PREFLARE HXR AND CHROMOSPHERIC LINE EMISSION IN NOAA 0652 ON 25TH JULY 2004

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ABSTRACT

We present an analysis of the event preceding the July 25, 2004 flare at 13:37 UT. A combination of RHESSI, TRACE data and observation in Hα, CaII K lines allowed us to track processes taking place in a wide range of solar atmosphere layers - from the temperature minimum region to the corona. We scanned Hα and CaII K images for a localization of fast intensity changes and carried out spatial and temporal comparison with result of hard X-ray (HXR) and ultraviolet (UV) observations. We revealed that places of fast changes of Hα intensity are small-size structures which locate within the X-ray source. For some of them Hα intensity changes are in a good temporal correlation with the HXR bursts. The possible scenario of the event and its role in initiation of the subsequent flare are discussed.

Key words: HXR ; energy release; accelerated particle beams; pre-flare event; RHESSI; Hα.

1. INTRODUCTION

Fast temporal fluctuations of both hard X-ray and optical emissions are usually attributed to the propagation of beams of accelerated particles and to the dissipation of the energy in lower layers of solar atmosphere. It is rather difficult to prove a temporal correlation between HXR and optical emission variations, nevertheless, we've seen series of interesting results. Thus, we are able to mark out a couple of studying tendencies.

The first one is an investigation of rapid variations of the Hα line intensity and its correlation with HXR flux during the impulsive phase of chromospheric flares which have been reported by many authors, e.g. Trottet et al. (2000). The other one is comparison of the spatial distribution of hard X-ray sources and Hα flare kernels. For example, such study was done by Asai et al. (2002). They found that many Hα kernels brighten successively during the evolution of the flare ribbons.

In the multi-wavelength investigation of the solar flare by Kašparova et al. (2005a,b) considerable attention was paid to locations of the fast changes of Hα intensity. In agreement with predictions of some solar flare models, the hard X-ray sources are located on the external edges of the Hα emission and they are connected with chromospheric plasma heated by the non-thermal electrons. But the fast changes of Hα intensity are placed not only inside the hard X-ray sources, as expected if they are the signatures of the chromospheric response to the electron bombardment, but also away from them. This fact may indicate that the response of the lower atmosphere to the flare energy release is not restricted to the sites of propagation of the accelerated electrons (Kašparova et al., 2005a,b).

However, previous studies of the correlation between the chromospheric lines and HXR response were carried out for the case of the solar flare but the small-scale chromospheric emission events have been ignored. Nowadays, the accuracy of RHESSI observation allow us to realize such investigation and try to trace a pre-flare activity of active region (AR).

2. OBSERVATIONS AND DATA PROCESSING

We carried out the multi-wavelength study using RHESSI, Hα, TRACE, and MDI observations. The Hα and CaII K line slit-jaw images were obtained at The Vacuum Tower Telescope (VTT), Obsevatorio del Teide. They had 5 second cadence and were taken successively in chromospheric lines and whitelight. The duration of the series was usually about 1–2 minutes.

We used the data obtained in AR 0652 (N08W35) from 13:34 UT to 13:37 UT on July 25, 2004. In order to fix the heliographic coordinate system of the studying region,

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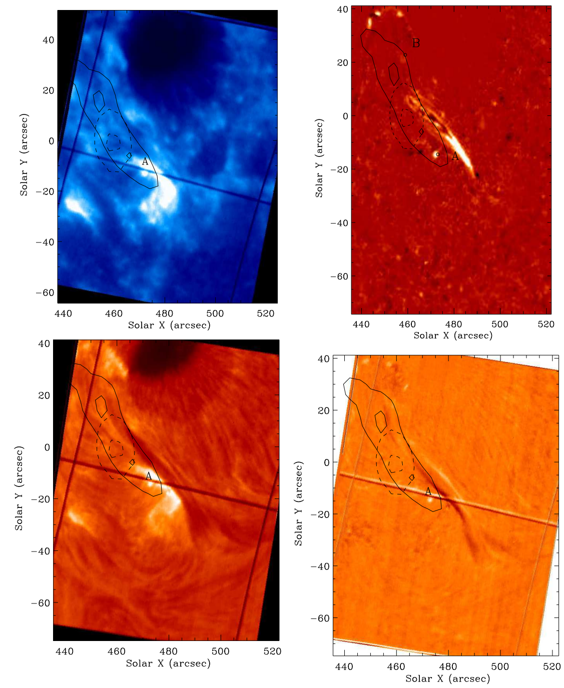

Figure 1. Left top: the CaII K line image at 13:34:58 UT. Left bottom: the Hα line image at 13:35:04 UT. Right top: The difference intensity image in 1600 Å band (13:34:16–13:35:01 UT). Right bottom: The difference intensity image in Hα (13:35:04–13:33:09 UT). RHESSI image at 12–25keV and 25–50keV are plotted as solid and dashed contours at 50 and 90% of the image maximum, correspondingly.

