SUMER/SOHO AND TRACE STUDY OF THE TRANSITION REGION BLINKER

František Tomasz¹, Ján Rybák¹, Aleš Kučera¹, Werner Cudt², and Hubertus Wöhl¹

¹Astronomical Institute, Slovak Academy of Sciences, 05960 Tatranská Lomnica, Slovakia
²Max-Planck-Institut für Aeronomie, 37191 Katlenburg-Lindau, Germany
³Kiepenheuer-Institut für Sonnenphysik, 79104 Freiburg, Germany

ABSTRACT

The most prominent transient event is presented from an extensive search for the transition region internetwork activity in the quiet solar atmosphere performed by SUMER/SOHO spectrometer and TRACE. SUMER spectra of Ly β line (1025.4 Å), two C II lines (1036.3 Å, 1037.0 Å) and O VI line (1037.61 Å) were used for determination of the spatial and temporal evolution of the transient event in the transition region. TRACE images taken in the 1216 Å passband, UV continuum (1700 Å) and Fe IX line (171 Å) were utilized in order to gain information about large-scale coronal structures and small-scale chromospheric variability in the vicinity of the transient event. The main physical and geometrical parameters of the event were derived for the transition region O VI line: the spatial extent of 11 000 km, duration for 9 minutes, intensity enhancement factor of 7 and the Doppler velocities of both signs up to 15 km/s. According to these values the event was identified as a transition region blinker. High deviations of the acquired O VI line profiles from single-Gaussian and some multi-Gaussian profiles reveal dynamics of the event - occurrence of the bidirectional jet which is not typical for blinkers. Besides rapid changes in intensity and in velocity, a rapid increase by a factor of 4.2 was found in the Gaussian width of O VI line as compared to the internetwork. Surrounding chromospheric and coronal structures around the event are discussed on base of the simultaneously taken TRACE images.

1. INTRODUCTION

There are several possible phenomena in solar atmosphere which can contribute to heating of the corona. Observations of the quiet Sun with high spatial and temporal resolution in various levels of solar atmosphere reveal transient phenomena, e.g. blinkers [1,2,3] or explosive events [4,5,6]. Innes et al. [7] reported explosive events that show spatially separated blue shifted and red shifted jets which could be a manifestation of the magnetic reconnection occurring in the quiet Sun. Explosive events appear as extremely broad line profiles with Doppler shifts of ±150 km/s. Blinkers are flashes which were identified in quiet Sun network as intensity enhancements of order 10-40% using CDS [1]. In spite of all this fact energy input of these phenomena to corona is still unclear.

This contribution tries to investigate one particular transient event in the transition region in detail. For this purpose SUMER spectra of four lines and TRACE images in three channels were combined and various layers of the solar atmosphere are studied.

2. INSTRUMENTS AND DATA

SUMER [8] is a normal incidence spectrometer designed to investigate structures and associated dynamical processes occurring in all parts of the solar atmosphere within a temperature range from 5×10⁴ to 2×10⁷ K. SUMER provides spectra with high spatial, spectral and temporal resolution.

Using the SUMER spectrometer, the Ly β 1025.40 Å line, two C II 1036.34 Å and 1037.02 Å lines and O VI 1037.61 Å line were acquired on 5 May 1999 from 8:12 UT to 13:15 UT. During this period of almost 5 hours 1200 exposures with exposure time of 14.25 s were taken. The narrow slit with dimensions of 0.3”×120” was used for this observation. The center of the slit was pointed to the position of x = −65.25” (north–south) and y = 223.3” – 267.9” (east–west). In order to observe the same target on the surface compensation of the solar rotation was applied. The selected lines cover formation temperatures ranging from 2×10⁴ (Ly β) via 3×10⁴ (C II) to 3×10⁵ K (O VI). The hydrogen line is formed in the chromosphere, the carbon lines in the lower part and the oxygen one in the upper part of the transition region.

Each spectral profile of C II and O VI lines was fitted with single Gaussian profiles. Thus, three basic characteristics were obtained: the central intensity I₀, the Doppler shift V₀ and the Gaussian width W. Zero level of V₀ was derived from C II internetwork. In addition to these characteristics, the continuum intensity I_c and χ² which is measure of fitting accuracy were calculated.

