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The Wolf-Rayet binary HD 68273

K. S. Ganesh and M. K. V. Bappu

Abstract

A series of 127 spectrograms of this binary obtained at Kodaikanal during 1965 and 1966 have been used for a study of radial velocities of the emission and absorption lines. The period is found to be 78.5 days. The spectral type of the O component is O7.5 as determined from a single high dispersion Mount Stromlo coude spectrogram. The velocity curves of the Wolf-Rayet component are determined for HeII 4686, the CIII complex at 4652Å and CIV 4441. The velocity curve for the O component is from measures of the absorption line H5. Arguments are presented to show that the velocity curve of CIII 4652 is the best suited for the study of masses of the components. The eccentricity of the orbit is 0.17. The gamma-axis for HeII 4686 is red-shifted with respect to that of H5 by 82 km/sec. The values of $m_o \sin^3 i$ and $m_w \sin^3 i$ are 46.3 and 13.0 solar masses respectively. The inclination of the orbit is likely to be such that the system exhibits eclipses. The W-component seems to be the most massive yet known among the very small group of Wolf-Rayet stars.

Introduction

The spectrum of HD 68273 has long been known to be composite and variable. The spectrum has been described by Cannon (1901) and Worssel (1916) from objective prism spectra obtained at Arequipa and the Cape respectively. Perrine (1918) first announced the striking spectral variations of both emisson and absorption lines. These have been confirmed in a recent study by Smith (1955) who found that the variations were both short-lived and infrequent. Smith also gives a list of wavelengths of both emission and absorption lines, as seen in high contrast low dispersion slit spectra obtained by him, with the 60-inch reflector at Boyden station. Sahade (1955) announced that radial velocities measured indicated the star to be a binary that exhibits the spectra of two components, with most of the absorption lines associated with a companion of spectral type O. From the few measures that Sahade had at his disposal, a period of the order of 24 days was indicated. Gaposchkin (1959) estimated from radial velocities obtained at Mount Stromlo that a tentative period of 16.2 days could be assigned for the orbital motion. His visual estimates indicated light variability with a small range, thus holding out promise of the system being an eclipsing binary.

The brightness of HD 68273 enables the examination of its spectrum in the far ultraviolet by the techniques of rocket spectroscopy. Stecher and Milligan (1962) from objective grating spectra find the energy distribution from 1600 Å to 3000 Å to depart substantially from that of a black body at 30000°K. Aller and Faulkner (1964) have determined photoelectrically the energy distribution in the domain 3400—5900Å. They estimate a colour tempeature of 32000°K on the basis of measures of monochromatic magnitudes made at Mount Stromlo on five nights. One needs to recognize in such continuum flux measurements, the role played by the continuum of the O star.

HD 68273 is the brighter star of the optical double Gamma-Velorum. The fainter component HD 68243 is of MK type B2IV and is 2.4 mag. fainter than HD 68273. The absolute magnitude of the Wolf-Rayet star is $M_V = -5.6$, if a value of $M_V = -3.3$ is ascribed to HD 68243 on the basis of the MK classification type assigned. One assumes also, following Schlesinger and Jenkins (1940) that both HD 68243 and HD 68273 form a proper motion system. This Wolf-Rayet star along with Zeta Puppis probably excites the Gum nebula, which is the largest HII region known in our galaxy.

The number of Wolf-Rayet binary systems that exhbit the spectra of both components is very small. Of these, the best studied is V444 Cygni which has a Wolf-Rayet star of the nitrogen sequence along with an early type star. Sahade has shown that the absorption lines indicative of an early type star are seen on the spectra of HD 68273. Since HD 68273 contains a WC7 star with an early type companion, presumably an O star, it furnishes the possbility of determination of a reliable mass for the WC7 star and an O star, if the orbital parameters can be derived in detail and also, if the orbital plane is favourably inclined for detection of an eclipse. Only one other system HD 168206 (WC7+O) has preliminary spectroscopic orbits available for both the components. It, therefore, is of great interest to study the system of HD 68273 in detail and increase our information pertaining to the masses of these early stars.

