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On a long-period component of HD 108 radial velocity variability

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New results of the search of periodic spectral variability of HD 108 are presented. The period of radial-velocity variations $P = 1627\ d$ is confirmed.

Keywords: Runaway stars; Photometry; Radial velocity

1 Introduction

The star HD 108 ($O7Ifpe$, $V = 7^m.36$) as one of the most unusual and rare stars in the Galaxy is a very interesting object of research. It is one of the so-called "runaway" or high velocity stars [1–3]. The catalogue [4] lists it among "X-ray quiet OB_2'+c binaries" – binary objects consisting of a supergiant and a compact satellite. The stars peculiar spatial velocity is estimated as $V_p > 98$ km/s [2]. The estimate of the height of the star above the Galactic plane is $z = -80$ pc [3, 5]. The star belongs to the Cas OB5 association [6]. Its evolutionary status is analogous to that of the X-ray binary HD 153919 = 3U 1700–37 [7]. According to [8], astronomers presently know of only three objects in the Galaxy with a similar degree of peculiarity. A sufficiently detailed description of other unusual properties of the star is given elsewhere [9–15]. Here we consider not the multiple peculiar features of the star which, though widely discussed still lack any generally accepted explanation, but just one subject: a long-period component of the star radial velocity variability.

HD 108 has been for a long time known as a spectral and photometric long-scale (years) variable [9–11, 16]. The periodic ($P = 1627\ d$) component of the radial velocity variability of the absorption lines He II $\lambda = 4200$, 4542 Å was first found by the author [11]. It should be remembered that the author used his original observational data obtained over 1982–1991 (51 data points) and radial velocity values from [7] (31 data points), [17] (17 data points) and [10] (25 data points), totalling 124 data points. The authors of [12] added 80 newer CCD data points of the radial velocities of the He II

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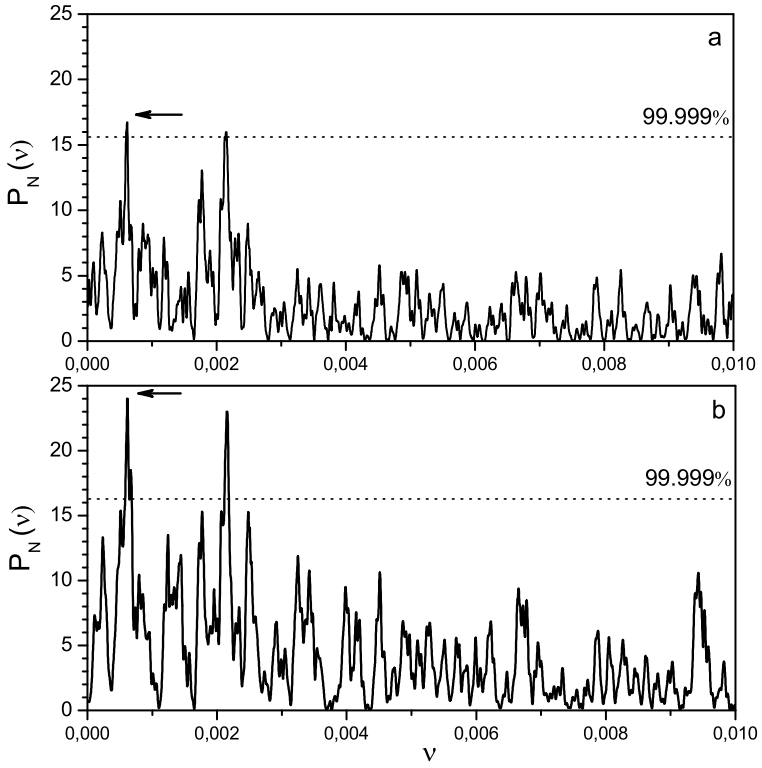


Figure 1 The Scargle's periodograms for the sample of observational data on the radial velocities of absorption lines He II $\lambda = 4200$, 4542 Å: a) from [11]; b) from the present paper (see text). The highest peaks corresponding to the period $P = 1627$ d are indicated by arrows. The probability level 99.999% is marked by a horizontal dashed line.

