Transition region eruptive event observed with CDS/SOHO in the quiet Sun network

P. Gömöry, J. Rybák, A. Kučera

Astronomical Institute of Slovak Academy of Sciences, Tatranská Lomnica, Slovakia

W.Curdt

Max-Planck-Institut für Aeronomie, Katlenburg-Lindau, Germany

H. Wöhl

Kiepenheuer-Institut für Sonnenphysik, Freiburg, Germany

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AIM

To derive parameters of the network active event using the CDS spectroscopic measurements of the chromospheric He I line and the transition region O V line.

DATA

- instrument: CDS/SOHO NIS spectrometer (Harrison et al., 1995)
- observation mode: 1D sequences ⇒ fixed slit position at the disk
- spectral lines: **He I 584.33 Å** (2.0×10^4 K)**, O V 629.73Å** (2.5×10^5 K)
- slit: 2" x 240" oriented in the north – south (NS) direction
- exposure time: 5 s; telemetry: 4.1 s
- number of exposures: 190; observational run duration: 1729 s
- scanned area: 168" (NS) x 4.4" (EW); no rotation compensation
- target: quiet solar atmosphere at the disk center
- date and time: May 14, 1998, 23:25 UT - 23:53 UT
- campaign: JOP 78 run (Kučera et al., 1999)

DATA REDUCTION

- correction of the most obvious instrumental features of the CDS/NIS spectral data[1]: spectrum rotation and tilt; wavelength change with scan mirror position; CCD flatfield; micro-chanel plate burn-in; other fixed pattern effects; cosmic rays; NIS bias; NIS continuum; NIS data (noise) statistics; spatial offset between NIS1 and NIS2
- data conversion to the physical units (intensity to erg/cm^2/s/ster/Å and Doppler shift to km/s)
- spectral profile fitting by the Gaussian profile and the linear background using relative weights of the data (Poisson statistics[2]) with help of the CFIT algorithm of S. Haughan[3]
- wavelengths calibration: wavelength scales adjusted using the mean redshifts of the transition region (TR) spectral lines (Peter and Judge, 1999) and the laboratory wavelengths (Macpherson, 1999) applied to the averaged positions of our internetwork measurements

[1] Correction of these features: SSW/IDL procedures. More details: http:// solg2.bnsc.rl.ac.uk/software/uguide/uguide. shtml.
[2] CDS Software Note nr. 49 by W. Thompson: http://orpheus.nascom.nasa.gov/cds/home/swnotes/
[3] CDS Software Note nr. 47 by S. Haughan: http://orpheus.nascom.nasa.gov/cds/home/swnotes/

- data selection: only data with the normalized residuals < 1.5 used for analysis

RESULTS

- 2D maps of He I and O V intensities and Doppler shifts displaying the emission of the chromosphere and transition region in internetwork and network
- parts of the maps, covering mainly the network, are given in Fig. 1

Typical network

- 2D maps exhibit typical network in the slit area between 126" and 142"
- He I and O V intensities and Doppler shifts obtained in the typical network are given in Tab. 1

Table 1.: Typical network He I and O V intensities and Doppler shifts.
*(**Mean value** : this value was obtained averaging the data within the given interval along the slit and over the whole duration of observation; **average deviation from the mean** : this parameter gives the average of the differences between the particular data and their mean values derived within the given interval along the slit; **maximal deviation** : the maximal difference between the mean value and the data; **typical deviation** : the estimation of the real deviations according to the signal/noise ratio of data)*

	He I 584,33Å		**O V 629,75Å**	
	intensity (erg/cm^2/s/ster/Å)	Doppler shifts (km/s)	intensity (erg/cm^2/s/ster/Å)	Doppler shifts (km/s)
mean value	586.5 ± 63.1	-0.42 ± 2.2	263.2 ± 58.6	7.08 ± 3.2
average deviation from the mean	± 69.4	±3.03	±35.2	±4.67
maximal deviation	~ 100	~ 5.8	~ 50	~ 6.2
typical deviation	~ 30	~ 2.6	~ 25	~ 3.7

Nontypical network

- the area between 114" - 124" we designate here as nontypical network
- the average intensities and Doppler shifts were computed as a spatial average of over 12"
- temporal variation of He I and O V averaged intensities are shown in Fig. 2
- temporal variation of He I and O V averaged Doppler shifts are shown in Fig. 3 (thin line histograms)
- Doppler shifts of He I and O V spectral lines show large scatter, because of low S/N ratio, this scatter is not real (see top errorbars in Fig. 3); therefore temporal variations of He I and O V Doppler shifts were smoothed using the running mean of 5 data points (Fig. 3, thick lines)
- He I and O V intensities and Doppler shifts obtained in the nontypical network are given in Tab. 2

Table 2.: Nontypical network He I and O V intensities and Doppler shifts.

