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Properties of the base of streamers from UV and EUV observations

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Abstract.
In this paper we investigate the physical parameters of a streamer observed during the Spring 2000 quadrature of SOHO, the Sun and Ulysses. The analysis was carried out using SOHO/CDS and SOHO/SUMER coordinated observations of the low corona. We analysed six days of observations of the same region, deriving electron temperature, density, emission measure and composition. We found full agreement in the results from the two instruments. We conclude that we were observing an omogeneus streamer, with coronal composition and not completely isothermal.

Key words. Sun – EUV diagnostic

1. Introduction

The configuration of quadrature reached twice times per year by the SOlar and Heliospheric Observatory (SOHO) and Ulysses satellites gives the oppurtunity of make coordinated observations to investigate the solar plasma during its flow from the corona to the interplanetary medium (Suess & Poletto 2001). This kind of observations are very important because they allow to investigate the variation of the physical parameters with the solar distance, giving information on the origin, on the Sun, of the solar wind.

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The understanding of the variation of the elements abundance in the solar athmospere and solar wind, are at the base of all unsolved problems in solar physics. Several studies have been carried out on this topic (i.e. Meyer 1996, Fludra et al. 1999, Raymond et al. 2001), but the problem is still opened. In addition the previous studies on the composition in corona, we mention the depletion found in streamers at 1.5 $R_{\odot}$ with respect to the photospheric values (Raymond et al. 1997, Parenti et al. 2000), which was not visible in the low corona (Feldman et al. 1998). The electron temperature measured in streamers show that they are often isothermal (Raymond et al. 1997, Feldman et al. 1998). The density in these structures has been found to decrease with the solar distance according to the hydrostatic law (Gibson et al. 1999). We present a summary of the results for the radial and temporal variation of electron temperature, density and composition in a streamer, obtained with the SUMER (Wilhelm et al. 1995) and CDS (Harrison et al. 1995) instruments on board of SOHO. In particular we concentrate the study along the Ulysses direction. The full decription of the present analysis can be found in Parenti et al. (2003). Results from other instruments which partecipate to the quadrature observation can be found in Bemporad et al. (2003)

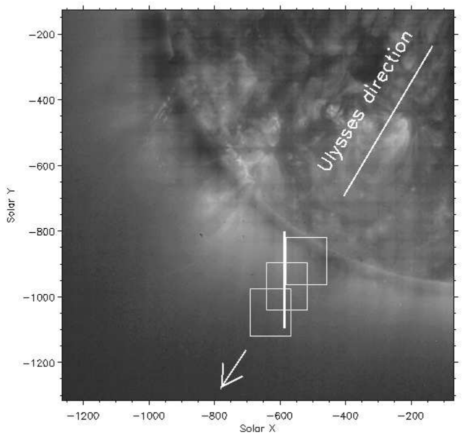

Fig. 1. SOHO/EIT images at 195 Å with the SUMER slit and the CDS/NIS rasters superimposed, for the June 13 (left) and 17 (right). The rasters are represented by the white rectangles. The SUMER slit is shown as a thick white segment. The arrow indicates the Ulysses direction at a latitude -58.2°.

2. The Observations

The observations were carried out between the 13 and 18 June 2000, pointing the two instruments on the radial to Ulysses at -58.2° in the South-East quadrant. CDS observations consisted of full NIS spectra, obtained rastering the corona with the $4'' \times 120''$ slit up to 1.3 $R_\odot$. The SUMER observations were taken pointing the slit number 1 at the Ulysses radial at 1.2 $R_\odot$. A full detector A spectra was obtained for each spatial position. Figure 1 shows the solar corona as seen by the EIT 195 Å channel on June 17 with the CDS rasters and the SUMER slit superimposed. Full detailes of the observation can be found in Parenti et al. 2003.

A careful inspection of the solar corona during the time of observations has shown the Ulysses direction to cross a streamer which seems to be present for all the days of the observation.

3. The Results

The following analysis was carried out applying the spectroscopic diagnostic techniques for optically thin lines (Mason & Monsignori Fossi 1994). We used the the CHIANTI database (Dere et al. 1997, Young et al. 2003), assuming Mazzotta et al. (1998) ionization equilibrium and adopting the coronal composition of Feldman & Laming (2000).

