PERIODICAL VARIATIONS OF RADIAL VELOCITIES AND PROFILES OF THE SODIUM LINES IN THE SPECTRUM OF THE SUPERGIANT 89 HER (F2 IBE)

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The variations in the spectral parameters of the sodium doublet Na I D line of the high latitude supergiant 89 Her were investigated on the basis of the spectrograms obtained at the 2-m telescope of Shamakhy Astrophysical Observatory for 1975–2017. It has been found that the sodium doublet Na I D line's radial velocity of the absorption component varies with a period of 5000 days. The orbital elements of the binary system were determined for the first time within the spectral-binary system model.

1. INTRODUCTION

The variations in the spectral parameters of the sodium doublet Na I D line of the high latitude supergiant 89 Her were investigated on the basis of the spectrograms obtained at the 2-m telescope of Shamakhy Astrophysical Observatory for 1975–2017. It has been found that the sodium doublet Na I D line's radial velocity of the absorption component varies with a period of 5000 days. The orbital elements of the binary system were determined for the first time within the spectral-binary system model.

The star 89 Her=V441=HD163506 (spectral class F2 Ibe, V = $5^m.46$) behaves like a pulsating variable star and is the strongest example of a UU Herculis type star. Its absolute stellar magnitude M_v, according to various estimates, lies in the interval between $-6^m and - 9^m$. The star is located at a galactic latitude b = 23.19" and longitude l = 51.43" [1] at a distance z = 2.2 kps from the galactic plane. The temperature of 89 Her is T_{eff} = 6000 K, and the acceleration of gravity on its surface log g = 0.5 [2]. This star, where it was classified as a variable supergiant.

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The observational data obtained over the course of an extended time interval (>15000 days) provide a unique possibility of determining the supposed long-period variations in the atmosphere of the star 89 Her. Based on the analysis of the observations of the radial velocities measured from the sodium doublet Na I D lines in the spectrum of the supergiant 89 Her, the conclusion that confirms its binary nature is made for the first time. It should be noted that the absorption profile of the sodium doublet Na I D line has a complex form. At different times of the phase observations of the binary system's orbital motion, it consists of two, three, or four components. Unfortunately, the data for the third and, especially, the fourth component turned out to be very scarce. For this reason, mainly the parameter values for the second component are analyzed in the present study.

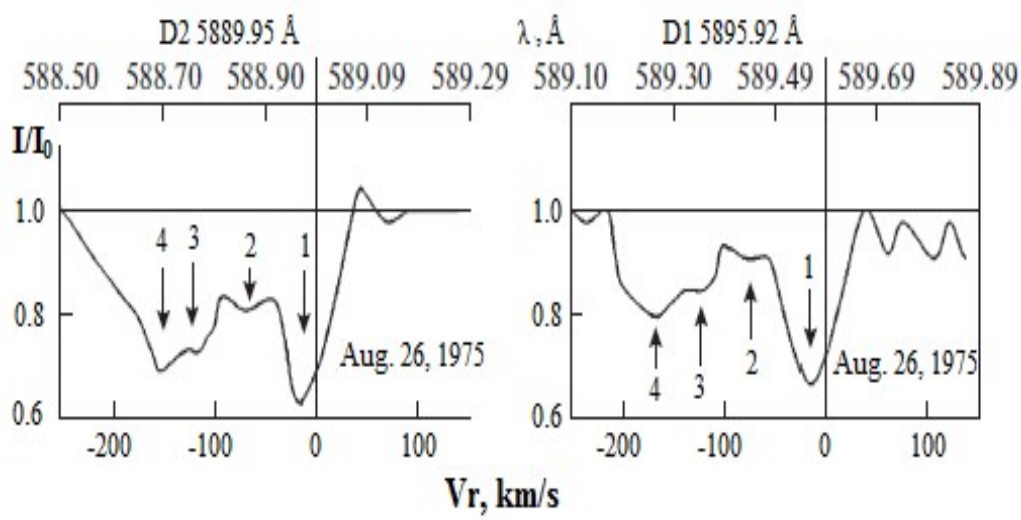

Fig. 1. Line profiles of the D Na I doublet obtained on August 26, 1975.

Fig. 1 shows the line profiles of the sodium doublet Na I D obtained by the authors at the 2-m telescope of Shamakhy Astrophysical Observatory in the coude focus (D = 12 Åmm) in 1975. It can be seen that four components were observed in the sodium doublet Na I D of the 89 Her spectrum on August 26, 1975. Here, the first component is associated with the interstellar absorption, while the others form in the circumstellar shell. It can be seen from Fig.2 that the radial velocity values (Vr) of the sodium doublet Na I D2 line vary with time. All measurement series of the radial velocity Vr of the sodium doublet Na I D2 were analyzed by means of the statistical spectral Fourier analysis with the use of the Scargle method. It has been found that the radial velocity of the Na I D absorption line vary with a period of approximately 5000 days. This is interpreted as the motion of the star 89 Her around an invisible component. Fig.3 shows the phase curve

