# Measurements of 350 – 440 nm flux in solar flares

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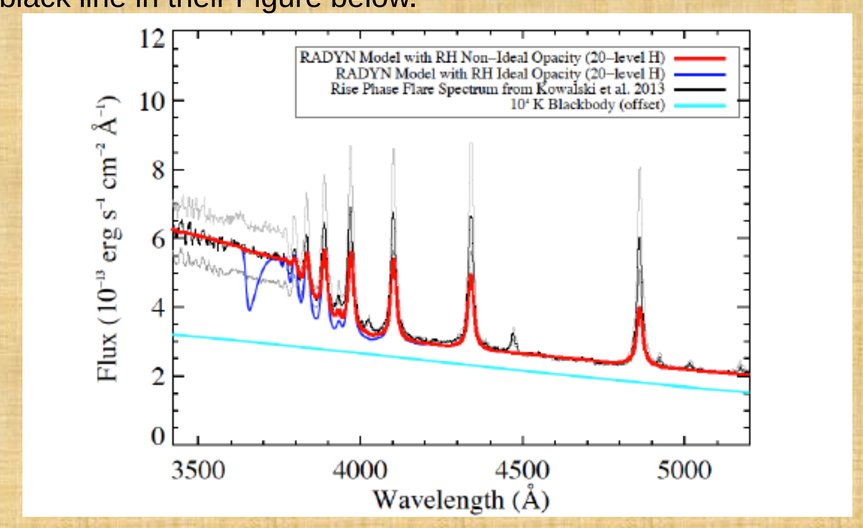
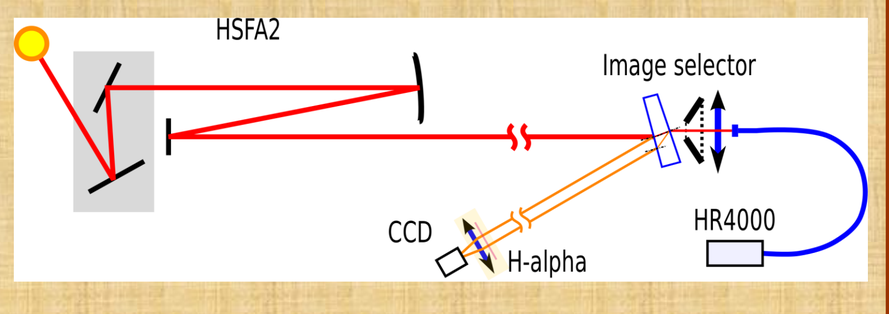
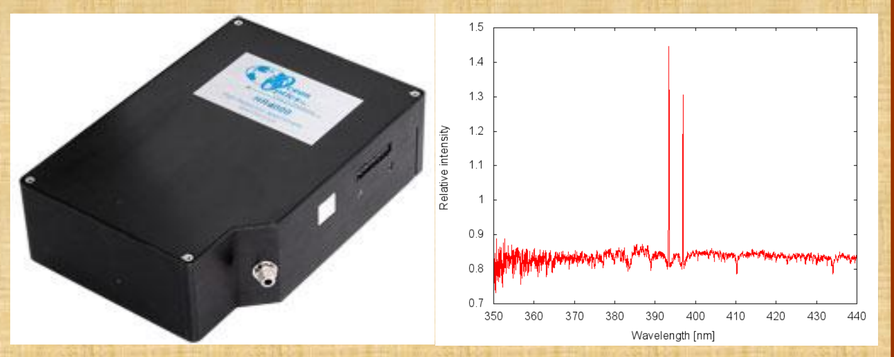
Study of continua in solar flares brings new information both to the topic of white-light flares and the physics of storage and release of the flare energy. Measurement of an increased Balmer continuum during a large stellar flare at M-type dwarf was reported by Kowalski et al. 2013, ApJS, 207, 15, see the black line in their Figure below.