Selected areas of the CDS rasters were used to derive a radial profile of electron temperature and density along the Ulysses direction. Figure 2 shows an example of the results for temperature. These profiles were obtained applying the line ratio technique. The CDS data show the streamer to have a double component in temperature. This result was also confirmed by an Emission Measure (EM) analysis, which suggested a two temperature plasma, one at about 1.4 $\times 10^6$ K and 1.9 $\times 10^6$ K at 1.2 $R_\odot$. A similar analysis was carried out on the SUMER data. However, due to the slit position, CDS and SUMER field of view intersect only in one point along the Ulysses direction, which corresponds to 1.2 $R_\odot$. The EM analysis on SUMER data suggested an isothermal plasma with a temperature almost stable at 1.3 $\times 10^6$ K over all the days and the latitudes covered by the of

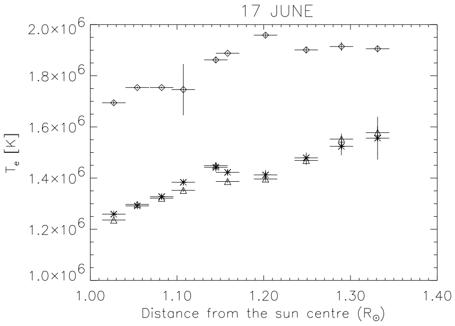

Fig. 2. CDS electron temperature derived from the ratios [Fe xvi] 360.761/[Fe xiv] 334.172 (diamonds), [Fe xiii] 348.183/[Fe xii] 364.467 (stars) and from [Mg x] 609.794/[Mg ix] 368.070 (triangles) for 17 June data.

the observations. Both the SUMER and CDS temperature derived at 1.2 $R_\odot$ (the Ulysses direction) over all the campaign are reported in Figure 3 (Top). We notice a good agreement between the two measurements.

Figure 3 (Middle) reports the electron density derived from the two instruments applying the line ratio technique. The data refer to a distance of 1.2 $R_\odot$ in the Ulysses direction. The figure shows that the streamer remains homogeneus over all the period of the quadrature. The bottom pnel of Figure 3 shows the EM derived over the same period and distance from the two instruments. Also these results show the homogeneity over time of the observed streamer. With the EM analysis we could also study the element composition. Although our data cannot allow to derive the absolute abundances, we could test that the relative elemental abundances are compatible with coronal values for distances up to 1.3 $R_\odot$.

4. Conclusions

This paper summarise the results we obtained analysing CDS and SUMER data of a streamer in the low corona observed dur-

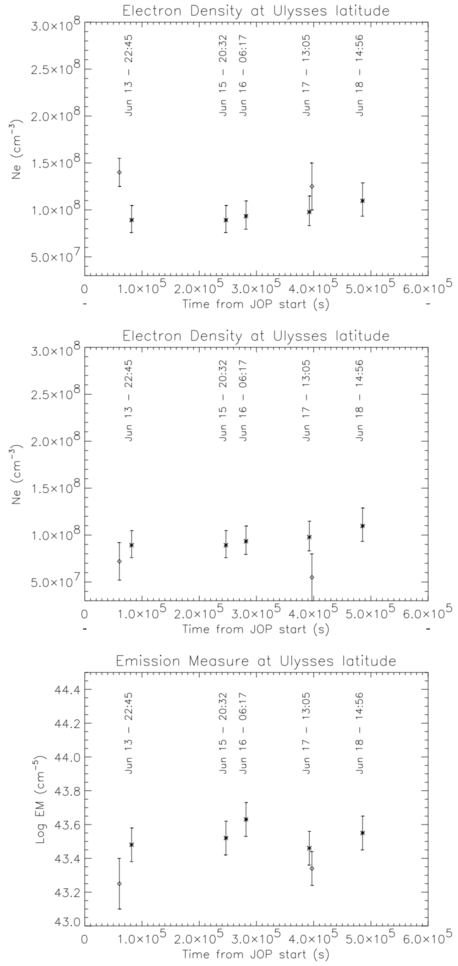

Fig. 3. SUMER (stars) and CDS (diamonds) temporal variation of density (Top), temperature (Middle) and Emission Measure (Bottom) along the Ulysses direction at 1.20 $R_\odot$.

ing the Spring 2000 SOHO-Ulysses quadrature. The streamer we were observing showed an almost constant temperature of 1.3 - 1.4 $\times 10^6$ K during all the period of our observations. Both the instruments indicate the presence of an isothermal component of the plasma in their field of view which emits at a temperature smaller than 1.6×10^6 K. A second component at about 1.9 $\times10^6$ K is seen by CDS. We believe that this component is not seen in the SUMER data because of the absence of lines emitting at such temperatures, in the waveband covered by the SUMER. Along the Ulysses direction, where the field of view of the two instruments overlap, the measurements of the density are very similar. There is not much change of these quantities during the period of the observation, to indicate that there is no significant change in the structure that is crossed by the fields of view. Differently from SUMER, CDS finds a small increase of EM on June 17 from the contribution of the low temperature plasma. Both CDS and SUMER data indicate a depletion of EM with distance. This result, combined with their density results, along the Ulysses direction and across the streamer, shows that there is a change in the streamer morphology.

Both the instruments can measure the relative abundances of the observed plasma. The results show compatability with the coronal composition, which indicate that there is an overabundance of the low FIP (First Ionization Potential) elements with respect to photospheric values.

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