SPECTRAL DIAGNOSTICS OF THE MAGNETIC FIELD ORIENTATION IN A ROUND-SHAPED FILAMENT

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ABSTRACT

During several campaigns focused on prominences we have obtained coordinated spectral observations from the ground and from space. The SOHO/SUMER spectrometer allows us to observe, among others, the whole Lyman series of hydrogen, while the Hα line was observed by the MSDP spectrograph at the VTT. For Lyman lines, the non-LTE radiative-transfer computations have shown the importance of the prominence-corona transition region (PCTR) and its relation to the magnetic field orientation for the explanation of the observed line profiles (Schmieder et al. 1998, Heinzel et al. 2001). Moreover, Heinzel and Anzer (2001) developed new 2D models which demonstrate how the shapes of Lyman lines vary depending on the orientation of the magnetic field with respect to the line of sight. To confirm this result observationally, we focus here on a round-shaped filament observed during three days as it was crossing the limb. The Lyman profiles observed on the limb are different from day to day and we interpret these differences by the change of orientation of the prominence axis (and therefore the magnetic field direction) with respect to the line-of-sight.

Key words: Filament, hydrogen Lyman lines, solar magnetic field.

1. OBSERVATIONS OF THE FILAMENT

The filament/prominence used for this study was observed from October 15 to 17, 1999 (N45°-55°, W50°-90°), as a target of the MEDOC coordinated campaign between SOHO and ground-based instruments. A filament with a round shape was observed during 3 days before crossing the limb. We concentrate our study on the observations obtained mainly with the SUMER spectrometer and in addition we used observations made with the Multi-channel Subtractive Double Pass spectrograph (MSDP) operating on the german solar telescope VTT in Tenerife. The VTT observations are presented in Figure 1 and Figure 2 shows the MEDOC spectroheliograms and SOHO/EIT at 304 Å. High-constrain spectroheliograms of Big Bear give a 3D view of the fine structure of the filament on October 14 and October 15. On October 14 we see the full structure before it reaches the limb. The foreward part F1 (located at N50°) is observed as a prominence on October 15. The south part F2 is lying along the parallel at N45° and is integrated along the line-of-sight as a prominence observed in Hα (VTT). On October 16 we see

Figure 1. Prominences observed on October 15 at 11:47 UT, on October 16 at 11:37 UT, and on October 17 1999 at 11:37 UT with the MSDP at the VTT. The arrows indicate approximately the central position of the SUMER slit and give the north direction. The field-of-view is 228 × 100 arcsec.
Figure 2. Observations of a round-shape filament/prominence (F1, F2, F3, F4) from October 13 to October 17 1999: in the left column, from Meudon in Hα with superposed heliographic coordinates grids, and in Ca K3 line for Oct 17 (notice the eruption of the prominence at 08:26 UT); in the right column are presented one observation with SOHO/EIT at 304 Å at 07:19 UT (top panel) and the observations in Hα obtained at Big Bear around 16 UT. Notice the round-shape channel in the He II 304 EIT image. The arrows followed by numbers point the latitudes N40°, N30° and N60°.
a long prominence extended along 10⁸ on the limb which should correspond to F2, F3 and F4. The feet of the prominence are still on the disk (Fig. 1). The F3 section is visible at high altitudes on October 17 at 08:26 UT (see the Melon spectroheliogram in Fig. 2). According to the coordinates of the filament F3 on October 14 (W53°), the F3 prominence on October 17 has already crossed the limb. Later on October 17, only the north part F4 (N55°) is still observable as a prominence in Big Bear.

2. LYMAN LINES

SUMER observed the Lyman line series using two wavelength ranges, one centered on Lβ and the other on the higher lines in the series (L4/Lα, L5/Lc..). For the context the rasters were performed in L4 (949.74 Å) and in SVI line (944.54 Å) scanning the region of the filament/prominence at the beginning and end of the sequences of observations. The observations were performed for October 15, 16 and 17 using 75 spectra separated by a step of 1.5 arcsec (Fig. 3). Below each raster we present 4 spectra as examples of prominence spectra. On October 15, L4 is weak in the prominence and the profile is reversed except in the spectra corresponding to the right side of the raster when the prominence is more important with some ejected bubbles. On October 16 all the profiles are reversed while on October 17 they are not reversed. We notice that the spectra of the raster on October 15 are not as noisy as on October 16 and 17 because the observations were done with the largest slit (1 arcsec). Figure 4 shows typical examples of Lyman line profiles (Lβ, Lδ, Lc, L5, L7) for the three days. Recent studies of non-LTE radiative transfer have shown the importance of the prominence-corona transition-region (PCTR) to explain the profiles of the Lyman line series observed by SUMER spectrometer aboard SOHO (Schmieder et al 1998, Heinzel et al 1997, 2001). Heintzel and Anzer (2001) developed two dimensional magneto-hydrostatic models with a multi-level transfer approach and computed profiles of Lyman lines for different configurations of the PCTR. They show that the Lyman β and higher lines are more reversed if the line-of-sight is crossing the field line and are in emission when the structure is viewed along field lines.

3. CONCLUSION

We relate the different shapes of the Lyman lines to the geometry that we can deduce from the observations. On October 15 and 16 the prominence, parts F1 and F3 respectively, has still its feet on the disk, both of them are oriented along a North-South meridian and the prominence corresponds to the top of an arch which seems to be in the plane of sky. On October 17 the prominence, parts F2 and F3, has crossed the limb and it is not in the disk plane but far behind with some inclination. The line-of-sight integrates the filament F4 (end of F3) along its axis. Because the prominence is already crossing the limb, the line-of-sight integrates the radiation through two segments of the filament making a sharp angle between them. In the prominence, reversed profiles are visible on October 15, on October 16 but not on October 17. The reversed profiles are interpreted as due to a perpendicular orientation of magnetic field relative to the line-of-sight. Reversed profiles correspond to the top of the prominence when the fine structure is in the plane of sky, thus the PCTR is thin. Non-reversed profiles correspond to a long portion of prominence integrated along the line-of-sight. The PCTR is thicker in that case. This is in agreement with the non-LTE computations in 2 D made by Heintzel and Anzer (2001).

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Figure 4. Examples of $\mathrm{L\beta}$, $\mathrm{L\delta}$, $\mathrm{L\epsilon}$, $\mathrm{L\gamma}$, $\mathrm{L\delta}$, $\mathrm{L\beta}$ profiles in the prominences averaged over a large number of pixels along the slit (15 to 20 arcsec) (continuous line) and a blob (dashed line) observed on October 15, 16, 17 1999. On October 15 the $\mathrm{He\ II}$ line in the wing of $\mathrm{L\delta}$ is very strong but this can be an observational artefact. The numbers indicated in each panel correspond to the integrated intensity values.