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# TRANSITION REGION ERUPTIVE EVENT OBSERVED WITH SOHO/CDS IN THE QUIET SUN NETWORK

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**Abstract.** CDS observations of the quiet Sun network in the chromospheric He I 584.33 Å and transition region O V 629.73 Å emission lines over a time period of ∼ 29 min are presented. One eruptive event was detected in this time series of data. The parameters of the network eruptive event are derived and the type of this small-scale activity is identified. The lifetime of the event was ∼ 1 min and it was found only in the transition region emission line. This event had no chromospheric counterpart. All O V spectral profiles of the eruptive event were blueshifted and the maximal Doppler shift was -14.7 km s$^{-1}$. During an initial phase of the eruptive event, the O V intensity enhancement factor was 2.3. These parameters indicate that the observed event could be the transition region explosive event but measured with limited resolution of the CDS instrument.

**Key words:** Sun - transition region - explosive event - blinkers

## 1. Introduction

The UV and EUV emission spectra of the solar transition region (TR) were observed by several space instruments: *Skylab*, *Solar Maximum Mission*, *NRL High-Resolution Telescope and Spectrograph.* After the launch of the *Solar and Heliospheric Observatory (SOHO)*, new opportunities have become available for the study of dynamical events in the outer solar atmosphere. Especially it is possible to investigate short-time and small-scale variability of the dynamical events with high temporal and spatial resolution. Using the instruments on board SOHO it was discovered that the quiet Sun is far from a stationary state, particularly in the transition region. The observations made by the *Coronal Diagnostic Spectrometer (CDS)* revealed the existence of flashes, known as blinkers, which display their most significant brightenings in the TR temperature lines (Harrison, 1997). Another kind of the small-scale activity at the TR temperatures, known as explosive events, was revealed by the NRL HRTS experiments (Brueckner & Bartoe, 1983) and confirmed by the *SUMER* spectrometer on board SOHO (Innes et al., 1997). Purpose of this work was to observe eruptive events with the CDS instrument and to describe parameters of these small-scale activity events.

## 2. Observations and data reduction

The data discussed here were obtained by the CDS/NIS (Normal Incidence Spectrometer) instrument (Harrison et al., 1995) between 23:25 UT and 23:53 UT on May 14, 1998 at the disk center. A quiet Sun region was observed in He I 584.33 Å ($2.0\times10^4$K) and O V 629.73 Å ($2.5\times10^5$K) lines. A 1729 s long time series of the spectral images was made using the 2"×240" slit (N–S orientation). A set of 190 images with an exposure time of 5 s and a cadence of 9.1 s was obtained. The 'sit-and-stare' observation mode was used, thus the slit position was fixed in the plane of sky. Although the CDS has an ability to compensate for the solar rotation, this was turned off during these observations. Since the solar surface rotates at a speed of ∼9 arcsec per hour, a new ∼4" area of the solar surface is observed by the CDS every ∼25 min. The resulting scanned area was 168" (NS) × 4.4" (EW). The data were corrected for the most obvious instrumental features of the CDS/NIS.[1] Then the spectral data were converted to

