SPECTROSCOPIC STUDY OF THE HOT SUPERGIANT ζ PERSEI

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ABSTRACT. The preliminary results of the high-resolution spectroscopic study of the hot supergiant ζ Persei (B1 Ib) are presented. It was found that the radial velocity of ζ Persei measured in the He I 6678 Å line varies from night to night probably in the α Cygni manner.

Key words: Stars: oscillations stars: early-type - stars: massive, supergiants; stars: individual: ζ Per.

1. Introduction

α Cygni variables are nonradially pulsating supergiants covering the whole range of effective temperatures of β Cephei and SPB (Slowly Pulsating B-stars) variables. The typical periods of α Cygni-type stars are from few days to more than 10 days.

Progenitor of this class of pulsating variables is α Cygni (A2 Iae). Paddock (1935) found that the radial velocity of α Cygni varies with average quasi-period of 11.7 day and amplitude of 2.6 km/s. Luccy (1976) has reanalyzed the data of Paddock and provided 16 pulsation modes from 6.9 to 100.8 day as well as more long-period variation (about 800 days) was supposed by him due to orbital motion.

Waelkens et al. (1998) discovered a sample of B-supergiants to be periodically variable with SPB-type periods from the Hypparcos mission. These stars and additional several ones were subjected to detail spectroscopic and frequency analyses by Lefever et al. (2006), who found their photometric periods to be from 1.5 to 24 days. Saio et al. (2006) detected both p and g modes in the B2Ib/II star HD 163899 from MOST space-based photometry.

The radial velocity of ζ Persei (HD 24398, B1 Ib) was found to be variable by Bouigue (1950) using photographic spectra of the star, obtained by the author during 17 nights in 1948. Bouigue proposed 1.765-day period of radial velocity variations and explained it by orbital motion of the star. Calculated by him orbital parameters are: T = 2432865.600 d, P = 1.765 d, K = 6.0 km/s, γ = 22.2 km/s, e = 0.45, ω = 349°, $a$sin$i$ = 130000 km. But the later investigation of Muller et. al. (1956) has not confirmed a possible binarity of the star. In this paper we present the result of high-resolution spectroscopic study of ζ Persei from 1997 to 2010.

2. Observations

High-accuracy 262 spectroscopic observations of ζ Persei have been performed in the line He I 6678 Å during 25 nights from 1997 to 2010 using coude spectrograph of the 2.6-m Shajn telescope at the Crimean Astrophysical Observatory (Butkovskaya & Plachinda 2007). Signal-to-noise ratios of a single spectrum were typically 300-900 with resolving power of spectra approximately 25000.

3. Results

Fourier analysis of the radial velocity of ζ Persei was performed using Period04 code. The results of this study are summarized in Table 1. In the top part of Table 1 the multifrequency solution obtained with using only our time-string are presented ($Nyquist = 23.1$ d^{-1}, $step = 1.34 \times 10^{-5} d^{-1}$). In the bottom part of the Table 1 the multifrequency solution calculated with using our data and data of photographic measurements of Bouigue (1950) and Muller et. al. (1956) are presented ($Nyquist = 45.5\ d^{-1}$, $step = 2.22 \times 10^{-6} d^{-1}$). All data cover 62 years. In order to obtain the uniform time-string, the radial velocity data from paper of Bouigue (1950) were corrected on -1.26 km/s and radial velocity data from paper of Muller et. al. (1956) were corrected on -4.03 km/s. From Table 1 one can see, that obtained in these two calculations results are well coincided.

The radial velocity data folded in phase with the main period of 51 day are presented in the Fig. 1.

In our study we found also the period 1.734 day closed to one obtained by Bouigue (1950) and explained by him as the orbital period. But in our opinion, this period and other two periods presented in Table 1, can be explained by the non-radial oscillations in

Table 1: Multifrequency solutions for ζ Persei radial velocity data.

