FINE-STRUCTURES AND DYNAMICS OF A FILAMENT IN EUV LINES: SOHO/CDS and SUMER, TRACE

B. Schmieder 1, 2, O. Engvold3, J.E. Wiik1, E. DeLuca 3
1 Institute of Theoretical Astrophysics, P.O. Box 1029, Blindern, N-0315 Oslo, Norway
2 Observatoire de Paris, Section Meudon, F-92195 Meudon Principal Cedex, France
3 Smithsonian Astrophysical Observatory, 60 Garden Street MS 58, Cambridge, MA 02138, USA

ABSTRACT

During the June 1998 MEDOC campaign, a polar crown filament was followed during 4 days from June 18 until its eruption on June 21.

The paper presents the fine structure and dynamics from observations in Hα, using the Swedish Vacuum Solar Tower (SVST) telescope at La Palma, and in the coronal Fe IX/X 171Å line with TRACE. The filament was in addition observed over a wide range of temperatures with the spectographs aboard SOHO - CDS and SUMER. These observations allow us to derive the velocity field of the filament and its environment. Preliminary results are presented.

1. Introduction

Recent magnetic models of filament have been proposed to explain the support of dense cool material in the high corona and the connection of filaments with the chromosphere (feet or barsbs) (Aulanier and Démoulin 1998; MacKay et al. 1999). They introduce in a bipolar background, respectively a flux rope or a high density current to represent the main body of the prominence. The feet are related directly to the mixed magnetic polarities existing in the channel. Schmieder et al. (1991) and Zirker et al. (1998) have observed highly dynamical plasma of mixed, opposite directions, which appears to be associated with closely spaced fine structures. These findings may be interpreted as field aligned flows (Zirker et al., 1998).

Recent multi-wavelength observations offer the opportunity to study the dynamical behavior of the plasma at different temperatures in order to understand the environment of the filament and the nature of support. The use of CDS and SUMER spectrometers aboard SOHO provide such possibilities.

2. Observations of June 19 1998

A southern polar crown filament was observed at La Palma between June 18 and June 21 1998 (Fig. 1)

(Cengvold et al. 1999). TRACE was following this target and observed its slow eruption on the night of 21 June. In the days preceding of the DB the filament was rising slowly and reaching an altitude of about \( \sim 110 \, 000 \, \text{km} \) before its disappearance (Fig. 2).

The main objective of this paper is to present the filament observations obtained with the two spectrometers of SOHO; SUMER and CDS, and compare the small-scale dynamics with data from TRACE and Hα from the SVST. CDS was rastering part of the filament. The SUMER slit was also positioned to cross the field-of-view of CDS and it was set to observe some of the lines in the hydrogen Lyman series.

2.1 Observations with CDS and in Hα

CDS was observing the filament and its channel (at heliographic positions around 45° 28E) between 06:45 UT and 09:30 UT. Five rasters (240 x 120 arc sec) of the region were obtained in 6 lines: He I (584.33Å; 2000K), He II (607.63Å; 5 x 10^4), O IV (554.51Å; 2 x 10^5K), O V (629.75Å; 2 x 10^5K), Ne VI (582.77Å; 4 x 10^5K), Mg IX (368.06Å; 1MK).

We identify the bright regions in the upper part of the CDS field-of-view with positive polarities in the SOHO/MDI magnetogram which correspond to the network or some plage regions located along the northern edge of the channel. The southern edge corresponds to negative polarities which appear very weak in the longitudinal magnetic field map due to the high latitude location of the filament.

Between the two edges some very weak mixed polarities are observed which possibly could be related to the presence of filament bars or feet (Martin 1990; Aulanier et al. 1998). It is remembered that the present filament is situated very high in the corona (see above) and bars are barely observable the Hα observations from La Palma. Possible locations of bars is not obvious from the CDS scans in O V shown in Figure 3. One weakly developed bar seen in Hα (La Palma) is, regrettably, outside the field-of-view of the CDS frames.

