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Plasma Parameters of a Prominence Observed on October 16/17 1999 by SUMER and CDS/SOHO

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Abstract. The aim of the present study is to confirm and enrich the results obtained so far on dynamics and diagnostics of solar prominences. A prominence observed on October 16/17, 1999 in the frame of the updated JOP09 was studied. A density diagnostics was made on the basis of the line intensity ratio O IV 1401/1404. The Doppler velocities were derived using SUMER Si IV, O IV and CDS O V 629.73 Å lines.

1. Introduction

The solar prominences, about one hundred times cooler and denser than the surrounding corona, are one of the most puzzling events observed on the Sun (Tandberg-Hanssen 1995). Our knowledge about their plasma parameters and especially the prominence electron density is still quite uncertain mainly because of the prominence filamentary structure. Wiik et al. (1997) using the intensity ratio O IV 1401.16/1399.76 (SUMER) derived N_e of the prominence-corona transition region (PCTR) in the range 3×10^9 to 3×10^{11} cm^{-3}. Madjarska et al. (1999) by the intensity ratio O IV 1401.16/1404.81 obtained $N_e \sim 1.3 \times 10^9$ - 1.4×10^{10} cm^{-3}. The aim of the present study is to provide additional information on prominence diagnostics.

2. Observational material

The SUMER and CDS observations were obtained simultaneously on October 16 and 17, 1999 during MEDOC Campaign # 4 in the frame of JOP09. The CDS observations (Harrison et al. 1995) were obtained with detectors NIS with a slit $4'' \times 240''$ and raster size $240'' \times 240''$ pointing at coordinates $X = 727''$ and $Y = 694''$ between 19:18 UT and 23:36 UT.

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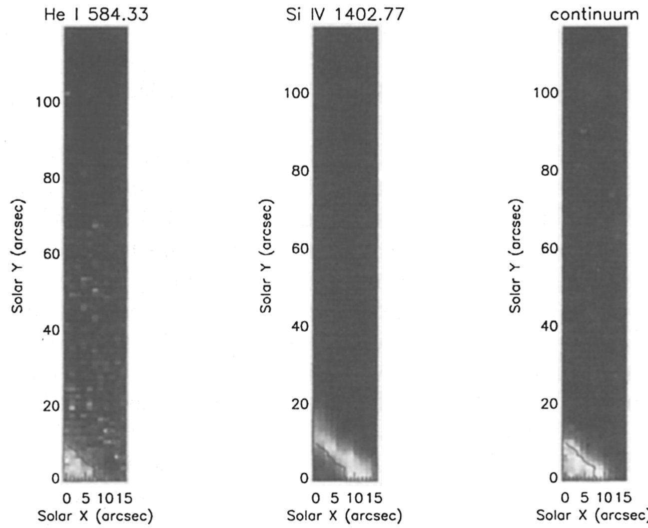

Figure 1. Intensity maps in He I 584.33, Si IV 1402.77 lines and continuum 1400 Å. The contour overploting the images in the Si IV line and continuum is rescaled in order to obtain the limb position as it is defined in He I line.

The SUMER (Wilhelm et al. 1997) data consist of: one raster in He I 584.33 Å, obtained with an exposure time of 6 s (19:00 UT - 19:05 UT), followed by one raster with a full spectrum centered on the Si IV 1402.77 Å line (19:06 UT - 19:26 UT), and a temporal series of 234 full spectra centered on the Si IV 1402.77 Å line, obtained exposing 100 s (19:55 UT - 02:55 UT). During all observations a slit $0.3'' \times 120''$ was used centered at coordinates $X = 727''$ and $Y = 694''$. Three spectral lines Si IV 1402.77 Å and O IV 1401.16 Å, 1404.81 Å were selected from the full spectrum and analyzed in the present study.

In order to study the problem of prominence material identification along the SUMER slit during temporal series, a context raster has been registered in He I 584.33 Å followed by a smaller raster with a full spectrum centered on Si IV 1402.77 Å. The analysis shows that two important corrections should be made in order to align images taken in different wavelengths: the magnification factor which makes the slit projected on the detector different for different reference wavelengths and the vertical displacement of the slit image as a function of the wavelength. As well as it is obvious from Fig. 1 that the limb brightening observed in the optically thin lines (Si IV, O IV) gives to the image a completely different appearance compared to the He I image (an optically thick line), which also should be taken into consideration.

3. Results and discussion

One of the methods of electron density determination uses the intensity ratio of lines emitted by one and the same ion. This method provides the value of the electron density without taking into account the size of the emitting volume, element abundance value or ionization degree (Mason and Monsignori Fossi 1994).

In the UV spectral range registered by SUMER density sensitive ratios such as O IV 1401/1399, 1401/1404 and 1401/1407 can be used. Unfortunately, each of these lines has certain blends. The O IV 1399.78 is blended in the red wing by a still unknown line; O IV 1404.81 is blended by two lines, S IV 1404.88 and the second order line O III 702.34; O IV 1407.38 - by O III 703.85 (second order).

The line intensity ratio O IV 1401/1404 was used to derive the electron density of the PCTR. The contribution of S IV 1404.88 (5%) and O III 702.34 (18%) was subtracted from the feature at λ 1404.81 Å (see Madjarska et al. 1999, Judge et al. 1998). The mean electron density value obtained is $7.65 \pm 0.24 \times 10^9$ cm^{-3}, which corresponds to an electron pressure of 0.18 dyn cm^{-3}.

The Doppler velocities were derived in PCTR ranging from -2 $\pm$ 1 to -7 $\pm$ 3 km s^{-1} (blueshift in O IV 1401.16) and from -2 $\pm$ 1 to -8 $\pm$ 3 km s^{-1} (blueshift in Si IV 1402.77). The solar disk was used to obtain the reference wavelength. The values remain in the same range during all the observations.

The CDS Doppler velocity maps were obtained in O V 629.76 Å for each raster and each pixel taking the quiet sun as a reference wavelength. We distinguish two regions in the prominence: a northern one with an average velocity equal to -24 km s^{-1} and varying with time from -28 up to -20 km s^{-1}; a southern one with an average velocity equal to -3 km s^{-1}, and varying with time from -6 up to +1 km s^{-1}. These values correspond to the amplitudes of the velocity values obtained with SUMER in O IV and Si IV lines.

4. Conclusions

Three effects should be taken into account when a prominence material is identified aligning slits obtained at different wavelengths: instrumental - magnification and vertical displacement, and solar - limb brightening in optically thin lines. The intensity ratio of O IV 1401/1399 was found useless because of an unknown blend in the red wing at λ 1399 Å. The prominence shows velocities which correspond to horizontal motions of elongated structures. During the observations, the prominence does not show any significant structure changes, a fact which is confirmed by the constant temporal velocity evolution.

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