[1] More details: http://solg2.bnsc.rl.ac.uk/software/uguide/uguide.shtml

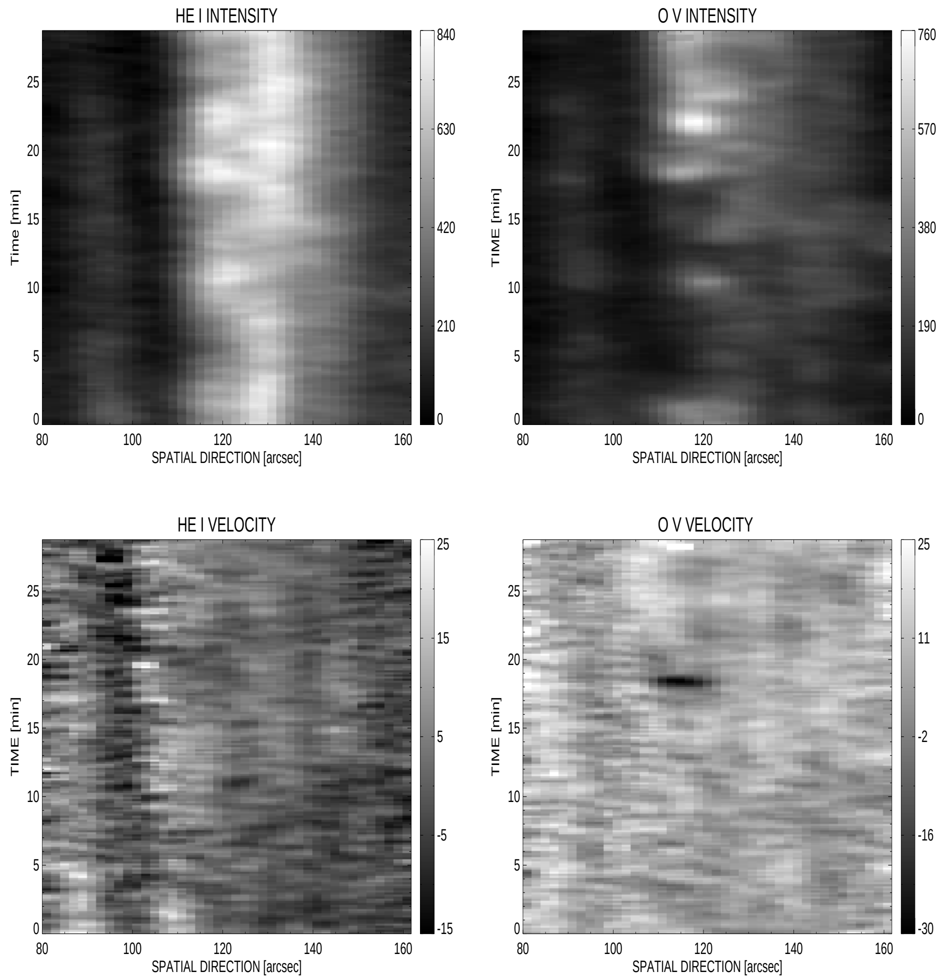


Figure 1: The 2D maps of He I and O V intensity and the Doppler shifts. The horizontal axis describe spatial direction along the slit and the vertical axis describe time. The solar rotation was not compensated, so the vertical axis presents also the spatial extent of the observed solar features. The intensity values are given in $\mathrm{erg\,cm^{-2}s^{-1}sr^{-1}\AA^{-1}}$ and the Doppler shifts in $\mathrm{km\,s^{-1}}$. Positive shifts: toward the solar surface; negative shifts: toward the observer.

the physical units: intensity to erg $\mathrm{cm}^{-2}\mathrm{s}^{-1}\mathrm{sr}^{-1}\mathrm{Å}^{-1}$ and the Doppler shift to $\mathrm{km\,s}^{-1}$. A single Gaussian profile with a linear background was then fitted to each spectral profile using the relative weights of the data (Poisson statistics[2]) with help of the CFIT algorithm of S. Haughan.[3] The scales of wavelength were adjusted using the mean redshifts of the transition region lines (Peter & Judge, 1999) and their laboratory wavelengths (Macpherson & Jordan, 1999) applied to the averaged positions of our internetwork measurements. Only data with the normalized residuals of fits lower than 1.5 were used for analysis.[3]

## 3. Results

The time-space 2D maps of He I and O V intensities and the Doppler shifts, covering mainly the network, display emission of the chromosphere and the transition region (Fig.1). The 2D maps exhibit a typical network in the slit area between 126" and 142". The area, displayed on the maps between 114" and 124", is designated here as a nontypical network, because the intensity and the Doppler shift variations are quite different here comparing to the typical network. The average values of intensities and the Doppler shifts were computed as a spatial average over 18" in case of the typical network and over 12" in case of the nontypical network.

The 2D map of O V Doppler shift (Fig.1, bottom right panel) shows an eruptive event in the transition region between 114" – 122" and 1064 s – 1138 s. This event is not visible in He I Doppler shift and in He I intensities. The temporal variations of O V averaged intensities and the Doppler shifts are shown in Fig.2. The Doppler shifts of O V spectral line show large fluctuations because of low S/N ratio (Fig.2, bottom panel). These fluctuations are not real (Fig.2 bottom panel, upper error bar). Therefore the temporal variations of O V Doppler shift were smoothed using the running mean of 5 data points (Fig.2, thick line).

Lifetime of the event was 74 s. This corresponds to 0.2" target shift caused by the solar rotation, what is less than the slit width.