We measure spectra from a selected part of the solar flare region. As a measuring device we constructed a post-focal device consisting of an image selector and a fast spectrometer. A small H-α telescope takes snapshots from the reflecting optical surface in front of the diaphragm of the selector. See the schema below.

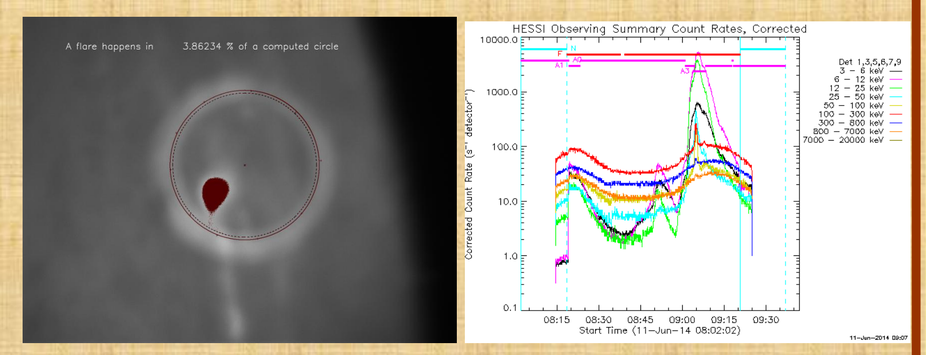



Horizontal solar telescope HSFA2 (red line) creates solar disk image Φ 32 cm at the optical surface (blue wedge). Light is partly reflected to the Hα telescope (light brown) and partly enters to the light collector through one of 7 diaphragms placed on a rotating wheel. Optical cable (blue arc) feeds the spectrometer HR4000 (right down).




The HR4000 high-resolution spectrometer with a 3648-element CCD-array enables optical resolution of 0.02 nm (FWHM). The specific range and resolution depends on the grating and entrance slit choices.

Recently, we put the device into operation and observed a few flares. We present preliminary results of the X1.0 flare on June 11, 2014 at 8:46 UT. See the Hα image as reflected from the Image Selector and the RHESSI plot below.




Left: Hα image from the reflected light from the selector. Flare kernel is marked red, the bright ring with a red circle determines the entrance diaphragm collecting the light into the fast spectrometer. Right: RHESSI plot for the flare observed near the eastern limb image (East to the right).

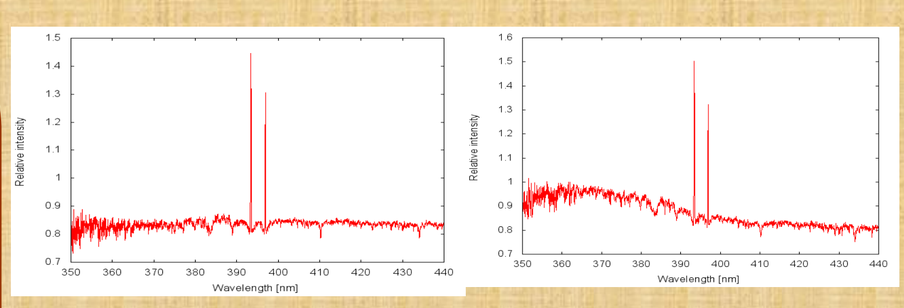
We studied the spectral flux in several individual channels as the Balmer continuum, Balmer limit, Ca H or K lines, Fe lines, G-band etc. Eg. the Balmer2 stands for 351.10 - 363.03 nm.