The main body of "cold" plasma seen Hα is also clearly recognized in O V (Fig. 3). The appearance
Figure 1. Polar crown filament observed in Hα on June 19 1998 by the SVST telescope in LaPalma (100 × 250′): (a) filament observed in Hα line center at 07:50:31 UT, (b) Doppler image derived from nearly simultaneous images recorded in Hα ± 0.25Å. The North is more or less oriented towards the bottom of the image.

Figure 2. Polar crown filament observed with TRACE at 171Å (left panel) on June 19 1998, (right panel) on June 21 1998. The filament is below the filament channel because of perspective effects. The channel is dark because of lack of the coronal line emission, the filament because of the absorption of the coronal line by the cool plasma. North is up.

Figure 3. CDS intensity, Dopplershift and line width of the fine structures in the filament channel in O V (image center at -300, -700′′) on 19 June 1998 at 07:27 UT (left panel) and at 07:49 UT (right panel)
Table 1. Characteristics of Lyman lines in the filament channel and on the disk (SUMER data) in unit $10^{-10}$ erg/s/cm$^2$/str/Hz ($I_0$ is the central intensity, $I_p$ the peak intensity).

<table>
<thead>
<tr>
<th>Lines</th>
<th>filament structures:</th>
<th>explosive</th>
<th>jet</th>
<th>disk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$I_0$</td>
<td>$I_p$</td>
<td>$I_0$</td>
<td>$I_p$</td>
</tr>
<tr>
<td>L4</td>
<td>0.20-0.4</td>
<td>0.40-0.5</td>
<td>0.5</td>
<td>1.3</td>
</tr>
<tr>
<td>L5</td>
<td>0.18-0.3</td>
<td>0.25-0.33</td>
<td>0.4</td>
<td>0.6</td>
</tr>
<tr>
<td>L6</td>
<td>0.09-0.2</td>
<td>0.17-0.25</td>
<td>0.3</td>
<td>0.5</td>
</tr>
<tr>
<td>L7</td>
<td>0.09-0.17</td>
<td>0.14-0.18</td>
<td>0.3</td>
<td>0.4</td>
</tr>
</tbody>
</table>

of the low intensity features in He I and O V could suggest that we are here observing the Prominence Corona Transition Region (P-CTR), rather than a presumed broader and more diffuse coronal cavity. It shall be pointed out, however, that the dark filament structures seen in transition-region and coronal lines in the EUV may, alternatively, be caused by absorption of neutral hydrogen in the hydrogen Lyman continuum (Kucera, Andretta, Poland 1998; Engvold et al. 1999). This view agrees with earlier observations with SMM/UVSP (see Schmieder 1989, and references therein) which hardly showed any brightness signature of filaments in the C IV 1548A line (at the long wavelength side of the hydrogen Lyman continuum).

In He I and O V lines one observes the characteristic fine structures of filaments/prominences, which in the present case are oriented SE-NW. Their endpoints occasionally seem to point to small, bright elements, but the significance of this possible association remains open. In the TRACE map at 171 A one also notices fine bright structures with similar orientation, and some of them also appear to be anchored in bright points, possibly belonging to the network (see the right side of the raster, close to the northern edge of the filament channel). These structures could possibly correspond to low parts of loops. The thread-like structures in the CDS raster-frames are changing from one frame to the next, but somewhat less quickly than observed in the noticeably higher resolution of the Hα images from La Palma.

Time lapse movies of the Hα observations from La Palma show appreciable horizontal motions of speeds typically 10-15 km s$^{-1}$ (Engvold, Zirker and Martin, 1999). The vertical (line-of-sight) velocities are about a factor of three less (see also Doppler images in Figure 1 b). We have not been able to derive transverse velocities from the CDS data, but the Doppler line-of-sight velocities appear significantly higher (~15 km s$^{-1}$) than derived form the cooler gas in Hα. The dark filament structures seen in the right-hand parts of the frames shows largely red shifts (downwards motion). The middle and left-hand side shows both blue and red shifts, side by side, as earlier seen in observations with the SMM/UVSP. In the event that the apparent filament absorption in the transition-region lines is due to "cold" hydrogen continuum one should not expect to observe any variation in the Doppler signals, in which case a P-CTR line emission may be subject to severe absorption. Alternatively, some of the observed shifts could also be due to instrumental effects, as discussed by Haugan (1999). Hence, the question of Doppler signals and dynamics of this "19 June" filament remains open. Implications of a "cold" continuum must be studied further.