[2]CDS Software Note nr. 49: http://orpheus.nascom.nasa.gov/cds/home/swnotes

[3]CDS Software Note nr. 47: http://orpheus.nascom.nasa.gov/cds/home/swnotes

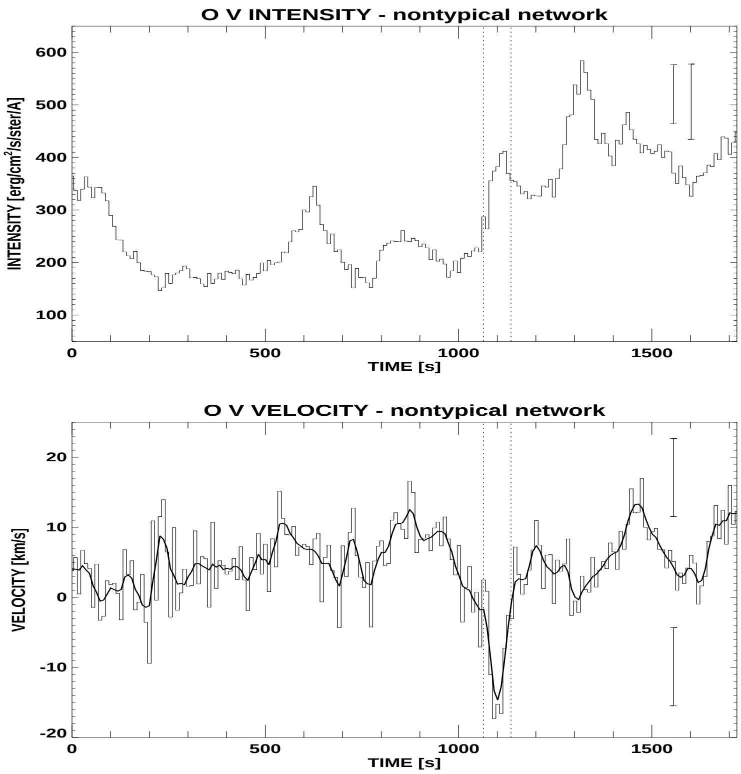


Figure 2: Top: Temporal variation of the averaged O V intensities in the nontypical network. The square root error from the displayed values is $\pm 33.7\ \mathrm{erg\,cm^{-2}s^{-1}sr^{-1}\AA^{-1}}$ (left error bar). The average value of deviation from the displayed values is $\pm 55\ \mathrm{erg\,cm^{-2}s^{-1}sr^{-1}\AA^{-1}}$ (right error bar). The dotted lines mark the time interval, in which the TR eruptive event was observed. Bottom: Temporal variation of O V Doppler shifts in the nontypical network. The thin line displays the averaged O V Doppler shifts. The thick line shows the smoothed temporal variations. The square root error from the displayed values is $\pm 5.6\ \mathrm{km\,s^{-1}}$ (top error bar). The average value of deviation from the displayed values is $\pm 5.5\ \mathrm{km\,s^{-1}}$ (bottom error bar). The dotted lines show the time interval, in which the TR eruptive event was observed. Positive shifts: toward the solar surface; negative shifts: toward the observer.

The maximum Doppler shift of the eruptive event was -14.7 $\mathrm{km\,s^{-1}}$ (blue shift). The basal value of the O V line intensity in the nontypical network was $180\,\mathrm{erg\,cm^{-2}s^{-1}sr^{-1}\AA^{-1}}$. During the initial phase of eruptive event the intensity of the O V line increased 2.3 times compared to the basal value. Then the O V line intensity decreased again to a new basal value which was $350\,\mathrm{erg\,cm^{-2}s^{-1}sr^{-1}\AA^{-1}}$, and two new bursts of O V intensity were detected. The intensity enhancement factors in the bursts were 1.6 and 1.4 respectively. The new basal value was used to derive these parameters. There is no correlation between the O V intensity and the O V Doppler shift temporal variation at the time interval in which the two bursts were detected.

All spectral profiles of O V line (except one) were found to be single Gaussians in the time-space area which is covered by the eruptive event. An attempt to determine the representative high S/N spectral profile of the O V line summing of the several profiles was made. Nine spectral profiles were averaged for three positions along the slit 114" – 118" and for three exposures within time interval 1083 s – 1101 s. The resulting spectral profile has shown that the two component Gaussian fit is better compared to the single one.

## 4. Discussion and conclusion

The most obvious eruptive phenomena in the transition region network are the blinkers and the explosive events. Blinkers and explosive events are supposed to have the same physical origin – the magnetic reconnection but with different geometry of the magnetic field (Chae et al., 2000). Explosive events could be results of the collision of a network

Table 1: Properties of the eruptive event.

| | | |
|---|---|---|
| Transition region: | Intensity enhancement factor | 2.3 |
| | Lifetime | 74 s ($\sim$1 min) |
| | Doppler shift | -14.7 $\mathrm{km\,s^{-1}}$ |
| | Spatial extent | 7300 km |
| | Location | network |

flux thread and an internal flux thread. On the other side, blinkers can result from the collision of two network flux thread (Chae et al., 2000). This distinction causes different physical parameters of blinkers and explosive events. Comparison of the typical properties of blinkers and explosive events (Harrison, 1997; Innes et al., 1997) with parameters of the observed eruptive event (Tab.1) shows that our eruptive event has a lifetime typical for the explosive events. The occurrence of the detected bursts is also typical for the explosive events. The Doppler shift amplitude of our eruptive event is typical for the blinkers but due to the wide CDS slit the real Doppler shift amplitude could be significantly larger. The lower Doppler shift amplitude could be also due the line-of-sight projection effect. Our eruptive event shows only negative (blue) Doppler shift. This fact is not compatible with the typical explosive events (Innes et al., 1997) but due the 'sit-and-stare' observation mode the second part of the bi-directional jet could be outside the fixed slit position. On the other hand, size of the eruptive event and the intensity enhancement factor of O V line are typical for blinkers. Explosive events are mainly observed in spectral line Si IV and in other lines colder than the O V line. This might explain a difference between parameters of our eruptive event and typical explosive event. Based on these results we can identify this event as the transition region explosive event but observed with the CDS instrument with limited spatial resolution of 2".

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