Measurements of Continuum Flux in Solar Flares

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Abstract. A broad-band diagnostics of chromospheric flare plasma needs to analyze spectra covering many spectral lines and various continuum features. The flare spectra are well detected on the background of the solar disk, but the detection of flare line emission from the Sun-as-a-star in optical is much more difficult due to a strong background radiation. When the flare/background radiation contrast is strong enough to be detected, we need a device for measuring the flux from a selected part of the flaring region. Here we present technical demands for such an instrument and its brief description. This device denoted as Image Selector is a post-focus instrument installed at the horizontal solar telescope HSFA2 of the Ondřejov observatory, described by Kotrč (2009). Its core consists of a system of diaphragms, imaging Hα telescope and a fast spectrometer with dispersion of 3 px per Å but with cadency reaching up to 50 frames per second. The first solar flares observed recently by this novel technique provide quite interesting results. Our analysis of the data proves that the described device is sufficiently sensitive to detect variations in the Balmer continuum during solar flares.

1. Introduction

Detections of the Balmer continuum enhancement during flares had been tried many times, but the results were rather controversial. In some cases the Balmer jump was detected (e.g. Zirin & Neidig 1981, Hiei 1982), in others only a smooth transition from the so-called ‘blue continuum’ (Donati-Falchi, Falciani, & Smidhile 1985, Kowalski et al. 2015) to the Balmer continuum was detected (see also summary by Neidig 1989). Many flare spectra with good spectral resolution have been collected at the Ondřejov Observatory during the sixties, but Švestka 1966, claimed that there was no evidence of the Balmer-continuum enhancement. However this might be because of the photographic technique used at that time. Only recently, Heinzel & Kleint 2014, have found a clear signature of the continuum enhancement in the far wing of Mg i h-line during an X1-class flare observed by the Interface Region Imaging Spectrograph (IRIS) satellite and they attributed this emission to the Balmer continuum. This is promising, but in order to determine reliably the spectral shape of the continuum, we need simultaneous observations of the Balmer continuum in more than one narrow-band channel. We therefore started a systematic observing program of detecting the Balmer continuum from ground and for that we designed a novel instrument.
2. Technical Demands

We decided to develop a special instrumental setup. This would allow to detect optical spectra in a certain wavelength range only from a limited area of the solar disk covered by an active region where the flare occurrence is expected. We have considered the following technical requirements for the ground-based feeding telescope and for the new post focal spectroscopic instrument:

A high ratio $D/f$ of the objective to have enough light ($D$ and $f$ are the diameter and focal length, respectively). A stable guiding system to follow the selected active region for a long time. Imaging of the active region through the H$\alpha$ filter including imaging of the diaphragm position on the H$\alpha$ filtergram. A broad-band spectrometer with high sensitivity in the continuum working with high cadency up to 50 recordings per second.

An accurate image selector of the target region on the solar disk.

Note that the seeing issues, extremely important for slit instruments, are not critical here because of the flux integration of the whole active-region/flare area.

3. Observations

We measure the total flux by a fast spectrometer from a limited but well defined region on the solar disk. Using a system of diaphragms, the disturbing contribution of a bright solar disk can be eliminated as much as possible. Light curves of the measured flux in the spectral range 350 - 440 nm are processed, together with the H$\alpha$ images of the flaring area delimited by the appropriate diaphragm. The spectral flux data are flat-fielded, calibrated and processed to be compared with model predictions. Assuming that the Balmer-continuum kernels have at least a similar size as those visible in H$\alpha$, we find the flux increase in the Balmer continuum to reach 230% - 550 % of the quiet continuum during the observed X-class flare. We also found temporal changes in the Balmer continuum flux starting 16 minutes before the onset of the flare in H$\alpha$. More details can be found in Kotrč, P., Heinzl, P. and Procházka O.: New observations of Balmer continuum flux in solar flares, Instrument description and first results, Solar Physics, 2016, submitted.

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