2.2 SUMER.

The SUMER spectrometer on board SOHO is fully described in Wilhelm et al. (1997). The SUMER slit crossed the filament between 05:10 UT and 10:23 UT with a 40 A wide window centered on the Lyman lines L0 to L-9, S VI (944.5 Å, 933.4 Å). The slit was at a fixed position (-350, -696). We get a series of 281 spectra, each with an exposure time of 60 sec (Figs. 4). The filament profiles of Lyman lines (L0 and L-5) show two peaks as it was already observed (Schmieder et al. 1998), the higher order lines also show a weak reversal. The profiles are slightly asymmetric, which may be interpreted as flows of plasma in filament structures. It would be interesting to compare with the Doppler shifts observed with CDS such a comparison requires a non-LTE modeling of Lyman lines (see discussion in Schmieder et al. 1998).

The characteristics of the Lyman line profiles are shown in Table 1 and Figures 5. On the disk the profiles have no reversal. The disk intensities are comparable with the disk-averaged values of Warren, Mariska and Wilhelm (1998), slightly higher. Depending of the thickness of the filament the ratio $I_p/I_0$ ($I_0$ is the central intensity, $I_p$ the peak intensity) of lines observed in the filament is between 1 and 2. In the filament channel we observed frequently active events: a jet at 08:00 UT in UV lines, an explosive event between 07:00 and 07:15 UT. The jet exhibits a strong blue shift in S VI line (0.5 Å) and a large blue peak in Lyman lines. The explosive event has broadened profiles with high intensity peaks. The central intensity is comparable to the disk value, but the peaks are asymmetric and have intensity reaching the double of $I_0$ (disk).

These two active events are not really detectable in the CDS raster. The explosive event lasts 15 min., the jet few minutes so that is certainly the reason.

3. Conclusion

A possible interpretation of fine structures observed in UV lines (CDS) could correspond to heating at transition region temperature, and even at coronal temperature of the loop leg plasma of the arcade overlaying the filament. This idea has been already proposed for filament observed in Si IV with SUMER. The extrapolation of the magnetic field from photospheric observations confirmed the existence of magnetic lines in the same directions as the ones we
had observed (Kucera et al. 1999). One observes noticeably lower Doppler shifts in the ground-based high-resolution Hα images from La Palma than in the transition region line of O V from SOHO/CDS. A possible contribution from "cool" hydrogen continuum absorption in the transition-region lines observed with the CDS, must to be investigated further before firm conclusions can be drawn about the nature of the velocity in the P-CTR, and variation of line-of-sight velocities with temperature of the gas.

In the filament channel strong broadenings of the lines observed by SUMER were identified to a jet or an explosive event. That suggests the frequent occurrence of emerging/cancelling flux, even in a low magnetic flux region existence (near the inversion magnetic field line).

Acknowledgments:

The SUMER project is financially supported by DLR, CNES, NASA and PRODEX. SUMER is part of SOHO the Solar and Heliospheric Observatory of ESA and NASA. These observations have been obtained during a MEDOC (Orsay) campaign. O.E. is grateful for invaluable support from the staff of the SVST/La Palma during the observing campaign of June 1998.

REFERENCES


Schmieder B.: 1989, in Dynamics and structures of Quiescent prominences (Ed., E.R. Priest), Kluwer Academic Publisher. p. 15


Figure 5. Profiles of L-4 and S VI in an explosive event, a jet, a filament and on the disk.