HD 64315: A Very Massive Spectroscopic Binary

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Abstract We present the results of a spectroscopic campaign on the early-type double-lined binary HD 64315 conducted between October 2006 and February 2007. Alter the reduction of 100 echelle spectra, we fit model atmospheres to the two components and find $Teff_1 \sim 40000K$ and $Teff_2 \sim 38000K$. We calculate the radial velocity curve for both components and we obtain a period of 2.71 ± 0.01 days and mass ratio $q = 1.05$. We derive minimum masses for both components of the binary system 7.5 ± 0.2 $M_\odot$ and 7.1 ± 0.2 $M_\odot$. The projected semimajor axes are 9.75 ± 0.05 $R_\odot$ and 10.23 ± 0.05 $R_\odot$. We also compare these results with those obtained in a previous study. [10].

1 Introduction

Massive stars are major contributor to the chemical and dynamical evolution of galaxies. Spectroscopic binaries are the natural laboratories where we can determine the most important parameters of stars, such as masses, radii and ionizing fluxes. In spite of this, the parameters of massive stars are not very well known, because of their extreme rarity: for every 20 $M_\odot$ star in the Milky Way there are roughly a hundred thousand solar-type stars; for every 100 $M_\odot$ star there should be over a million solar-type stars [3], and only about 30 double-lined spectroscopic binaries (SB2) with O-type components have definite orbital solutions [1].

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HD 64315 is the main ionizing source of the HII region Sh2-311 [8]. This object has been classified as O6Vn by [11] and [10], found that HD 64315 was a spectroscopic binary and carried out a spectroscopic campaign, finding orbital period 1.34 days. In this work, we present a new analysis of this binary system based on a new high quality spectroscopic campaign (performed with the FEROS instrument). We determine the radial velocity curve and obtain the stellar parameters for HD 64315.

2 Spectroscopy analysis

2.1 Observations

A total of 100 spectra, grouped in observing blocks of 4 spectra, were obtained at random times between October 2006 and February 2007 with the FEROS instrument at the ESO/MPG 2.2-m telescope Table 1 provides the Modified Julian Date (MJD) at mid-exposure time.

Table 1 Summary of the observations collected for the study

	Date	MJD		Date	MJD
1	3/10/2006 9:01	54011.37865	14	8/12/2006 5:41	54077.23895
2	6/10/2006 7:53	54014.33959	15	11/12/2006 4:45	54080.20024
3	6/10/2006 8:08	54014.33959	16	11/12/2006 7:29	54080.31581
4	8/10/2006 7:47	54016.32665	17	14/12/2006 8:08	54083.34002
5	12/10/2006 7:05	54020.29790	18	15/12/2006 7:28	54084.31320
6	12/10/2006 9:20	54020.39134	19	16/12/2006 6:55	54085.29133
7	14/10/2006 9:14	54022.37726	20	17/12/2006 6:16	54086.26344
8	2/12/2006 7:17	54071.30271	21	19/12/2006 4:49	54088.20279
9	3/12/2006 6:12	54072.26029	22	19/12/2006 8:08	54088.34311
10	4/12/2006 7:18	54073.30600	23	21/12/2006 2:21	54090.09965
11	5/12/2006 7:38	54074.32013	24	22/12/2006 3:11	54091.13468
12	6/12/2006 7:29	54075.31606	25	5/2/2007 4:55	54136.20710
13	7/12/2006 6:47	54076.28489			

The FEROS instrument is a high efficiency ($\sim 20\%$) echelle spectrograph with a wide wavelength range (the complete optical spectral region is obtained in one exposure), high resolution (R=48000) and high spectral stability [2]. It is operated at the European Southern Observatory (ESO) in La Silla, Chile. The FEROS data were reduced using the reduced using the reduction pipeline that runs under the MIDAS environment. We used the optimal extraction mode to reject cosmic rays and improve extraction quality.

2.2 Radial Velocities

Initially, we used the spectrum 25 (in which both components are well separated, to determine the projected rotational velocities and the stellar parameters of the two components. First, the projected rotational velocities were obtained by using the Fourier technique [9]; then, we estimated the atmospheric parameters using a fit to synthetic spectra generated with the code FASTWIND [6];[5]. To this aim, we take into account the dilution effect affecting the spectra of each star. The results are presented in Table 2. Finally, to obtain radial velocities, we have used the spectral lines of H, HeI and HeII (Table 3), which are clearly seen in the combined spectrum.

