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Low-resolution spectroscopy of the chromospherically active stars 61 Cyg AB with small telescopes

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We carried out high-speed low-resolution spectroscopy of two stars, 61 Cyg A and B with small telescopes. They are known as chromospherically active stars of the K5V (A) and K7V (B) spectral types. These two stars are supposed to have high-powered chromospheres. Spectroscopic monitoring of both stars showed variations of intensity in the Balmer lines and the Mg b triplets at time intervals ranging from seconds to several minutes. From the spectrum data one can find that relative variations in the H_α, H_β lines and the Mg b triplets are about 1% and the relative power of chromospheric activity about $2 \cdot 10^{-4}$.

Key words: instrumentation: detectors, methods: observational, techniques: image, processing techniques: spectrometric, stars: imaging

INTRODUCTION

Main chromospheric activity indicator is the presence of a distinct emission component in the nuclei of the H and K CaII and hydrogen lines. These emissions, for example, in spectra of Arcturus and some other stars vary periodically, by analogy with the solar cycle. It is assumed that these variations are associated with microflares, the main source of coronal heating in chromospherically active stars.

61 Cyg AB are BY Dra type variables. Long-term X-ray monitoring of 61 Cyg binary with XMM-Newton was used to investigate possible coronal activity cycles [2]. The X-ray light curves were compared with the long-term monitoring of chromospheric activity, as measured by the Mt. Wilson CaII H+K S-index. Besides variability on short time scales, typical for the RY Dra type variables, long-term variations of the X-ray activity were found clearly present. For 61 Cyg A distinct chromospheric activity cycle was found resembling the solar behaviour. The coronal activity of 61 Cyg B also follows the chromospheric variability. 61 Cyg A was the first star where a persistent coronal activity cycle has been observed [2].

The hydrogen Balmer lines are formed at the middle chromosphere. In active stars they often show filled-in absorption features. They can be used also as a diagnostic tool for the presence of plages and prominences on the stellar surface.

The purpose of this work was the detection of rapid variations of spectral lines in sub-second range. Spectra and variations in the spectra at different time scales allow us to confirm the presence of rapid variations in the sub-second range for both stellar components of 61 Cyg.

OBSERVATIONS

We present low-dispersion (R ∼ 100) optical (3900–8000 Å) spectra of 61 Cyg AB binary stars obtained with the AZT-2 (D = 70 cm, F = 10.5 m) and the Sky Watcher 1201 EQ5 (D = 12 cm, F = 1 m) telescopes. They are equipped with the diffraction grating “The Star Analyzer SA-200” for low-dispersion spectroscopy. We used the Atik CCD Camera 314L and the commercial DSLR Camera Canon 350D.

On August 18, 2013, we obtained 305 low-resolution grating spectrograms of 61 Cyg AB. The observations were acquired with the AZT-2 Cassegrain telescope in Kiev equipped with a grism spectrograph [5], and the Atik CCD Camera 314L. The exposure time was 0.1 s and the sampling interval of 0.9 s. The spectrograms cover a wavelength range from about 3700 Å to 9000 Å, and have a resolution of R ∼ 100. The signal-to-noise ratio is typically about 100.

We obtained also 100 low-resolution grating spectrograms of 61 Cyg A with the Sky Watcher 1201 EQ5 on March 13, 2014, equipped with the commercial DSLR Camera Canon 350D. The exposure time was 2.0 s at ISO 800, the read-out time was 3 s, and the sampling interval was 5.0 s. The spectrograms cover a wavelength range from about 4100 Å to 6800 Å, and have the spectral resolution 51 Å per

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pixel in the vicinity of the H_β line. The signal-to-noise ratio is typically about 10 for a star of V = 5.21. A sample spectrum is shown in Fig. 1. Spectroscopic monitoring of 61 Cyg AB sar in the quiescent state showed variations in the Balmer lines H_α (6563 Å), H_β (4861 Å) and the Mg b triplets (5163–5186 Å) in the sub-second range.