The spectroscopic observations

The spectra were obtained at Kodaikanal over the period February-April 1965 and November 1965-April 1966. A total of 127 spectrograms, obtained with the cassegrain spectrograph attached to the 51 cm reflector, have been measured for radial velocity. The spectra have a dispersion of 125 Å/mm. They were obtained in the second order of a 600 lines/mm Bausch and Lomb grating blazed in the first order at 7500Å. Most of the spectra were obtained on Ilford N-40 process plates. A few spectra were obtained in 1965 in Ilford Thin Film Half Tone plates. The spectra have a width of 300 microns. A projected slit width in the camera focal plane of 15 microns was used. The velocity measures of the emission lines were confined to those of HeII 4686, CIV 4441 and the emission complex at 4652Å originating predominantly from CIII. The velocity measures of the O component depend entirely on the measures of the hydrogen lines 4340Å, 4100Å, with occasional measures on HeII 4200 and HeI 4471. These are all listed in Table 1. Previous investigators of this system have reported on the appreciable scatter in the velocity measures made by them. We find this to be prevalent even in our measures. The emission lines are in general weak and diffuse, but the high contrast photographic emulsion used enables the spectra show up the emission features with appreciable contrast.

TABLE 1

Velocity measures of HD 68273

Plate	JD of observation	Phase (in period)	Velocities in Km/Sec.					
			4686e	4652e	4441e	4340a	4200a	4101a
1	2	3	4	5	6	7	8	9
27	2438817.20	0.04	+ 97.9	+ 57.4	..	− 31.1	..	..
33a	818.17	0.05	+154.2	+ 73 5	..	− 65.6	− 15.7	− 21.9
33b	818.18	0.05	+ 41.6	+ 09.0	−150.5	− 13.8	−104.9	− 58.5
40	820.12	0.07	+149.7	+ 49.0	..	+ 4.1	− 46.4	− 90.6
45	820.27	0.08	+ 88.9	+ 16.8	−108.7	− 22.8	..	+ 32.9
49	821.26	0.09	+121.6	− 7.7	..	..	..	− 31.4
54	822.28	0.09	+ 65.3	0.0	−108.7	− 40.1	− 34.3	− 59.2
55	824.23	0.09	− 70.4	..	−150.5	..	..	..
58	825.29	0.14	+ 49.3	+ 8.4	−142.4	+ 03.5	..	+ 32.9
65	827.22	0.17	+ 09.0	− 32.2	..	− 57.3	..	− 03.7
66	827.27	0.17	− 39.7	− 56.8	−201.8	+ 38.0	..	− 22.7
69	828.23	0.18	+ 9.0	− 96.7	− 134.3	+ 38.0	+ 47.0	..
73	830.12	0.20	− 41.0	0.0	..	+ 29.0	+ 02.1	−132.3
76	831.24	0.22	+ 56.9	− 07.7	− 49.3	+ 72.5	..	−22.7
80	834.18	0.25	−103.7	− 57.4	−219.4	− 05.5	..	+ 05.1
82	834.24	0.25	+ 15.4	+ 89.0	−236.3	− 40.1	+ 20.0	− 13.2
87	837.13	0.29	− 31.4	−129.6	− 58.1	+ 72.5	+ 2.1	+ 69.4
92a	843.10	0.37	+ 01.0	+ 33.0	+ 35.0	+ 11.7	..	− 59.2
92b	843.13	0.37	+ 09.0	+ 08.4	−253.0	− 57.3	..	− 22.7
95	851.22	0.47	+ 56.9	+ 97.4	−108.7	− 22.8	+ 28.6	− 29.2
99	858.19	0.56	+121.6	+ 49.0	− 41.2	+ 03.4	..	− 77.5
100	859.17	0.57	+ 72.9	+ 40.6	+ 27.0	− 22.8	..	− 49.7