We fit every spectral line to a synthetic spectrum generated by adding two spectra corresponding to the stellar parameters shown in Table 2 and varying the radial velocities and dilution factors for both components of the binary system until the synthetic spectrum matches the observed spectrum (see an example of the quality of the fits in Figure 1). We notice that a change of 10 km/s in the radial velocity does not result in significant changes to the quality of the fit. Therefore we consider

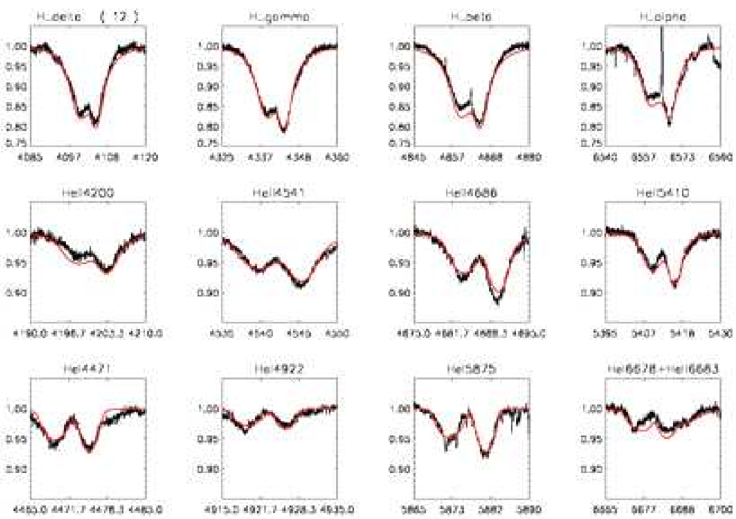

Fig. 1 Example of the type of fit used to measure the radial velocities of both components. This fit corresponds to spectrum 12.

Table 2 Atmospheric parameters derived from the fit of the H and HeI-II lines in the spectrum 25 with FASTWIND synthetic spectra. Note that both components to early O-type stars.

	Star1	Star2
Teff (K)	40000	38000
log g	4.2	4.0
Vsini (km/s)	120	235

Table 3 List of spectral lines analyzed.

Spectral lines	($\dot{A}$)
Hδ	4100
He II	4200
Hγ	4340
He I	4471
He II	4541
He II	4686
Hβ	4860
He I	4922
He I	5015
He II	5410
He I	5875
Hα	6563
He I	6678
He II	6682

a formal error for the radial velocities ± 10 km/s.

We calculate for every epoch the radial velocity of both components. After this, we apply the heliocentric corrections. Then, we have a set of 25 pairs of radial velocities. If we represent these results against the orbital phase we obtain Figure 2, corresponding to the radial-velocity curves of both stars. With our results we cannot calculate exactly the value of the eccentricity as we lack coverage over the phase range $\Theta = 0.6 - 0.8$ but the good fit with a sine-shape curve means that the radial-velocity curve is close to that of a circular orbit. Thus the eccentricity should be near to zero.

2.3 Period

Since our radial-velocity data were obtained over unequally spaced intervals of time we decided to use the Lomb-Scargle normalized periodogram [4];[7], optimized for this type of data sampling. This method provides a measure of the spectral power in the signal as a function of frequency. We used the package PERIOD, included in the STARLINK software, to obtain possible candidates for the period. We found 2.71 $\pm$ 0.01 days and confirmed this value by using two other different techniques (Phase-dispersion-minimization and Fourier Fast Transform).

3 Results and Conclusions

If we assume circular orbits for both stars, then we obtain the orbital parameters in Table 4.

The period we find is almost twice that obtained by [10], the only previous existing spectroscopic analysis. If we fold our data to the period they proposed, we do not find a reasonable shape. Hence, we suspect that the period provided by these authors is an alias of the period we find and that this is the correct period. As a consequence, we obtain different values for the orbital parameters. The errors of the

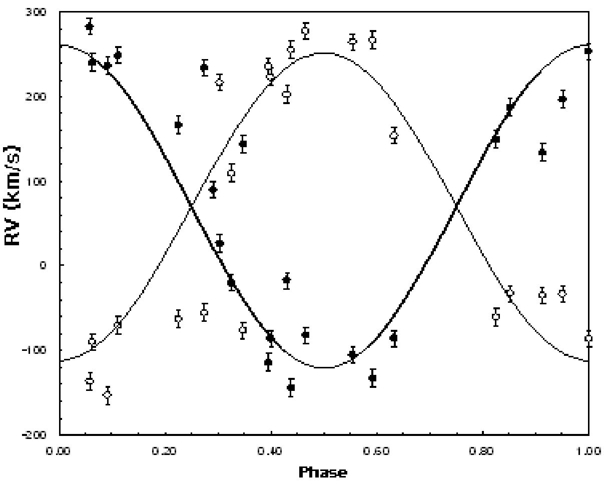

Fig. 2 Radial velocity curves for both components (star 1: line, empty circles; star 2: bold line, filled circles).

Table 4 Orbital parameters derived from a fit to the radial velocity curves (Figure 2)

Parameter	Value
K_1 (kms^{-1})	182 ± 3
K_2 (kms^{-1})	191 ± 3
$m_1 \sin^3 i$ ($M_\odot$)	7.5 ± 0.2
$m_2 \sin^3 i$ ($M_\odot$)	7.1 ± 0.2
$q=(m_1/m_2)$	1.05
$a_1 \sin i$	9.75 ± 0.05
$a_2 \sin i$	10.23 ± 0.05

minimum masses are around 3% and the errors projected semimajor axes are around 0.5%. Both components have similar masses and temperatures, in good agreement with the spectral type. With further data, including extensive photometry, we will improve masses and more accurate orbital parameters.

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