$\lambda = 4200$, 4542 Å absorption lines, which have been observations from 1986 to 2000 made by 1.93 m and 1.52 m telescopes of the Observatoire de Haute-Provence, but did not confirm this period. The period might have failed to be detected because the adopted frequency step-interval was too rough. In our turn, we added 80 data points to the 124 ones and re-analyzed the data sequence (204 instead of 124 data points). Three techniques seeking for hidden periodicity have already been used [18, 19] (as modified by [20] and [21]). The first two Fourier methods yielded the maximal peak at the frequency corresponding to 1627 d period with minor deviations dependent on the choice of the frequency step-interval. The non-parametric method [21] also used in [12] yielded no steady response at the corresponding frequency. When this particular method was applied to this particular data sequence the peak priority showed a dependence of the frequency step-interval. Basically, the maximal peak corresponds to the double period $P = 3215$ d (parameter $\theta = 0.85$); the second significant peak corresponds to $P = 1610$ d (parameter $\theta = 0.93$). It should be

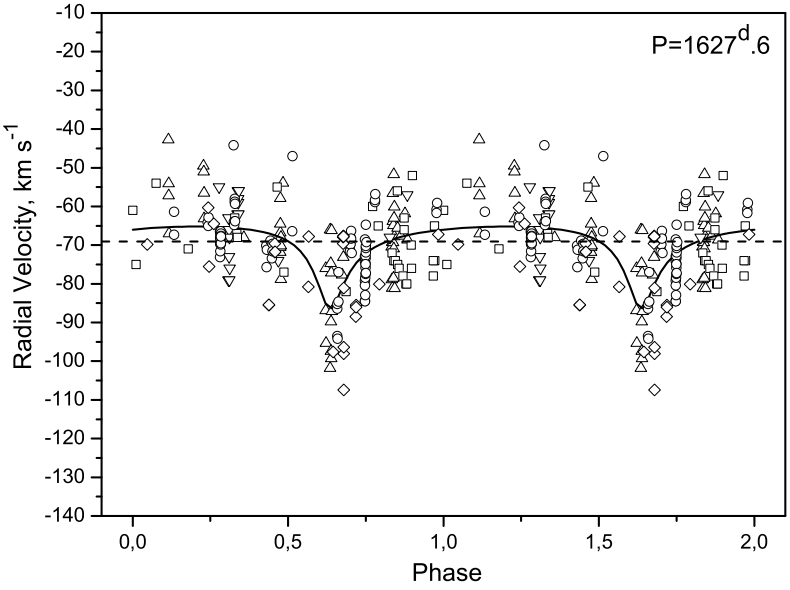


Figure 2 The combined radial-velocity curve for the absorption He II $\lambda = 4200$, 4542 Å lines with elements of period $P = 1627.6$ d: □, V_r from [7]; ∇, V_r from [17]; ◇, observations from [10]; △, our observations from [11], ◯, V_r from [12]. The solid line represents a theoretical curve constructed with the orbital elements given in the text. The dashed line cuts off the γ velocity. The epoch JD 2426260.901 is taken as the zero phase.

recalled that according to Lafler–Kinman method the greater the significance level, the lesser the parameter θ.

Figure 1 shows a fragment of Scargle's periodogram for the sample of observational data on the radial velocities of absorption lines II from [11] (a) and from the present paper (b). We clearly see the dominance of two peaks for the periods $P_1 = 1627$ d and $P_2 = 465$ d, with the significance level exceeding 99.999%. The second peak is obviously false being related to yearly observational on-off time ratio [11]. Comparison of these two periodograms reveals a strong symmetric increase of the significance levels as a result of adding the 80 new CCD points representing 40% (!!!) of the whole inhomogeneous observational sequence.

Using the Powell technique [22] we drew a theoretical radial velocity curve (the solid line in the plot) and recomputed the spectroscopic orbit elements for $P = 1627$ d. Table 1 lists the new elements of the spectroscopic orbit together with those from [11]. Comparison of the two sets of elements shows no basic differences in their values. This means that by adding 40% new CCD spectroscopic data we do not significantly distort the light velocity curve (see Fig. 2 from this paper and Fig. 3 from [11]).

The result that we report confirms once more the existence of a periodical component of the variability of the light velocity of the absorption lines He II $\lambda = 4200$,

Table 1 Elements of the spectroscopic orbit of HD 108.

Elements	Barannikov 1999 [11]	Present paper
γ, km/s	−51.2	−69.2
Φ_0	0.94	0.63
K, km/s	6.7	10.6
ω, rad	−1.76	3.01
e	0.29	0.62

4542 Å the period being $P_1 = 1627\ d$. To confirm this result - the existence of such a long period – high precision spectral observations of HD 108 should be continued. One possible explanation: a double star with a low-mass satellite on a long-period orbit. Other possible explanations: mass-loss rate variations, an opaque disk around HD 108, hypothetical polar jets, etc. To understand the real nature of this long-term variability and answer many other important questions, multiwavelength investigations of the star should be continued.

Here γ is the velocity of the system's center of mass, Φ_0 is the phase of the orbital period corresponding to the time of the visible star's passage through periastron, K is the semiamplitude of the radial velocity curve, ω is the longitude of periastron, and e is orbital eccentricity. The epoch JD 2426260.901 (the earliest date of obsarvation of HD 108) is taken as the zero phase.

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