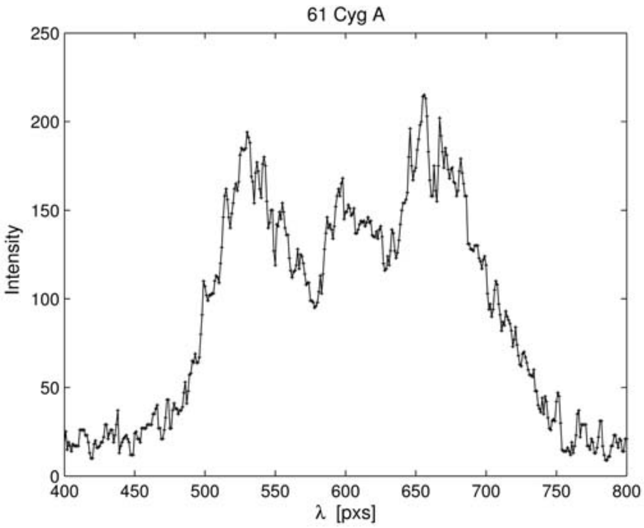

Fig. 1: A sample of raw spectrum of 61 Cyg A with the Sky Watcher 1201 EQ5, equipped with the commercial DSLR Camera Canon 350D.

RESULTS AND CONCLUSIONS

Spectroscopic monitoring of the "spotted" stars 61 Cyg A, B showed variations in the Balmer lines and, perhaps, the Ca II H, K lines, as well as in the Mg b triplets in the sub-second range (Figs. 2–4). The relative variations usually defined as an r.m.s. deviation divided by the mean.

Fig. 2 depicts a plot of relative power variations in the spectra depending on the wavelength. Note "emission" features in the spectra of 61 Cyg A at wavelengths of the Balmer lines H_β, H_δ and, possibly, the Ca II H, K lines. Using the spectrum data one can find that the total variations in the intensities of the H_β line is about 1% and about 0.5% in H_δ and the relative power of chromospheric activity is about of $2 \cdot 10^{-4}$. The relative power of chromospheric activity was estimated as a ratio of variations in the active lines to the luminosity of a star on the whole.

Fig. 3 demonstrates detectable activity in the spectrum of 61 Cyg B in the Balmer lines H_α and H_β on the short timescale down to 0.9 s.

Variations in the Balmer line H_β and the Mg b triplets in Fig. 4 reveal different activity on 61 Cyg A acquired another day than depicts in Fig. 2.

Of prime importance, that the spectrum data obtained with different resolving time demonstrate transient activity in the Balmer lines and, possibly, the Ca II H, K lines. The different time resolution follows from the initial 0.9 s resolution data rebinned over 9, 45, 90 s intervals. The presence of peaks in variations of spectra indicates the transient nature of chromospheres' activity in both stars 61 Cyg.

As it was mentioned by [1], variability of the chromospherically active stars could be explained by assuming that the heating of its corona results from a large number of small flares. It is well-known that the solar corona is heated by the two most favoured agents involving magnetic fields, namely magnetohydrodynamical waves and transients, such as flares, micro- and nanoflares (see [3] and references therein).

