Analysis of Chromospheric Proxies of Coronal Bright Points

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Abstract. Recent work has focused on the comparison of soft x-ray and EUV coronal bright points (CBPs), He I (1083 nm) dark points, dm-waves (VLA) bright points and the Heα wing and magnetogram signatures outside active regions. With the horizontal spectrograph (HSG) at the Vacuum Tower Telescope (VTT), NSO/SP, we obtained several-hour time sequences of CCD spectra taken simultaneously in the Ca II K line and near the He I 1083 nm line.

Besides the well-known $K_{2V}$ and $K_{2R}$ fast variations, more energetic events occurring at 10 to 20 minute intervals were recorded. An accelerated video movie was made in addition to the CCD spectra.

We present power spectra of 3 minute and 5 minute oscillations in enhanced network and quiet Sun, in the two spectral lines, and examples of the energetic impulsive events. These events may be relevant to the heating of the corona.

1. Introduction

The heating of the corona by waves is probably a viable mechanism which needs more observations for confirmation, as discussed in Zirker (1993). CBPs are potentially the most promising prototypes of solar transient phenomena and their analysis offers an excellent insight into the problem. CBPs have been widely observed in soft X-rays, EUV, He I 1083 line (as dark points) and more recently, in dm waves at the VLA.

We used the Heα signature to locate the slit of our spectrograph and simultaneously analyze the behavior and the line profile of both the Ca II K line and the 1083 line of He I.

The observed region was quite typical of active chromospheric “network”; the slit crossed also a quiet part of a cell, presumably free of magnetic flux.

We discuss the $K_{2V}$ and $K_{2R}$ variabilities of Ca II line and the behavior of
the Fourier spectra of the intensity for low frequencies, and especially the 3 and 5 minute oscillations.

2. Observations

We report on a selected part of the observations performed on 1993 March 22, at the VTT (NSO/Sac Peak), using the universal birefringent filter (UBF) and especially the newly introduced HSG, which offers several spectral channels with multi-diode arrays (RCA 504 chips with 16x20 micron pixels). Special attention was paid to locating the slit near the disc center, in a vertical position relative to the horizon (no differential refraction effect due to the Earth’s atmosphere) and to follow the equatorial solar rotation all the time. The slit was positioned in the N-S solar direction in order to follow the same region during the whole sequence, using the computer-controlled guiding system of the VTT.

a) Before the start of the HSG time sequences (and after the end of the sequence), we used the UBF to perform a careful photometric survey of the field-of-view (FOV). The filtergrams were obtained in the following positions: true continuum; Mg I b1 center; Mg I b1 wing; Hα line wings; Hα line center and finally, in the Ba II line at 455.4046 nm. Note that the order corresponds to a contribution function increasing with height (except for the Ba II line), from 0 Mm to 2 Mm. A large set of images of fair quality were obtained near 15:08 UT, just before the start of the HSG sequence; images of poorer seeing were also obtained for almost 3.5 hours. The seeing was fair with a few pictures showing areas close to the diffraction limited resolution (0.2 arcsecond) of the VTT. The FOV corresponded to 140 x 210 arcseconds. The slit of the HSG was positioned a few minutes later on a “mini-plagette” situated close to the disc center, outside the active region, with several small Hα-wing brightenings and loops (see Plate 1). Images taken after the HSG sequences taken at 18:33 UT, show that the area of flux-like brightness in the vicinity of the slit has considerably decreased.

b) The main observations are sequences of simultaneous CCD spectra over a range of ± 130 pm near Ca II K, and near the line 1083 nm of He I over a range of ± 400 pm. Both spectra were taken at a 5 s rate. Pre–filters were used: a FWHM = 6 nm filter at 393 nm (central transmission was 40%) and a 1080 IR filter (FWHM = 20 nm).