TABLE 1—*contd.*

1	2	3	4	5	6	7	8	9
150	2439083.34	0.43	− 47.4	− 15.5	+168.1	+ 03.5	+ 47.1	− 31.4
151	083.38	0.43	+ 17.3	+ 16.8	−133.7	− 13.8	..	−141.1
152	083.41	0.43	− 23.0	+ 09.0	−218.7	− 57.3	+ 47.1	− 68.0
153	084.40	0.44	+145.9	+ 60.6	− 06.7	+ 64.2	..	+ 51.9
156	085.37	0.45	− 47.3	+ 32.9	−201.8	..	+ 55.7	..
158	086.31	0.47	+121.6	− 56.1	..	− 57.3	..	− 95.8
159	086.35	0.47	+ 09.0	0.0	−168.1	− 57.3	+109.9	− 95.8
161	086.44	0.47	− 23.0	− 47.7	− 08.0	− 04.8	+127.8	− 21.9
163	087.36	0.48	+ 25.6	+ 09.0	− 66.2	+ 03.5	+101.4	− 31.4
167	108.28	0.75	+121.5	+146.5	+120.2	+ 11.7	..	− 77.5
168	108.28	0.75	+177.9	+194.8	+ 94.5	+ 11.7	..	−141.8
169	108.34	0.75	+153.6	+178.6	+ 18.2	− 40.0	+ 28.6	− 87.0
171	111.35	0.78	+105.6	+146.4	+ 69.5	..	..	−114.0
176	112.24	0.80	+225.9	+178.6	− 24.3	+ 11.7	+ 10.7	− 59.2
177	112.27	0.80	+193.9	+146.4	..	− 22.8	+ 2.1	−151.3
181	112.32	0.80	+145.2	+130.3	+171.5	−109.8	+ 15.0	−132.3
185	119.23	0.89	+202.2	+187.0	+128.9	− 82.9	..	+ 5.9
186	119.26	0.89	+154.2	+219.3	+171.5	− 4.8	+ 28.3	− 58.5
187	119.28	0.89	+129.9	+154.8	+120.8	− 82.9	+ 02.1	−114.0
193	120.26	0.90	+298.8	+211.5	+128.9	− 40.1	+ 29.3	−114.0
194a	120.29	0.90	+242.5	+195.4	+154.6	−118.1	..	−178.3
194b	120.31	0.90	+210.5	+179.3	..	− 22.1	+ 20.7	− 68.0
197	124.27	0.95	+113.9	+ 81.9	− 31.7	− 48.4	..	..
198a	124.30	0.95	+121.6	+ 49.0	− 57.4	− 57.4	+ 02.1	−205.4
198b	124.32	0.95	..	+ 57.4	+104.0	− 57.3	..	−168.8

TABLE 1—*contd.*

1	2	3	4	5	6	7	8	9
198c	2439124.33	0.95	..	+154.8	−184.9	− 31.1	..	−196.6
202	125.28	0.96	+226.5	+138.7	− 66.2	−126.4	− 60.0	−150.6
203a	125.34	0.96	..	+130.3	+ 61.4	− 31.1	+ 20.7	− 42.4
208	134.26	0.08	− 71.0	−153.5	−185.0	− 65.6	..	+104.5
213a	135.33	0.09	− 47.4	− 96.7	−295.0	+ 29.7	+227.0	− 22.0
213b	135.35	0.09	− 55.0	− 96.7	−303.8	− 31.1	..	− 32.9
214	136.24	0.10	− 79.3	−104.5	−235.6	− 48.4	+ 97.1	− 40.2
215a	136.28	0.10	− 07.0	− 88.3	−150.5	− 13.8	..	+ 24.1
215b	136.30	0.10	+ 01.3	− 64.5	−116.8	+ 12.4	+272.0	+ 42.4
218a	137.19	0.11	− 71.0	− 40.0	− 83.0	+ 29.7	+137.1	− 68.0
218b	137.21	0.11	− 47.4	−104.5	−125.6	− 22.1	..	+ 24.1
221	140.31	0.15	− 95.3	− 88.4	−261.2	− 13.8	..	− 58.5
223	143.28	0.19	− 79.3	− 96.7	−133.7	− 65.6	+ 20.7	−187.1
228	145.30	0.22	− 23.0	−104.5	− 14.9	− 57.3	..	−214.9
231b . . .	146.16	0.23	..	− 80.6	− 66.2	− 23.5	+ 11.4	− 49.7
236a	147.20	0.24	− 86.8	−121.2	− 57.4	− 48.4	+ 83.5	+155.0
236b	147.21	0.24	− 25.2	− 72.2	+ 10.1	+ 38.7	+177.7	+ 42.4
241	151.32	0.29	−130.9	− 40.0	−116.8	− 4.8	+101.4	− 24.1
247	155.37	0.35	−104.3	− 72.2	−185.0	− 4.8	+ 11.4	− 12.4
249	159.22	0.39	−194.5	+ 32.9	− 99.9	+ 29.7	+ 65.0	− 40.2
249	159.22	0.39	+198.2	+ 36.6	− 96.2	+ 26.0	..	− 36.5
252c	160.36	0.41	..	+ 25.3	− 21.2	+ 57.5	..	+ 34.7
252d	160.37	0.41	..	+ 21.0	− 02.9	+ 15.4	..	+ 82.1
254	161.19	0.42	+ 95.1	+ 20.3	− 68.7	− 08.3	..	− 16.4
255	163.18	0.44	+103.5	+ 30.7	− 68.7	− 18.0	..	..