The Transition Region and Coronal Explorer (TRACE)
[9] is an imager which records filtergrams with high angular and temporal resolution in the temperature range from \(4 \times 10^3\) to \(4 \times 10^6\) K. Chromospheric layers were observed using UV 1700 Å continuum and \(\text{H} \alpha\) 1216 Å channels and the coronal ones using Fe x 171 Å channel. TRACE images were obtained on May 5, 1999 between 9:15 UT and 9:34 UT, with a spatial resolution of 0.5".

16 exposures with 46 s exposure time in Fe x, 28 exposures with 4.1 s exposure time in \(\text{Ly} \alpha\), and 28 exposures with 2 s exposure time in UV continuum channel were used for our study. Images were reduced for dark current, flat-field, cosmic rays and solar rotation followed by basic and advanced corrections for residual motions and normalisation of intensity (counts/s).

Cross-correlations of SUMER data (\(\text{Ly} \beta\)) and TRACE images (\(\text{Ly} \alpha\)) were performed to co-align post-facto data of both instruments. We determined the position of the SUMER slit in the TRACE filtergrams with an error less than 1" (Fig. 1).

3. RESULTS

The most prominent transient event observed in \(\text{O vi}\) line in the internetwork – according to the enhancements of the central intensity and the Gaussian width as well as changes of the Doppler shift – was selected for a more detailed study. Detailed spectral analysis revealed basic geometrical and physical characteristics and their relations to dynamics of the transient event [10]: diameter of the observed phenomena is \(\sim 11000\) km, duration about 9 minutes, intensity enhancement factor reaches value of 7 in relation to the quiet Sun value, spectral lines were both blue and red shifted with the corresponding velocities up to 15 km/s, the maximal broadening of the Gaussian width for factor of 4.2 was derived comparing to quiet Sun \(W\) value. The main result from this spectral analysis is that the selected transient event was denoted as a blinker. Relatively high values of \(\chi^2\) from the single Gaussian fitting comparing to the multi Gaussian one, pointed out that multi Gaussian fits are more appropriate, i.e. differences between the measured and the fitted profiles are smaller.

The blinker is not as remarkable in \(\text{C ii}\) than in \(\text{O vi}\) emission. Temporal investigation of the central intensities and other spectral characteristics revealed only continuous evolution of these spectral characteristics during the event. Intensity enhancement factor is also small, it reaches only 1.5 of \(I_0\) quiet Sun value. Velocities in both lines are rather small and mostly negative: from \(-12\) to \(+1\) km/s. The Gaussian width broadening factor reached the value of 3.75 relatively to the quiet Sun value.

There is no evidence of the presence of blinker influence in the TRACE Fe x images. On the other hand the 2D pattern of the network in UV continuum and \(\text{Ly} \alpha\) is similar. More over the enhanced emission at the time of blinker occurrence is visible in both channels. Intensity enhancement factor of \(\text{Ly} \alpha\) is 1.25 and it is comparable to the enhancement of \(\text{C ii}\) intensities (Fig. 2).

4. CONCLUSIONS

From the observed and the derived information we characterized the transient event as a blinker. In this case a non-typical feature of blinkers – the bi-directional structure – at its final phase was observed. Energy release during the blinker was not sufficient to heat plasma to coronal temperatures. Indeed, the blinker was only energetically powerful enough to affect layers where UV continuum and \(\text{Ly} \alpha\) are formed. Possible driving mechanisms of such a blinker could be magnetic reconnection or any other mechanisms which can explain observed bi-directional jets in a loop on the temporal scales of the order of tens of seconds and spatial scales of thousands kilometers. A more detailed work on this particular blinker is in preparation.
Figure 2. Comparison of the Ly β total emission distributed along the SUMER slit and Lyα intensity in the selected slice of the TRACE filtergram. Peaks on the left and right especially seen in Lyα are the network boundaries while the blinker is located at the position of about 72".

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