The spectra covered a distance of 38 arcseconds on the Sun. Spectra were directly recorded on exabyte tapes (32 bits) in files of 20 spectra (1 sec exposure time) of 256 x 403 pixels. Slitwidth was 0.3 mm, or 2.3 arcseconds at the scale of the focus (7.5 arcseconds/mm) resulting in a rather good signal-to-noise ratio with the 504 MDA chip.
Plate 1. UBF–picture taken in Hα±0, FWHM = 22 pm, at t = 15:08 UT; it shows the FOV around the analyzed regions and the position of the slit; note position of the 38 arcsecond-long slit.
The measured spectral FWHM is 10.2 pm in Ca II K and 36.1 pm at HeI 1083. Depending on the seeing, the spatial resolution along the slit can be significantly better than the slit width. A post facto processing of all spectra was made to remove the dark current, take into account the flat field and normalize each spectrum to remove effects due to the Earth's atmospheric transmission variations (we had a good clear sky). Further, to perform the quantitative evaluation of the run, all spectra were rebinned in 32 x 45 matrices; the resolution is now 1.2 arcseconds/pixel (5.8 pm/pixel in Ca II K and 17.2 pm/pixel in HeI 10830), which is not too far from the theoretical resolution given by the slit. This procedure also yields a large improvement of the signal/noise ratio without losing the high temporal resolution.

All spectra were converted into analog video signals and recorded on SVHS tape for a fast evaluation. Finally, continuous video slit-jaw filtergrams were recorded with a VHS VCR. They were taken using a Halle filter set in the Hα wing at 50 pm with a 50 pm FWHM. Ca II K₂ full disc spectroheliograms were also taken, and full disc maps from the daily solar patrol were also used.

3. Results and Discussion

We defined two regions which we called "active network element" (AN) typically 6 arcseconds long, and "quiet region" (QR), 3 arcseconds, using an empirical method.

Many events were seen in Ca II K₂ and K₃: it appears that our K-line sequences of spectra taken over a network element show a lot of dynamical phenomena with a dominant recurrence time around 3 to 5 minutes. More powerful phenomena, seen as bright K₂V events, also repeat (at 10 to 20 minute rate); see Fig. 1.

We also studied the time variations of intensities measured in each spectrum for the two lines, using fourier analysis. In Fig. 2 we present the amplitude spectra of the Ca II line intensity variations, for the AN and the QR, and at low frequencies. In K₁, the amplitude spectra for the QR and the AN have the same behavior; but the QR amplitude is higher than the AN amplitude, near 4 mHz.

![Figure 1. Ca II line intensity variations: (a) Measured in K₂V for the two regions, AN (full line) and QR (dotted lines); (b) The same in K₃.](image-url)
Figure 2. Amplitude spectra in the low frequencies for both the AN and the QR as observed; (a) in Ca II $K_1$; (b) in $K_{2V}$; (c) in $K_{2R}$; (d) in $K_3$ (AN in full lines, QR in dotted lines).

A large amount of power is observed at a period near 5 minutes in the AN, in $K_{2V}$ and $K_3$. The difference $K_{2V}$-$K_{2R}$ is usually considered as a good indicator of the velocities in $K_3$ (Rutten and Uitenbroeck, 1991, Lites et al. 1993). For our run, it will be considered in a forthcoming paper (Bocchialini et al. 1993a).

In Fig. 3 we present for the first time He I 1083 line results concerning the temporal variations of the velocity in the center of the line: the amplitudes of the variations are four times stronger in the QR than in the AN.

On the amplitude spectra of the velocities, we observed 5 minute oscillations in the AN and the QR, while 3 minute periods are prominent in the QR. The amplitude spectra of the continuum reveal 5 minute intensity fluctuations in both regions, which confirms the good signal/noise ratio of our observations. We interpret the results shown in Fig. 2 and 3 as a confirmation of the role of the magnetic field in channeling 5 minute period waves.

More discussions about these results will be presented in forthcoming papers (Bocchialini et al. 1993 a,b).

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Figure 3. He I line analysis: (a) Velocity variations as measured in the 1083 He I line in the AN region; (b) As (a), for the QR; (c) Amplitude spectra at low frequencies corresponding to velocity variations shown in (a) and (b) (units are arbitrary); (d) The amplitude spectra of variabilities as measured in the neighboring continuum.

References