## Motivation:

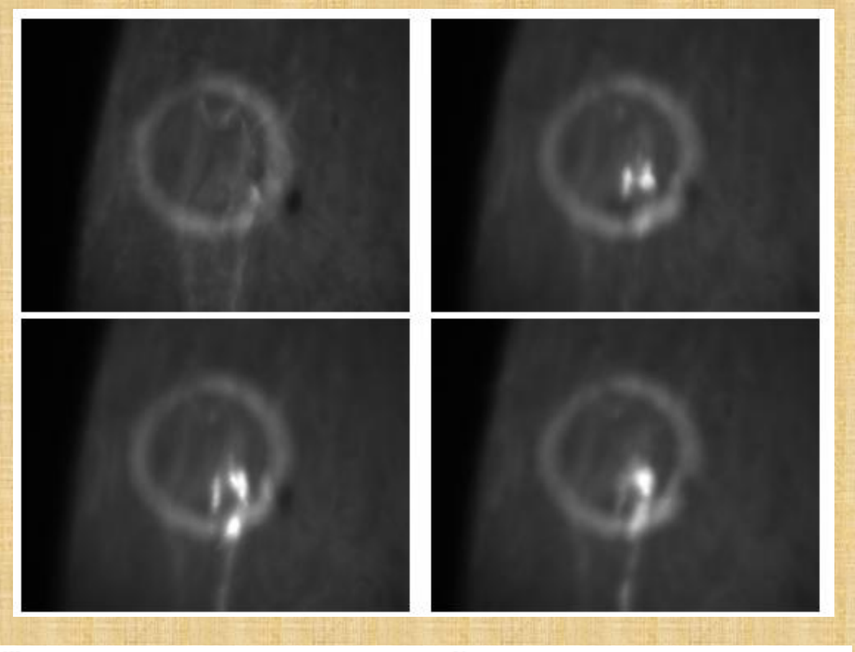
The flare EUV spectra are well detected on the background of the solar disk by the EVE spectrometer on SDO measuring an integrated flux of the Sun-as-a-star. On the other hand, the detection of flare line emission from the Sun-as-a-star in optical is more difficult due to a strong background radiation. When the flare/background optical radiation contrast is strong enough to be detected, a device for measuring the flux from a selected part of the flaring region can be developed. Here we describe a post-focus instrument installed at the horizontal solar telescope of the Ondrejov observatory. First data from one of the three solar flares observed recently are presented and analyzed.

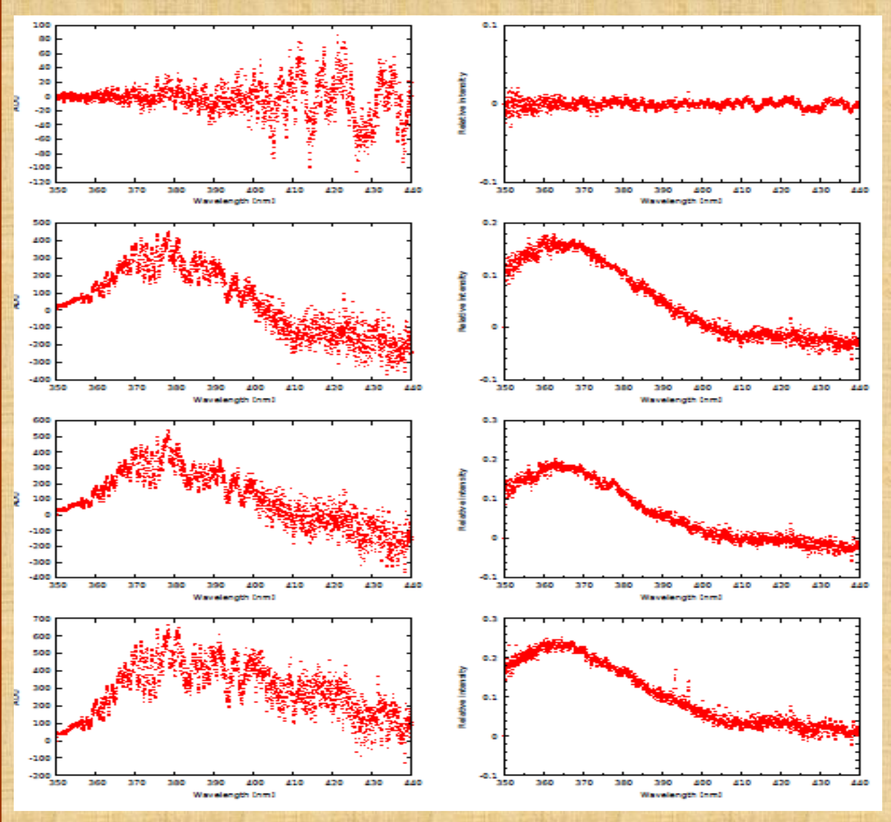
## Conclusions:

