resolution. By deconvolving the known or estimated effective MTF (of telescope, spectrograph slit and pixels) from the signal it is possible to partially overcome this limitation. We propose to deconvolve images (initially at a single, possibly averaged wavelength) obtained by SUMER, CDS and EIT in order to obtain a better estimate of size and brightness of small-scale features. SUMER and CDS images are to be constructed by stepping the slit over the solar surface (rastering mode). In order to obtain maximum resolution, at least in the direction perpendicular to the slit the narrowest SUMER and CDS slits and smallest scanning step sizes are to be chosen.

The deconvolution is to be carried out using various techniques, including recently developed wavelet-based techniques.

Since SUMER and CDS can record more than 1 spectral line simultaneously it is in principle possible to construct deconvolved maps in multiple spectral lines and to form line ratios at the new, improved spatial resolution.

In the case of SUMER the deconvolution can be carried out at every sampled wavelength in the line, thus allowing full line profiles to be reconstructed at the higher resolution. This means that it should also be possible to construct deconvolved maps of bulk and turbulent velocity. Except for the strongest lines in bright plage the line wings will, however, probably not be well reconstructed due to their low brightness.

We propose to use magnetograms to help with the interpretation of the data. They should help determine the nature of the small-scale structures seen in the SOHO data and their association with photospheric magnetic fields.

References

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Observing program

SUMER and CDS images are to be constructed by stepping the slit over the solar surface (rastering mode). In order to obtain maximum resolution the narrowest SUMER and CDS slits and smallest scanning step sizes are to be chosen. Since deconvolutions are more successful when the S/N is larger we plan to observe in relatively bright spectral lines. Smoothing in the spectral direction may also be employed to enhance S/N.

The observations are to be carried out during SOHO contact time, with the spacecraft in a dynamically quiet mode (jitter amplitudes and frequencies are to be recorded).

Ideal time for observations: last week of November 1996. If this is not possible, then in the first two weeks of December 1996.

Note that times and durations given below are very rough estimates.

SUMER observing sequence

Initial pointing:	To pre-selected locations
Slit:	0.3×120 arc sec^2 (slit 7)
Step size:	0.38 arc sec
Length of scan:	120 arc sec
Raster location:	316
Pixels per spectral line:	120×25
Compression:	16 bits $\rightarrow$ 12 bits
Number of rasters :	7 per spatial location
Solar rotation compensations :	yes
Co-operation requirements :	CDS (IIF), MDI (IIF)

Raster 1:

Spectral lines :	O VI 1031.9 Å, Ly β 1025.7 Å
Dwell time :	5 sec (quiet sun), 1 sec (active region)
Duration of raster :	30 min. (quiet sun), 6 min. (active region)

Raster 2:

Spectral lines :	O I 1302.2 Å, O I 1304.4 Å, O I 1306.6 Å
Dwell time :	5 sec (quiet sun), 1 sec (active region)
Duration of raster :	30 min. (quiet sun), 6 min. (active region)

Raster 3:

Spectral lines :	C III 977.0 Å
Dwell time :	2 sec (quiet sun), 1 sec (active region)
Duration of raster :	12 min. (quiet sun), 6 min. (active region)

Raster 4:

Spectral lines :	N V 1238.8 Å, Fe XII 1242.0 Å, N V 1242.8 Å, Mg X 609.8 Å, Mg 624.9 Å
Dwell time :	20 sec (only active region)
Duration of raster :	2 h

Raster 5:

Spectral lines :	Ly β 1025.7 Å, O VI 1031.9 Å
Dwell time :	10 sec (active region only)
Duration of raster :	1 h

Raster 6:

Spectral lines :	C III 977.0 Å
Dwell time :	5 sec but 1×120" slit (quiet and active sun)
Duration of raster :	12 min

Raster 7:

Spectral lines :	Ly β 1025.7 Å, O VI 1031.9 Å
Dwell time :	10 sec but with 1×120" slit (active region only)
Duration of raster :	12 min

After this set of 7 rasters the slit is moved to another location and the procedure is repeated in the following order.
1st set: Quiet sun disk centre,
2nd set: start 100" inside limb and scan for 120" towards limb,
3rd set: start 240" inside limb and scan for 120" towards limb,
4th set: start 400" inside limb and scan for 120" towards limb,
5th set: active region.
If possible repeat in active regions at different distances from the limb. Total time for all rasters
quiet sun: 4×1.5h = 6h.
Active region (one location): 4h.
Minimum time requirements: 14h (set by CDS+SUMER).
If SUMER is finished and CDS is still scanning then repeat the shorter scans until CDS finishes. Move to next location once CDS and SUMER are both finished.

CDS observing sequence

Initial pointing	To coordinates of IIF from SUMER
Spectrometer	NIS
Slit	2×240 arc sec^2
Raster area	120×240 arc sec^2
Step size	1.016 arc sec (if possible, else 2.032 arc sec)
Number of raster steps	120
Number of rasters:	3 per spatial location
Pixels per line	21×240
Compression:	16 bits $\rightarrow$ 12 bits

Raster 1:

Spectral lines :	O IV 554.5 Å
Integration time :	10 sec (quiet and active sun)
Duration of raster :	20 min.

Raster 2:

Spectral lines :	He I 584.3 Å
Integration time :	5 sec (quiet and active sun)
Duration of raster :	10 min.

Raster 3:

Spectral lines :	He I 584.3 Å, O IV 554.5 Å, O V 629.7 Å, Mg IX 368.1 Å, Fe XIV 334.2Å
Integration time :	60 sec (quiet and active sun)
Duration of raster :	2 h

Total time required for all rasters
quiet sun: 4×2.5h = 10h
active sun (one location): 2.5h
Minimum time requirements: 14h (set by CDS+SUMER).
After all rasters have been made for one region, and SUMER is not yet finished with its set of 7 rasters, then repeat the short rasters until SUMER is finished. When SUMER and CDS are both finished the slit is moved to the other region and the observations are continued there. Ordering of the regions to be studied: same as for SUMER.

EIT:

Regular images of the solar surface obtained by EIT are to be used. If S/N in the normal images is not sufficiently high a longer integration time may be useful.

MDI:

Magnetograms at *high resolution* (i.e. 1.2" resolution) of the regions observed by SUMER and CDS would be of *great* advantage. The higher the cadence the better. One magnetogram per SUMER or CDS scan would be satisfactory, or alternatively one magnetogram per hour. Co-operation requirements: SUMER (IIF)