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CHROMOSPHERIC ACTIVITY OF THE FLARE STAR YZ CMI IN QUIESCENCE ACCORDING TO THE FAST SPECTRAL MONITORING DATA

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ABSTRACT. Spectral monitoring of the flare star YZ CMi (U = 12.9, B = 12.7, V = 11.1) was carried out on the Zeiss-600 telescope at the Peak Terskol Observatory. We used a low resolution grating spectrograph with spectral resolution of ~ 100 Å and time resolution from 2 to 30 s. The spectra of the star in the quiescent state show variability in the lines H_β, H_γ, Mg b, possibly in CaII K + H_ε. Variations of the equivalent widths of the order of several percents were detected. The characteristic time of variations is about of a few minutes. The observed variations indicate the non-stationary activity of the flare star YZ CMi chromosphere in the quiescent state.

Keywords: Stars: variability – methods: statistical – stars: late-type

1. Introduction

Red dwarf star YZ CMi (dM 4.5e, R = 0.36 Rsun, M = 0.34 Msun, T = 2900 K) is one of the most bright and active flare star. According to the Crimean catalog of flare stars (Gershberg et al., 1999) optical photometry of flares contained in 164 articles, optical spectra of flares described in 55 papers. Studies of the star at quiescence state are practically absent.

In this paper, we show that the star YZ CMi demonstrates activity in the quiescent state. Activity appears in variations of chromospheric lines, in particular in lines of the triplet of magnesium Mg b (λ5167, λ5173, λ5184 Å) with amplitude of oscillation of about 2%. Fluctuations are quasi-periodic in character, in the period range from 40 to70 seconds during the observation time of about 15 minutes.

2. Observations

An array of 500 spectra of YZ CMi and two comparison stars has been obtained with a low resolution grism spectrograph (Zhilyaev et al. 2012) mounted on the Zeiss 600 telescope, at the Peak Terskol Observatory, on November 6, 2009. A spectral resolution was about of 100 Angstroms and a time resolution of 2.78 seconds. Averaged spectra of YZ CMi at quiescence and two comparison stars are shown in Fig. 1.

3. Results

The Allan power spectra for YZ CMi (Fig. 2) demonstrates high-frequency activity in the lines of chromospheric hydrogen H_β, H_γ and perhaps in H_ε and Ca II K (3968 Å), and in the triplet of magnesium Mg b (5168, 5173, 5184 Å). The amplitude of the variations in the lines of Mg b, determined by Fourier power spectrum is about 2.2% (0.02 magnitudes).

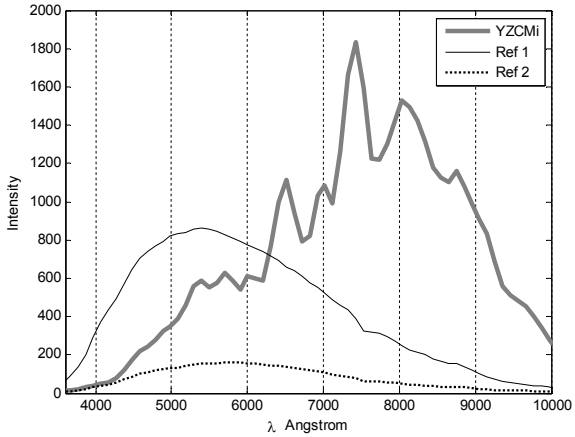

Figure 1: Averaged spectra of YZ CMi and two comparison stars.

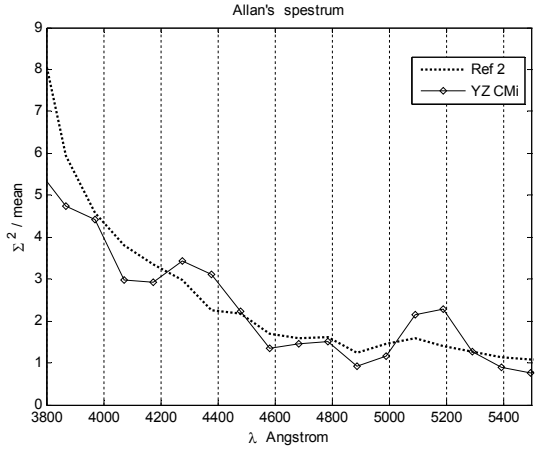

Figure 2: The Allan power spectra of YZ CMi and a reference star.

