Oscillations in Chromosphere and Transition Region Based on SUMER Measurements

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Abstract. We present the results from our observations with SUMER instrument onboard SOHO. Dynamics of the upper chromosphere and the transition region was investigated using the C II 1036.34 Å and O VI 1037.61 Å lines. The results presented here include spatial and temporal variations of the line intensities, Doppler velocities, and power spectra of the intensities as well as Doppler velocities in network boundary and internetwork regions. The spectra were taken in 15 s cadence at the disk-center during 3.8 hours.

1. Introduction

Dynamics of the chromosphere, transition region as well as of the corona and non-radiative heating of these layers are still unsolved problems in solar physics. Carlsson & Stein (1995) have shown, that chromospheric emission can be produced by non-linear motions without any increase in the mean temperature. On the other hand Steffens et al. (1995) indicated the existence of resonant oscillations in the chromosphere and Deubner at el. (1996) gave evidence for the standing-wave modal layers. Steffens et al. (1997a) pointed out that a dynamic reflecting layer above the chromosphere and an inhomogeneous transition region may influence the wave field. In this contradicting situation the SUMER spectrometer (Wilhelm et al. 1995) onboard the SOHO spacecraft opened a new possibility to study wave dynamics over the whole range of heights between the chromosphere and the corona. The aim of the present paper is to compare the dynamics as well as the intensity structures between the chromosphere (C II 1036.34 Å line) and transition region (O VI 1037.61 Å line) in both, the supergranular boundary (SGB) and the supergranular interior (SGI) regions.

2. Observations and data reduction

General summary of our observational runs performed beginning of Sept. 1996 was given by Curdt et al. (1997a). This contribution is based on measurements of Sept.7, 1996 when 3 large (38 x 120 arc sec) and 14 small (8 x 120 arc sec)