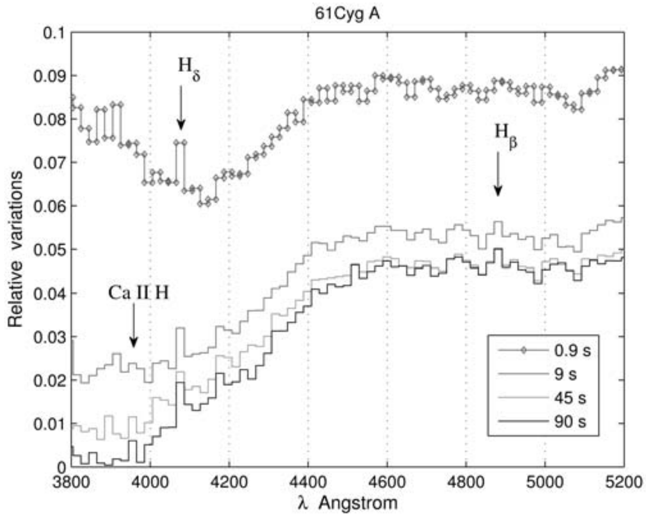

Fig. 2: The relative variations are shown in the spectrum of 61 Cyg A from a sample of 305 time-resolved spectra. Peaks of activity are clearly visible in the short-wave part of the spectrum. The variation curves are calculated from samples with a time resolution from 0.9 to 90 seconds.

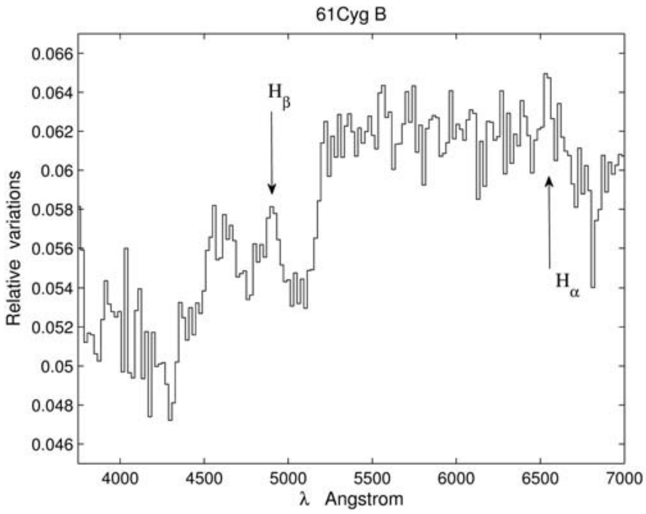

Fig. 3: Variations shown in the spectrum of 61 Cyg B demonstrate detectable activity in the H_α and H_β Balmer lines on the timescale of 0.9 s.

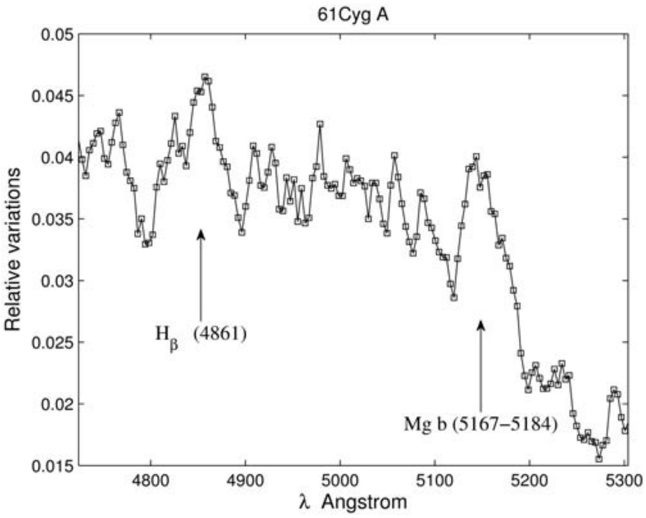

Fig. 4: Variations in the Balmer line H_β and the Mg b triplets of 61 Cyg A acquired with the DSLR Camera Canon 350D.

Photometric observations of three chromospherically active stars showed high-frequency variations in brightness in the UBV bands at sub second range [4]. Intensity variations are found peaked at frequency around about 0.5 Hz, spanning the range up to 1.5 Hz for BD +15 3364, II Peg, and up to about 35 Hz for SAO 52355. High-frequency changes, which were found in these stars suggests the existence of intense microflaring. Hence it follows, that time-resolved spectra could demonstrate activity on time scales compatible with radiative lifetime of flare events.

It appears that the observed variability patterns on 61 Cyg AB can be related to an ensemble of microflares with a duration ranging from tenths to tens of seconds.

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