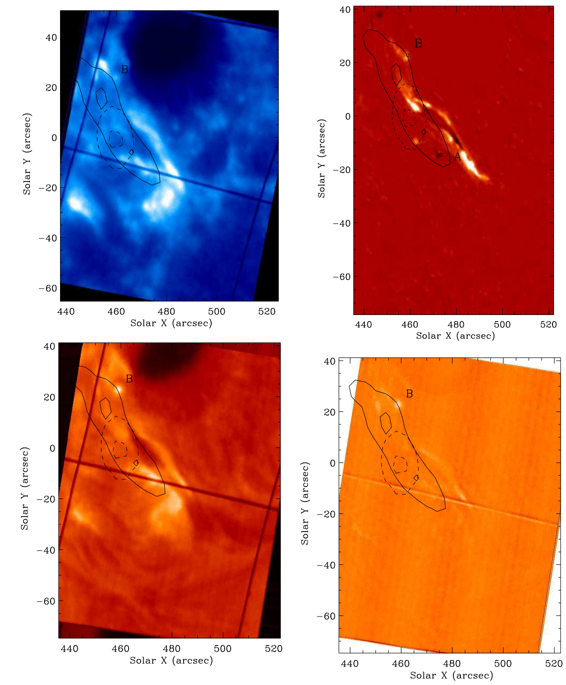

Figure 2. Left top: the CaII K line image at 13:36:32 UT. Left bottom: the Hα line image at 13:35:53 UT. Right top: The difference intensity image in 1600 Å band (13:35:01–13:35:46 UT). Right bottom: The difference intensity image in Hα (13:35:53–13:35:48 UT). RHESSI image at 12–25keV and 25–50keV are plotted as solid and dashed contours at 50 and 90% of the image maximum, correspondingly.

we use SOHO/MDI intensitygrams and 1600 Å TRACE observations. The accuracy of the heliographic coordinate determination is about 2 arcseconds.

For comparison Hα intensity changes with HXR flux, we used RHESSI data with temporal resolution 2 seconds. The HXR source images for 12–25 keV and 25–50 keV bands were reconstructed by PIXON algorithm. CLEAN algorithm had not revealed a clear source image for the 25–50 keV band and we had to use the PIXON imaging technique. The PIXON algorithm (Puetter and Pina 1994; Metcalf et al., 1996) is known to suppress spurious sources and to have high photometric accuracy.

We used 1600 Å images obtained by TRACE for detecting the changes in lower layers (the temperature minimum region). SOHO/MDI magnetograms and 195 Å images by TRACE were used for magnetic field structure analyzing.

3. THE FAST Hα AND CAII K CHANGES

We carried out a search for the fast increasing of the Hα and CaII K line intensities in observations obtained between flares (from 13:32 to 13:37 UT) and revealed two events which interested us.

It was difficult to detect the correct time of the first event ("A") shown on Fig. 1. We found no significant intensity changes for the set of CaII K line images from 13:33:14 to 13:34:58 UT. After the spectral region change at 13:35:04 UT a new bright spot–like feature (with size about 3 arc seconds) was seen on the Hα image. Possibly, the CaII K intensity increased weakly and gradually but, may be, the maximal rise was just between 13:34:58 and 13:35:04 UT when the spectral region was changing. The event was seen not only in chromospheric lines but in UV 1600 Å band which corresponds to the temperature minimum region. Unfortunately, temporal resolution of TRACE observations was 45 seconds that didn't allow us to compare fast intensity changes in upper and middle chromosphere with behaviour of the temperature minimum region. But we are able to associate "A" event with 1600 Å emission origin.

The second event ("B") consisted of several objects (Fig. 2) and its maximum felt within the Hα image series. This got us ability to compare temporal intensity evolution in Hα line in the event with HXR flux. We also found the objects in 1600 Å band associated with fast

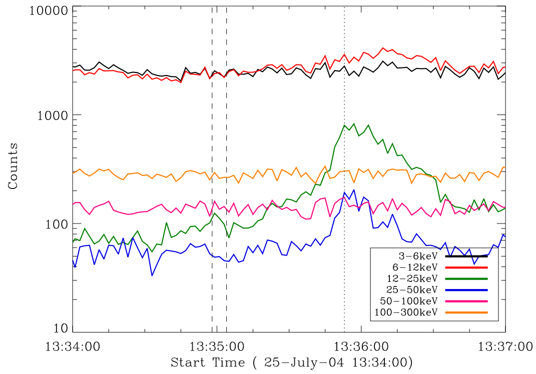

Figure 3. Temporal evolution of hard X-ray flux (RHESSI). The dashed lines correspond to the event "A" and show the interval between the change CaII K image series to Hα images. The dotted line corresponds to the event "B".