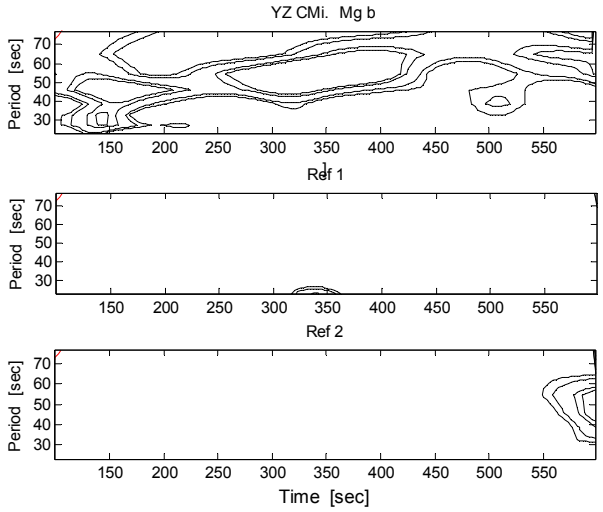

Figure 3: The wavelet power spectra of YZ CMi and comparison stars.

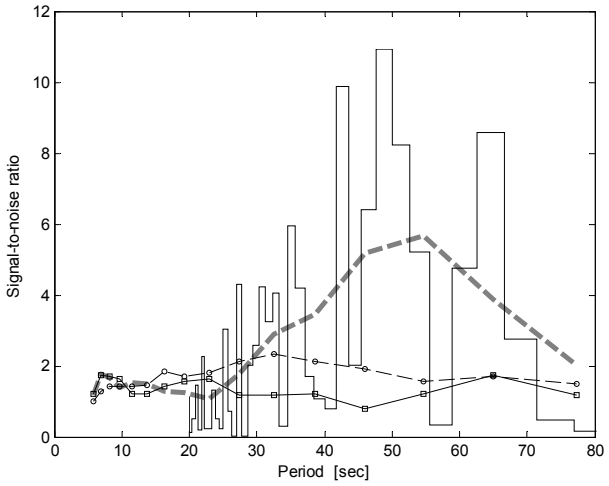

Figure 4: The global wavelet power spectrum of YZ CMi (thick line), the Fourier power spectrum (thin line) and the global wavelet power spectra of comparison stars (circles and squares).

The Allan power spectrum is equal to power spectrum of variation (dispersion Σ^2) relative to an average value of intensity. To calculate the spectrum the first differences of intensities in the spectra array are used (Zhang X. et al., 2008). For a Poisson random process, this ratio is equal to one. In the magnesium lines it is twice as large as can be seen in Fig. 2. The comparison star shows no variations in the power spectrum.

The wavelet power spectra of YZ CMi (Torrence et al., 1998, Fig. 3, top panel) and the comparison stars (middle and bottom panels) shows line intensity oscillations in chromospheric lines of triplet magnesium 5158Mg b (5168 - 5184 Å). YZ CMi for 15 minutes shows intensity oscillations with a period on average of about 50 seconds. Contours in the spectra correspond to significance levels of 90, 95, 99 % and more. The mentioned harmonic in the spectra of comparison stars are absent.

The time resolution in the wavelet power spectra is about of 100 seconds. Zug of oscillations of YZ CMi shows variations of oscillation period from 30 to 70 seconds. Thus, it is possible to estimate the average oscillation period of about 50 seconds. The relative amplitude of the oscillations is $\Delta I / I = 2.2\%$.

Fig. 4 demonstrates the global wavelet power spectrum of YZ CMi (Torrence et al., 1998), the Fourier power spectrum and the global wavelet power spectra of comparison stars. The power spectra of the comparison stars show the spectrum of the normal white noise, which has a chi-square distribution with two degree of freedom. The average value of the noise spectrum equals two. The value of the global wavelet power spectrum of YZ CMi at the maximum is equal to 5.65 and corresponds to the confidence level of 94%.

Thus, using the wavelet analysis we detected quasiperiodic pulsations of the chromospheric magnesium triplet lines with period of about 50 sec for a time of observation of 900 sec.

4. Diagnosis of oscillations

As part of the solar-stellar analogy, we can assume that the oscillations could be caused by the excitation of magnetohydrodynamic (MHD) oscillation of the flare loop (Stepanov et al., 2005). Plasma heating by MHD oscillations at the footing of the flare loop leads to the observed pulsations of YZ CMi in the optical range.

The diagnostic method of Stepanov et al. (2005) allows estimating the temperature, concentration of plasma and the intensity of the magnetic field of coronal loops from the observed characteristics of the light oscillations: the period, the modulation depth and decay time.

Clearly, there may be several coronal loops with different characteristics, which give rise to variations of the chromospheric lines of YZ CMi with different frequencies and decay time.

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