The results prove that the described device is sufficiently sensitive to measure possible changes of the Balmer continuum during a flare. For the flare analyzed we supposed that the plasma material radiating in Hα is the same as in Balmer continuum. Then the flux increase in Balmer continuum is 500 %. It is in an agreement with calculations of Zharkova and Kobylinsky (SolPh, 143, 1993, p. 259) who predicted such an increase up to order of 2.5 as an direct effect of accelerated particle beams. An increase of Balmer continuum beyond 284 nm detected in IRIS was reported very recently by Heinzel and Kleint, (2014, ApJL). Moreover, we found also interesting temporal changes of the Balmer continuum flux. They started even 14 minutes before the onset of the flare in Hα. It is very promising not only for proper mechanisms flare energy release, but also for their predictions. We need more flare observations to analyze the general aspects of the Balmer continuum flux and other neighbouring spectral channels during solar flares. The results might be important for stellar flares study as well.

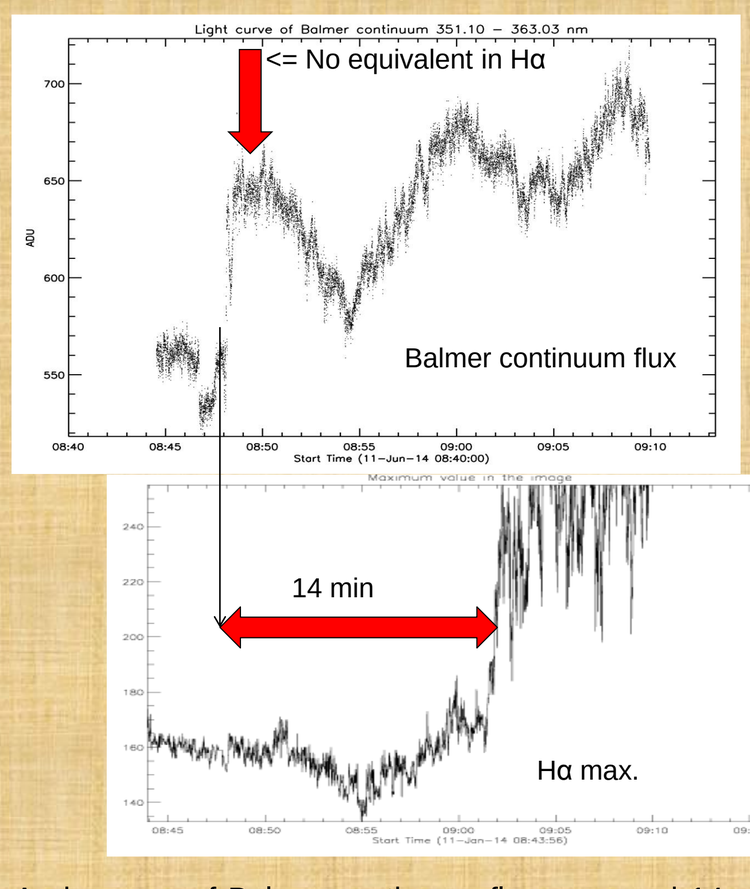



Examples of the measured spectra before the flare (left) and during the flare (right). See the CaII H and K and the increased continuum in the flare of which the “slit-jaw” images are below.






Left: Flare spectra minus non flare spectra.
Right: (Flare minus non flare) divided by non flare spectra




An increase of Balmer continuum flux appeared 14 minutes before the Hα flare began. It might be important for theory of flare mechanisms and for the short-time flare predictions.

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