PHOTOMETRY OF RAPIDLY EVOLVING CHROMOSPHERIC BRIGHT POINTS IN NOAA 9661 AS OBSERVED BY THEMIS AND THE ONDŘEJOV MULTICHANNEL FLARE SPECTROGRAPH

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ABSTRACT

Active region NOAA 9661 was observed on 13 October 2001 via narrow band Hα filters at THEMIS* ¹ and at the Ondřejov Multichannel Flare Spectrograph both at a cadence of 25 images per second. Rapidly evolving bright points located at various places close to the sunspot were noticed several times during the day from 6 UT until 13 UT. Quite often their sudden appearance and disappearance seemed to be strongly correlated. We expect these small areas to be magnetically interconnected and possibly heated by injections of the same population of electrons moving along the magnetic field lines. Light curves of Hα emission integrated over individual bright areas were derived to search for short-timescale variations and to analyze them, especially concerning their correlations between different pairs of these areas. A similar analysis was performed for a sites in all the active region for comparison and calibration purposes. Changes in correlations are discussed.

Key words: solar flare, bright points, magnetic field.

1. INTRODUCTION

It seems quite reasonable that magnetic field and loops interconnecting various sites in the chromosphere close to an active region can share possible disturbances modulated by plasma effects. As a result one could observe a correlation in the level of the intensity signal coming from these sites, while signal registered on other sites, that are not interconnected couldn’t be correlated at all. Such an investigation has been done for a case of a flare eg. by Kurt et al. (2000) or for cases of microflaring activity in the magnetic network by Cauzzi, Falchi

and Falciani (2001). We are investigating time series of the active region NOAA 9661 Hα filtergrams observed on 13 October 2001 via narrow band Hα filters at THEMIS and at the Ondřejov Multichannel Flare Spectrograph both using CCD video cameras at a cadence of 25 images per second.

2. OBSERVATION

In the active region NOAA 9661 there occurred several subflare phenomena at a disk position of N15 E50 on Oct. 13, 2001. The Ondřejov spectrograph observations showed only a small brightening in the region in the morning, see Figure 1 left, but many brightenings in the later hours, see Figure 1 right.

Figure 1. Ondřejov spectra and Hα slit-jaw.

The observation at THEMIS were performed during an observing campaign lasting from Oct. 10 to 16. The goal was the study of chromospheric flares at a high temporal resolution, by performing simultaneously high cadence (25 per sec.) wide field (about 4’ x3’ ) imaging in the Hα line center.

The small field of view was achieved first by setting a cooled circular field diaphragm of 4’ in diameter at the primary focus F1 of the telescope (this is the maximum allowable field for THEMIS), and then the light beam was doubled with a beam splitter before directing each beam to the final focus F2. The first beam passed through a Lyot type filter of 0.25 Å passband centered in the Hα line core and


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burst reported by Learmonth Obs. at 9:35 UT and a GOES C1.9 a X-ray event at 9:47-10:02, and on Oct. 16 a C2.8 event at 16:32-16:54, but none of these could be without doubts attributed to a particular active region.

3. DATA PROCESSING

All the series of Hα filtergrams were carefully examined and the interesting periods with bright point occurrence were selected and digitized. For further processing only series with no shift of the telescope guiding were used. Thus the selected time series began at 9:35:23 UT and lasted 188 seconds. To prove the guiding stability during this time interval we put a virtual frame on some parts of the filtergrams and we made an animation of the series of images. Looking at the animation we found no shift of the solar surface against the fixed virtual frame, i.e. against the grid of pixels of the CCD chip. In order to exclude some periodic variations on the electronic parts we made an average of all the pixels signal in frames for all the time series of the filtergrams (4700 frames taken with a cadence of 25 frames per second). We found no period in the function of the average nor at its autocorrelation function. This has been proved also by the Fourier analysis where no periods were found also in the FFT power spectrum nor in its autocorrelation function. Therefore we concluded that there is no instrumental influence resulting in some false periods in the data.

We marked a region of $350 \times 360$ pixels and covered it by a grid of squares $10 \times 10$ pixels each. Each pixel size is $1.1 \times 1.6$ arcsec, therefore the size of the each square is $11 \times 16$ arcsec. In each of those $1260$ squares we evaluated the integral of the signal for each frame of the 4700 series.

4. RESULTS

In the Figure 3 one can see the time series plot of the bright point No 1 integrals versus the corresponding bright point No 2 integrals. One can see a certain hysteresy, which means that each bright point achieved its maximum in slightly different time.

In the Figure 4 one can see the cross correlation function between the time series of integrals in bright point No 1 versus the corresponding bright point No 2. The maximum value of the correlation function (the correlation coefficient) is 0.848, that means a very high correlation between the two bright points occurred.

We compared the correlation between all the other sites in the active region. Therefore for each square time series we calculated the correlation coefficients with all the other squares time series, i.e. for all 793 170 combinations. All the correlation coefficients we
considered as a distribution, very similar to a Gaussian distribution, see Figure 5.

We analyzed the cases where the correlation coefficient values were higher than $\mu + 3\sigma = 0.68$ and the cases where the correlation coefficient value was smaller than $\mu - 3\sigma = -0.51$. We consider these cases as the ones where the correlation is the strongest. All the cases of such a defined strongest correlation can be seen in the Figure 6. This result was more or less expected, i.e. the marked network of squares with the high correlation covers mainly the Hα floculi, which are supposed to be interconnected by loops of magnetic field.

5. CONCLUSIONS

The higher values of correlation between the time series of signal values integrated over a square of 11" arcsec size concern only the sizes excited by emission, which generally corresponds to higher values of magnetic field. Having the described method elaborated, further analysis concerning the relation to magnetic field distribution and its time behaviour is planned.

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REFERENCES

Figure 7. The marked squares are the places where the absolute value of the correlation coefficient of the bright point No. 1 with all the others time series exceeds $\mu \pm 1\sigma$ of the distribution.

Figure 9. The marked squares are the places where the absolute value of the correlation coefficient of the bright point No. 1 with all the others time series exceeds $\mu \pm 3\sigma$ of the distribution.

Figure 8. The marked squares are the places where the absolute value of the correlation coefficient of the bright point No. 2 with all the others time series exceeds $\mu \pm 1\sigma$ of the distribution.

Figure 10. The marked squares are the places where the absolute value of the correlation coefficient of the bright point No. 2 with all the others time series exceeds $\mu \pm 3\sigma$ of the distribution.