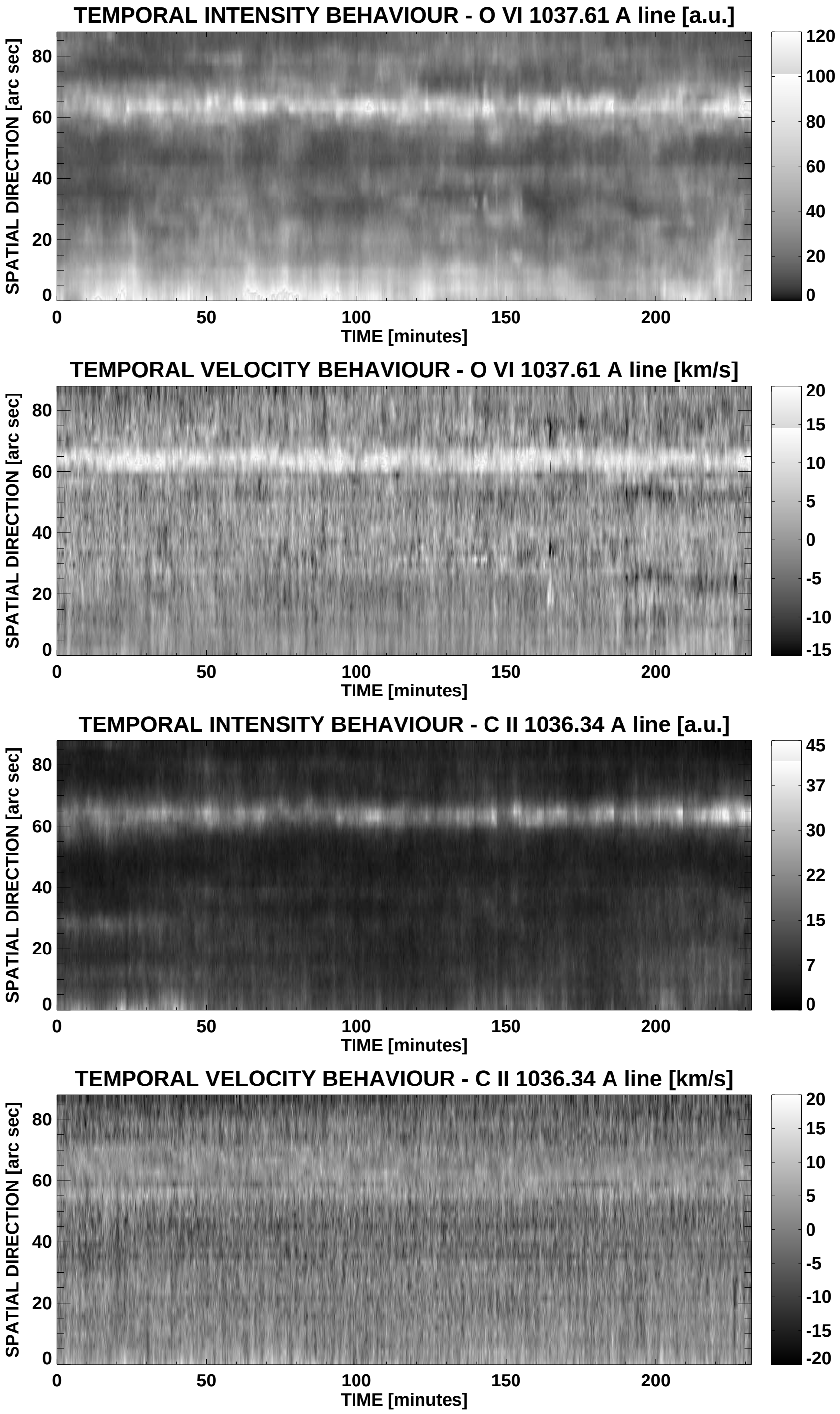

Figure 1. The time-slice maps of the maximal intensity and the Doppler velocity of the O VI and C II lines, as they were inferred from the long-term measurements with the resolutions of $\triangle$y=1.96 arc sec and $\triangle$t=15 sec.

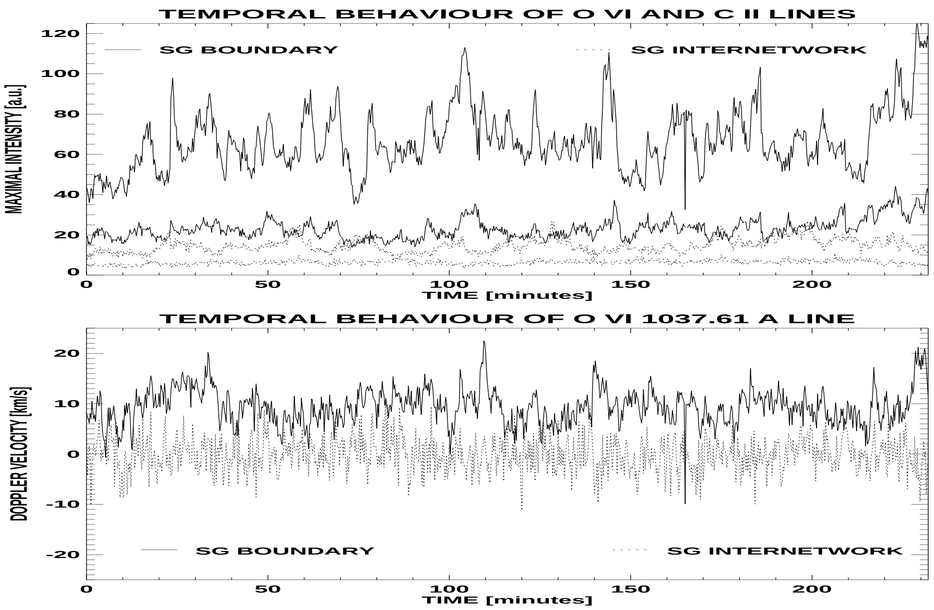

Figure 2. Comparison of the temporal behaviour of the intensities (C II and O VI lines) and the Doppler velocities (O VI line) in SGB and SGI regions.

scans were performed at the beginning of the run. Then almost 1000 exposures were taken in the center of the area with a stationary slit using 15 s integration time (long-term measurements) and, finally 300 exposures with integration time of 2.5 s were stored to the onboard memory.

In order to process raw SUMER data the common correction procedure was applied (decompression, the flat-field correction, destretching of instrumental spectral line curvature). Routinely acquired flat-field data of the SUMER detector A were available from two moments, 13 days before and 4 days after our observations. All steps of reduction were tested using both these flat-field data with the aim to estimate their different influence to the reduction. This phenomenon may not only affect individual data in spectral line profiles but also the inferred spectral line characteristics (see Curdt et al. 1997b). The intensities exhibit an inaccuracy up to 10%. The sensitivity of the Doppler velocities to different flat-fields is very high ($> 100\%$) at those parts of the detector which were dramatically affected by previous exposures. These parts were interpolated in our measurements, expecting no change in flat-field response during the course of the program.