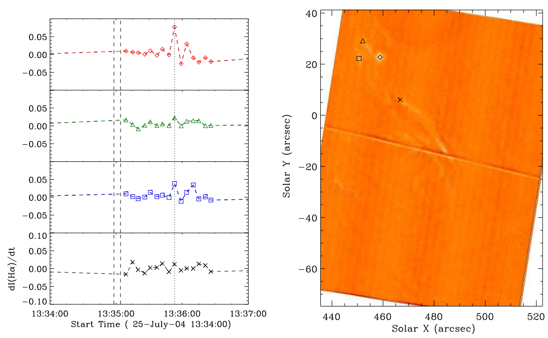

Figure 4. Left: Time evolution of dHα for different locations shown by corresponding signs on the right panel. Right: The difference intensity image in Hα (13:35:53–13:35:48 UT). The dashed and dotted lines are the same as on Fig. 3.

Hα changes.

4. RESULTS OF Hα INTENSITY COMPARISON WITH HXR

In spite of a small spatial scale of the observed emissions, we found their relation with HXR-bursts (Fig. 3). As it was noted above, the correct time of the event "A" wasn't defined but we mark temporal positions 13:34:58 UT and 13:35:04 UT in order to give an estimate of its connection with HXR-flux evolution. One can point out the pick of the 12–25 keV band flux during that period but a small amplitude of the pick makes such conclusion a speculative one.

The moment of the maximal intensity increasing of the event "B" agrees with the flux maximum in 12–25 keV and 25–50 keV bands (Fig. 3). But only the circular small–size feature demonstrates the good temporal cor-

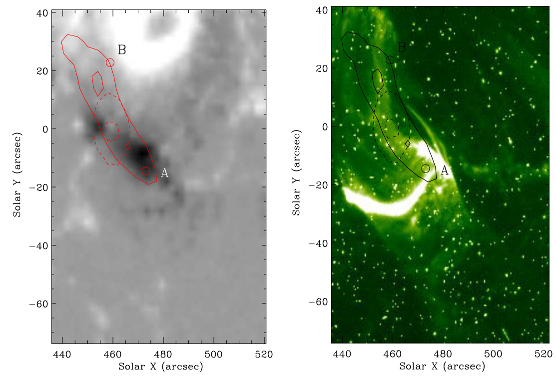

Figure 5. Left: The magnetogram of investigated region obtained by MDI SOHO at 13:35:30 UT. Right: The image of investigated region in 195 Å obtained by TRACE at 13:32:30 UT. RHESSI image at 12–25keV and 25–50keV are plotted as solid and dashed contours at 50 and 90% of the image maximum, correspondingly.

relation of the Hα intensity rise with flux in 12–25 keV and 25–50 keV bands (Fig. 4).

To analyze the event locations relatively to HXR sources we reconstructed source image for 12–25 keV and 25–50 keV bands from 13:35:44 UT to 13:36:16 UT and superpose them on the all images at Fig.1–2.

The both event centers ("A" and "B") located inside the 12–25 keV band source and outside the 25–50 keV band source. Furthermore, no essential emission at the chromospheric level (in Hα and CaII K lines) was detected in the region corresponded to non–thermal electrons (25–50 keV) but we found the intensity rise in the UV 1600 Å band (the temperature minimum region).

5. DISCUSSION

We revealed correlation of the fast increasing in the Hα and CaII K line intensity between two flares (from 13:32 to 13:37 UT) with HXR-data. The considered events were seen not only in chromospheric lines but in UV 1600 Å band. Also, it should be pointed out a slight increasing of the 50–300 keV band flux between these events.

We found no significant intensity changes for the set of CaII K line images from 13:33:14 to 13:34:58 UT for the event "A". However, the event "A" manifestation in Hα line and in 1600 Å band are obvious. Possibly, the CaII K line intensity increased weakly and gradually but, may be, the maximal rise was just between 13:34:58 and 13:35:04 UT when the spectral region was changing.

The second event ("B") consists of several objects but only the circular small–size feature demonstrates a good temporal correlation of the Hα intensity with flux in 12–25 keV and 25–50 keV bands. The both event centers

("A" and "B") located inside the 12–25 keV band source but outside the 25–50 keV band source. Furthermore, no essential emission at the chromospheric level (in Hα and CaII K lines) was detected in the region corresponded to non–thermal electrons (25–50keV) but we find the intensity rise in the UV 1600 Å band (the temperature minimum region).

We can speculate about the probable explanation of observations. In spite of temporal correlation of the intensity rise in the "B" center with HXR flux, the fast changes of chromospheric emission was generated by thermal electrons with energy about 12–25 keV only. The non–thermal electrons went through the chromosphere without any detectable effect and produce the emission in lower layers. Unusual fine structure of optical emission connected with HXR flux could be the result of complicated magnetic field structure (Fig. 5).

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