Frequency (d^{-1})	Amplitude (km/s)	Period (d)
	Our data	
0.019442	1.98	$51.433 \pm 3.5\times10^{-2}$
0.106212	1.20	$9.4151 \pm 1.2\times10^{-4}$
0.573990	1.02	$1.74220 \pm 1.1\times10^{-5}$
	All data	
0.019444	1.59	$51.429 \pm 5.9\times10^{-3}$
0.106241	0.97	$9.4126 \pm 2.0\times10^{-4}$
0.576688	1.18	$1.734040 \pm 6.7\times10^{-6}$

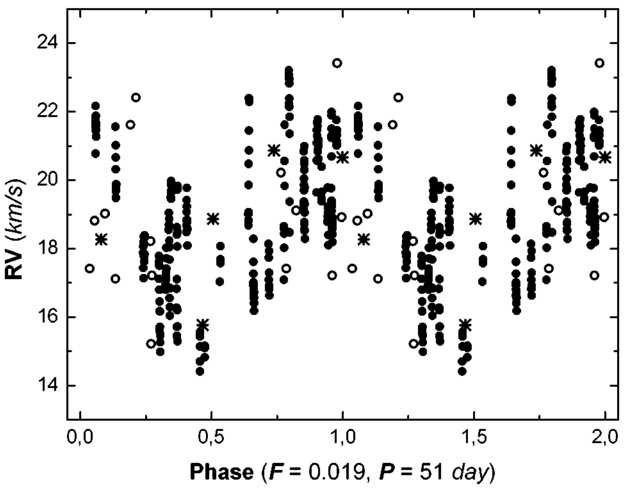

Figure 1: Our radial velocity data (*closed circles*) and single radial velocity measurements of Bouigue (*open circles*) and Muller et. al. (*stars*) folded in phase with the period of 51 day.

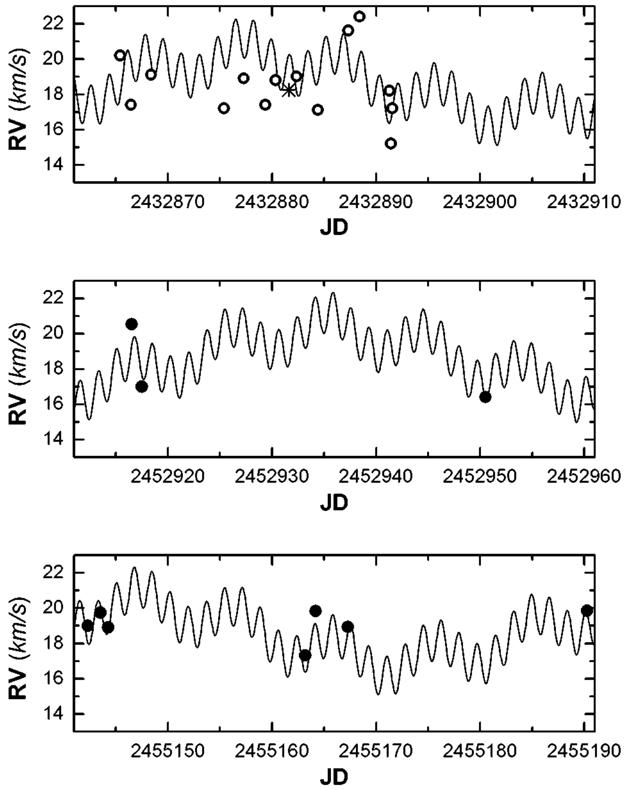

Figure 2: The examples of the three-frequency fit of our data (*closed circles* on middle and bottom panels) and data of other authors (Bouigue (*open circles*) and Muller et. al. (*stars*) on top panel) are presented.

the atmosphere of ζ Persei. So we suppose that ζ Persei is one of the α Cygni-type variable supergiant stars. In the Fig. 2 the examples of the three-frequency fit of our data (middle and bottom panels) and data of other authors (top panel) are presented.

We found also that the shot-term radial velocity variations with amplitude 1 - 4 km/s exist within some nights and these shot-term variations cause the scattering of our data. The shot-period oscillations with amplitude 0.5 - 1.2 km/s were also reported by Paddock (1935) for α Cygni.

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