3. Spectral characteristics calculations

The following definitions and limiting criteria were used for calculations of spectral characteristics: $\triangle\lambda$, $\triangle$y, $\triangle$t stand here for the spectral, spatial and temporal resolutions, respectively; the zero level of the continuum emission was proposed around the investigated lines; the individual spectral profiles were smoothed out

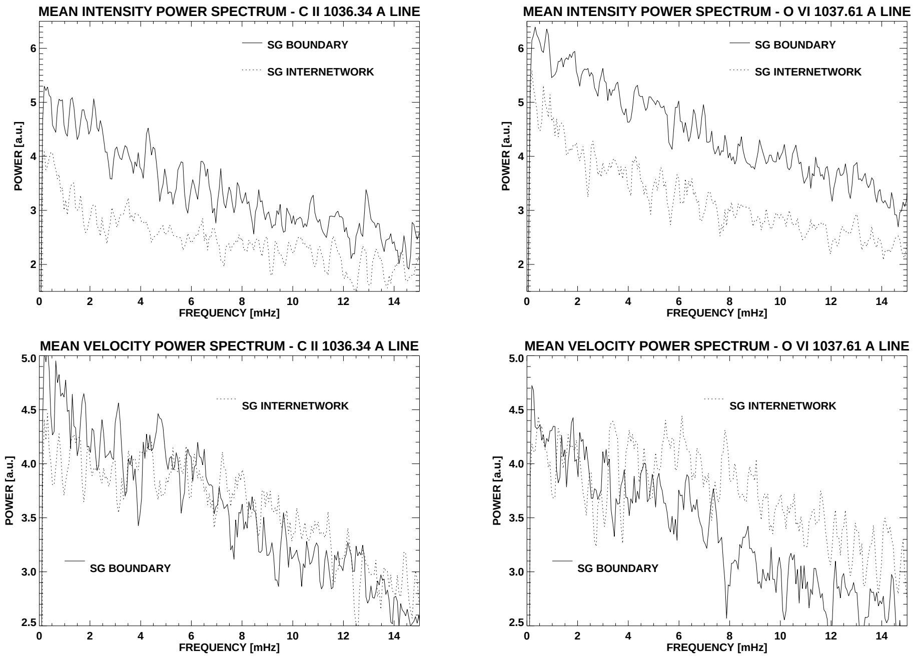

Figure 3. The power spectra of intensities and the Doppler velocities of the O VI and C II lines in the SGB and SGI areas.

using running mean averages of 5 points; $\triangle\lambda$=0.0445 Å and $\triangle$y=1.96 arc sec; the peak intensity and the Doppler shifts of the lines were computed from a second order polynomial approximation of 5 points selected symmetrically around the peak intensity of smoothed line profiles; the Doppler velocities were averaged over the whole domain in order to get a reference zero velocity.

4. Results and discussion

The time-slice maps of the peak intensity and the Doppler velocity behaviour of the O VI and C II lines are reproduced in Fig.1. The velocity time-slice map was originally heavily influenced by a significant long-term periodicity with an amplitude of about 5 km/s and a period of roughly 2 hours. This general movement of the spectral image in a wavelength direction may be ascribed to thermoelastic oscillations of the SUMER structure mechanics. We removed this influence by using a long-term smooth of a spatially averaged velocity pattern (see Curdt et al. 1997b).

Generally the time-slice maps of O VI line, which characterize the temperature region of $3\text{x}10^5$ K show significant differences between SGB and SGI regions as well as remarkable temporal changes of the presented characteristics. The bright SGB area (see positions around 63 arc sec in Fig.1) correlates with the systematic downflow (5 – 20 km/s) in the transition region (see Fig.2). The SGI region exhibits the velocities around the zero level but yet with a rather high standard deviation of 3 km/s also in the darkest areas (positions around 47 arc sec in Fig.1). A similar effect was already presented by Steffens et al. (1997b). The C II line time-slice maps represent the upper chromosphere of about 3x10^4 K. There is no correlation between the bright SGB area and velocities, and no flow was also found comparing the velocities between SGB and SGI.

Typical SGB and SGI mean velocity and intensity power spectra of both, C II and O VI lines are presented in Fig.3. The SGB and SGI signals were taken from identical positions at slice-maps as those for the Fig.2. Estimated noise levels of the power spectra were used as the lower boundaries of the plots. No dominant frequencies were inferred in the intensity power behaviour. On the other hand, the velocity power spectrum of the O VI line shows the enhanced SGI amplitudes in the range of 4 – 9 mHz according to the SGB signal. Other peculiarities of the velocity power spectra, including the opposite behaviour of the amplitudes in the SGB and the SGI signal (see C II line at 1.75, 3.0 and 4.75 mHz and the O VI line between 3.5 – 9.0 mHz), remains to be proved with a statistically larger data set.

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