Chromospheric Response to a Short-Duration Beam Heating: Observing Programme and Numerical Simulations

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Abstract. We present a new observing programme to detect fast intensity variations of optical lines, relevant to a flare pulse-beam heating. Namely we show some preliminary results of the Hα line intensity temporal variations detected by the Multichannel Flare Spectrograph of the Ondřejov Observatory. This instrument allows recording of fast line intensity/profile variations in selected optical lines (currently Hα, Hβ and CaII 8542 Å) by means of a video CCD system. While here an example of BATSE HXR complementary data is shown, our optical CCD system will in future operate simultaneously with HESSI and Czech HXR spectrometer onboard the MTI satellite. We also show first results of numerical simulations of pulse-beam heating of the chromosphere which demonstrate significant intensity variations of the Hα line. The numerical code is briefly described.

1. Introduction

During the impulsive phase of a flare, Hα line intensity increases as the result of an energy deposit in the chromosphere. The energy can be deposited in various ways, but two most important ones are the particle-beam heating and conductive heating. Particularly a beam heating is supposed to take place on rather short time scales, reaching seconds or even less. The corresponding hard X-ray (HXR) spikes have been detected. The question arises whether the optical lines, formed in chromospheric layers which are heated by the beam bombardment, do exhibit similar temporal variations as HXR. While Hα intensity follows more or less gradual increase of soft X-ray emission, short-duration HXR pulses are difficult to correlate with Hα variations. There are two basic questions addressed in this paper: (i) can we detect fast Hα variations reliably and if so, how they are correlated to HXR, and (ii) do the radiation-hydrodynamical (RHD) simulations predict such Hα variations?
2. 19 July 1999 Flare

On July 19, 1999 we observed a flare in NOAA 8836, both using the patrol-service telescopes and the Multichannel Flare Spectrograph - MFS (www.asu.cas.cz). After the flare has started, the MFS took a series of Hα spectra together with the Hα slit-jaw images (Fig. 1). Both have been recorded by the CCD video system with a cadence of 25 spectra/images per second (Kotrč et al., 1993). This allows us to detect very fast variations in the spectrum and to use the frame-selection technique for selecting best images. Fig. 2 demonstrates the Hα line intensity (maximal and integrated) variations with time during the onset of the flare. The flare was also detected by BATSE instrument and we show the HXR flux variations (full disk).

At 08:20:53 UT one can recognize a broader minimum in BATSE HXR flux which seems to coincide with an intensity drop in Hα as evident from Fig. 2. Also the general behaviour of the Hα emission follows rather closely the HXR one observed between 08:20:20 and 08:21:20 UT. The identification of such a coincidence between Hα and HXR on time scales of the order of seconds is very promising, however further analysis and more such observations are needed.

3. Numerical Simulations

Numerical code (RHD package) consists of three basic parts: hydrodynamics, particle code and the non-LTE radiative transfer part. The flare loop, extending from the corona down to the photosphere, is approximated by a vertical 1D
atmosphere. The code is fully time dependent. Hydrodynamical part solves the continuity, momentum-balance and energy equations. This is coupled to the particle code which evaluates the beam propagation through the atmosphere and determines the energy deposit at each depth (see e.g. Karlický and Hénoux, 1992). Finally, the non-LTE part solves the radiative-transfer problem for a multilevel hydrogen atom, in order to supply the ionization degree and radiation losses into the hydro part. Simultaneously, the synthetic spectrum is computed at each time. The non-LTE method is based on fast numerical approach called MALI (see Heinzel, 1995). The code also allows to compute the emergent time-dependent HXR emission which can be directly compared with HXR data. As an example, we show here the result of our preliminary simulations which start from the unperturbed VAL atmosphere (Vernazza et al., 1981) and then describe the chromospheric response to an electron beam of short duration. Fig. 3 displays the Hα line-core intensity as it increases with time. At the time $t = 0$ we recognize a standard absorption profile, while the intensity grows up rapidly during 2 sec (200 units in the plot). Note a short-duration intensity drop just after $t=0$ (Heinzel, 1991).

4. Conclusions

The numerical RHD code is now under further development. The results of simulations will be compared with new data obtained simultaneously by optical instruments (MFS spectra and images, including the linear polarization) and by HXR detectors on HESSI and onboard the MTI satellite (Färnık et al., 1998). From this we expect a better understanding of mutual relations between optical and HXR emissions on very short time scales.

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Figure 3. Numerical simulations of Hα line profile variations. Wavelengths are in arbitrary units, intensity in % of the nearby continuum.

References