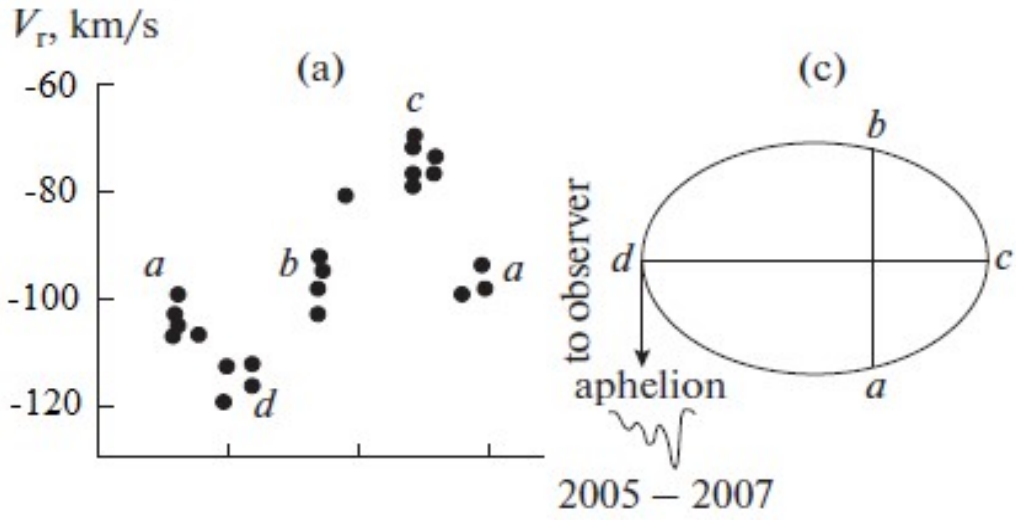

Fig. 2. Time variations of the radial velocity values Vr, as well as their dependence on the shape and orientation of the orbits of the spectral binary star 89 Her, obtained for the second component of the profile of the doublet D2 Na I 5889.953 Åline.

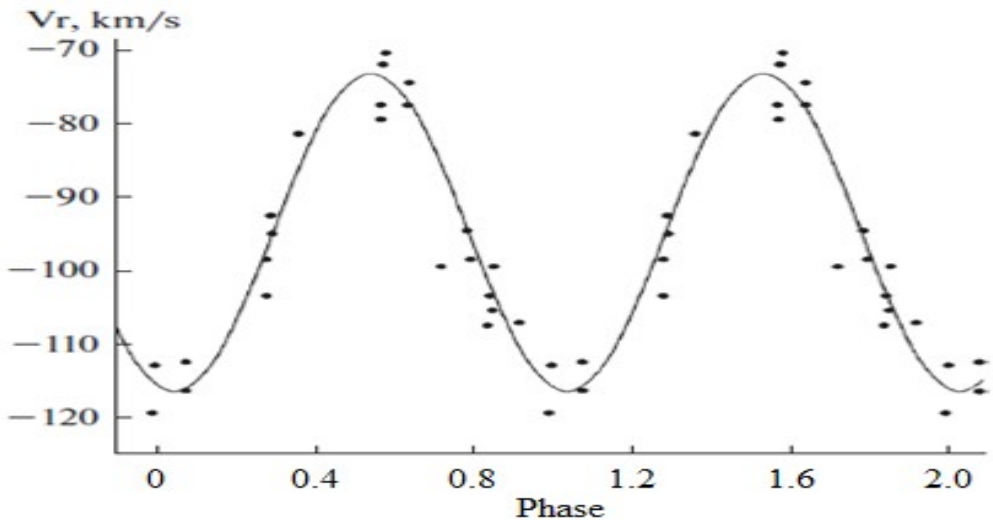

Fig. 3. Radial velocity curve from the D2 Na I line (approximation with a sine wave). The initial epoch is JD 2453949.58, Vr = –119 km/s, P = 5000 days.

of the radial velocities Vr constructed from the line of the second component of the sodium doublet Na I D2. The radial velocity curve was constructed from the elements MinRV = JD2453949.58+5000E. For the approximation with a sine

wave, the function

$$Vr = Asin(2\pi t/P)$$

was used, where P is the orbital period, A is the amplitude of the radial velocity variations, and t is the time. To calculate the orbital elements of the visible component, we used the classical Lehmann–Files method [3]. The following parameters orbital elements of the spectral-binary system: P=5000±300 days, γ=-94.2km/s, e=0.298±0.008, $\omega = 320° \pm 10°$, RVMin=JD2453949.58±0.1, f1=0.201, K=21 km/s, asini=9.1 a.v.(γ is the velocity of the center of mass, f1 is the function of mass, K = (ΔV/2) is the amplitude of the variations in Vr, asini is the semimajor axis of the orbit, and i is the angle between the normal to the orbital plane and the line of sight).

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