*(**Mean value** : this value was obtained averaging the data within the given interval along the slit and over the whole duration of observation; **average deviation from the mean** : this parameter gives the average of the differences between the particular data and their mean values derived within the given interval along the slit; **maximal deviation** : the maximal difference between the mean value and the data; **typical deviation** : the estimation of the real deviations according to the signal/noise ratio of data)*

	He I 584,33Å		**O V 629,75Å**	
	intensity (erg/cm^2/s/ster/Å)	Doppler shifts (km/s)	intensity (erg/cm^2/s/ster/Å)	Doppler shifts (km/s)
mean value	584.7 ± 61.1	1.5 ± 2.8	289.9 ± 63.6	8.6 ± 3.4
average deviation from the mean	± 71.5	±3.2	±55	±5.5
maximal deviation	~ 150	~ 5.2	~ 250	~ 7.5
typical deviation	~ 70	~ 3.7	~ 90	~ 4.3

- comparison of values in Tab 1. and Tab 2. shows that:
  - mean He I and O V intensities values: similar in the nontypical network and in the typical network
  - maximal He I and O V intensities deviations: higher in the nontypical network than in the typical network
  - typical He I and O V intensities deviations: higher in the nontypical network than in the typical network
  - mean He I and O V Doppler shifts values: in the nontypical network are lines more redshifted than in the typical network
  - maximal He I and O V Doppler shifts deviations: in O V line higher in the nontypical network than in the typical network but in He I line lower in the nontypical network than in the typical network
  - typical He I and O V Doppler shifts deviation: higher in the nontypical network than in the typical network

Eruptive event in the nontypical network of the transition region

- 2D map of O V Doppler shift (Fig. 1, bottom right panel) shows an eruptive event in the region between 108"- 123" and 1064 s - 1138 s
- this event is not visible in He I Doppler shift and in He I intensities; it means that it is completely transition region event
- lifetime of this event was 74 s; this corresponds to 0.2" target shift caused by the solar rotation (this shift is less than the slit width which was 2")
- Doppler shift maximum of the eruptive event is -14.7 km/s (blue shift)
- all spectral profiles of O V line (except one) are single Gaussian (typical example of such profiles is shown in Fig. 4)
- only one O V spectral profile (114", 1092 s) shows that two component fit is better (Fig. 5):

  - one Gaussian fit: I = 433.12 erg/cm^2/s/ster/Å; intensity
    ν_D = -38.1 km/s; Doppler shifts
    ξ = 0.34 Å; Doppler width
    χ^2 =1.16 erg^2/cm^4/s^2/ster^2/Å^2;
  - two Gaussians fit: I_1 = 71.72 ; I_2 = 386.45 erg/cm^2/s/ster/Å
    ν_{D1} = -123.8; ν_{D2} = -19.1 km/s
    ξ_1 = 0.37 ; ξ_2 = 0.31 Å

$$\chi^2 = 0.84 \text{ erg}^2/\text{cm}^4/\text{s}^2/\text{ster}^2/\text{Å}^2$$

- an attempt to determine the representative high S/N spectral profile of He I and O V line summing of the several profiles was made (9 spectral profiles were averaged; 3 along the slit: 114" - 118", 3 exposures in time: 1083 s -1101 s), the resulting spectral profile has shown better two component Gaussian fit compared to the single one (Fig. 6)

  - one Gaussian fit: $I = 408.7$ erg/cm^2/s/ster/Å
    $\nu_D = -33.3$ km/s
    $\xi = 0.34$ Å
    $\chi^2 = 0.88$ erg^2/cm^4/s^2/ster^2/Å^2
  - two Gaussians fit: $I_1 = 245.91$; $I_2 = 178{,}46$ erg/cm^2/s/ster/Å
    $\nu_{D1} = -33.3$; $\nu_{D2} = -23.8$ km/s
    $\xi_1 = 0.38$; $\xi_2 = 0{,}26$ Å
    $\chi^2 = 0.74$ erg^2/cm^4/s^2/ster^2/Å^2

DISCUSSION

- **explosive events** in the network (Innes et al.,1997):
  - lifetime of individual events: ~ 1- 6 min.; events come in bursts (up to 30 min.)
  - characterized with little brightening (Si IV line: 1393 Å, 6×10^4 K)
  - Doppler shifts: ~ 100 km/s
  - in explosive events are about equal numbers of profiles that show red, blue and simultaneous red and blue Doppler shifts
- **blinkers** in the network (Harrison, 1997):
  - pronounced in TR lines
  - lifetime: ~ 6- 40 min.
  - Doppler shifts: ≤ 20 km/s
  - characterized with strong brightening in the O III, O IV, O V lines

- **our** network eruptive event:
  - location: network
  - pronounced in TR O V line; not visible in the chromospheric He I line
  - lifetime: 74 s (~1 min.)

- spatial dimension: 12”
- maximal Doppler shift: – 14.7 km/s (blue shift)
- TR spectral profiles show only negative Doppler shifts (blue shift)
- only single Gaussian component spectral profiles

- comparison of these parameters shows:
  - lifetime: comparable with lifetime of the typical explosive event
  - intensity enhancement factor: 1.2 ~ typical explosive event
  - Doppler shift amplitude: typical for blinkers but due to the wide CDS slit the real Doppler shift amplitude can be significantly larger
  - Doppler shift sign: only blue shift (not compatible with the typical explosive event)
  - occurance: event is isolated, no burst detected (not compatible with the typical explosive event)

CONCLUSION

- CDS observation of the transition region network explosive event (probably)
- no chromospheric counterpart of the transition region event
- two component Gaussian fit of the representative event profile can not be interpreted as sum of a funnel and low lying loops emissions (Peter, 2000), as Gaussian components are very similar

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