TABLE 1—*contd.*

1	2	3	4	5	6	7	8	9
258a	2439164.14	0.46	..	−06.4	−90.3	..	..	−76.5
262a	165.14	0.47	+19.3	+35.5	−46.7	..	..	−122.0
262b	165.15	0.47	−14.3	+24.2	−33.3	..	..	−97.4
267a	167.26	0.50	+66.0	+58.0	−64.0	+40.5	..	−20.5
267b	167.27	0.50	+56.7	+51.3	−62.5	−04.8	..	−130.0
267c	167.28	0.50	+61.1	+69.3	−24.8	..	..	−156.6
269	168.18	0.51	+69.3	+61.4	−03.0	..	..	−44.2
274	170.09	0.53	+62.5	+95.1	−08.3	..	..	−137.3
275	170.12	0.53	+35.7	+67.4	−43.8	+28.7	..	−105.8
276	170.15	0.53	+40.0	+72.5	−56.9	+12.0	..	−79.6
284a	173.10	0.57	+140.8	+100.5	+103.6	−34.2	..	−47.7
284c	173.11	0.57	+136.6	+104.7	+45.8	−38.4	..	−89.1
288a	174.13	0.58	+112.4	+104.8	+98.3	−15.3	..	−93.4
288c	174.16	0.58	+105.2	+105.3	+65.3	−17.3	..	..
291a	174.12	0.60	+141.5	+113.3	+81.6	−22.4	..	−143.0
291c	175.16	0.60	+150.3	+126.3	+81.4	−44.3	..	−198.4
293b	176.13	0.61	+143.8	+127.4	+91.3	−85.7	..	+27.4
293c	176.14	0.61	+126.0	+110.1	+100.5	..	..	+10.2
296a	177.12	0.62	+143.9	+135.9	+100.7	+17.7	..	+163.2
302a	181.09	0.67	+203.5	+185.6	+135.9	..	..	−187.7
302b	181.10	0.67	+185.2	+178.1	+112.2	−36.1	..	−179.9
305	181.27	0.68	+166.7	+200.1	+110.8	−49.3	..	−104.4
306	181.37	0.68	+211.5	+155.6	+101.2	−61.1	..	−159.6
307a	182.15	0.69	+158.0	+77.3	+115.8	..	..	..
307b	182.16	0.69	+125.2	+182.8	+55.5	..	..	−136.1

311a	2439183.12	0.70	+165.8	+174.7	+ 55.8	− 63.2	..	−238.8
311b	183.13	0.70	+197.0	+189.4	+ 87.4	− 74.6	..	..
315a	185.31	0.73	+188.6	+197.6	+147.6	− 90.3	..	−278.1
315b	185.32	0.73	+182.0	+191.0	+166.7	−116.4	..	−249.2
318a	186.83	0.75	+240.6	+217.2	+119.0	..	..	− 98.6
318b	186.84	0.75	+169.6	+194.7	+ 85.0	− 41.6	..	−171.7
321a	187.60	0.76	+222.5	+191.3	+109.3	− 70.9	..	−227.3
321c	187.61	0.76	+238.3	+191.1	+109.2	− 70.7	..	−209.0
327a	191.67	0.81	+238.3	+207.2	+137.3	− 55.4	..	−128.2
328c	191.72	0.81	+240.7	+217.5	+137.9	− 57.1	..	−132.9
329b	191.75	0.81	+245.3	+222.1	+159.8	− 32.2	..	− 55.6
330c	191.80	0.81	+253.8	+239.0	+168.4	− 60.6	..	− 93.2
336a	193.78	0.83	+202.8	+203.7	+150.3	− 77.3	..	− 48.8
336b	193.79	0.83	+252.2	+245.7	+131.7	− 49.9	..	+129.9
338a	194.70	0.85	+247.9	+232.9	+149.1	− 41.1	..	+180.8
338b	194.73	0.85	+265.8	+217.8	+162.9	− 41.1	..	+180.8
344	202.59	0.92	+191.2	+183.7	+ 73.5	− 78.3	..	..
345b	202.62	0.92	+178.7	+171.8	+ 80.3	− 64.5	..	−185.8
345c	202.62	0.92	+162.2	+154.5	..	− 53.0	..	−204.1
349	207.66	0.01	+100.6	+ 44.1	+ 22.0	..	..	+ 00.8
350	207.68	0.01	+ 79.5	+ 22.8	+ 14.6	− 78.0	..	+ 30.5
351	207.72	0.01	+ 85.3	+ 36.9	+ 16.0	− 71.9	..	+ 00.4
352	207.74	0.01	+ 95.5	+ 31.3	+ 18.2	− 68.8	..	− 06.2
353a	207.77	0.01	+100.3	+ 59.7	+ 3.0	− 64.3	..	− 11.2
354	215.65	0.11	− 12.7	−102.3	..	+ 06.4	..	− 27.6

The orbital elements

The almost continuous series of observations from November 1965 to April 1966 indicate a period of 78.5 days. Figure 1 is a plot of the velocities of

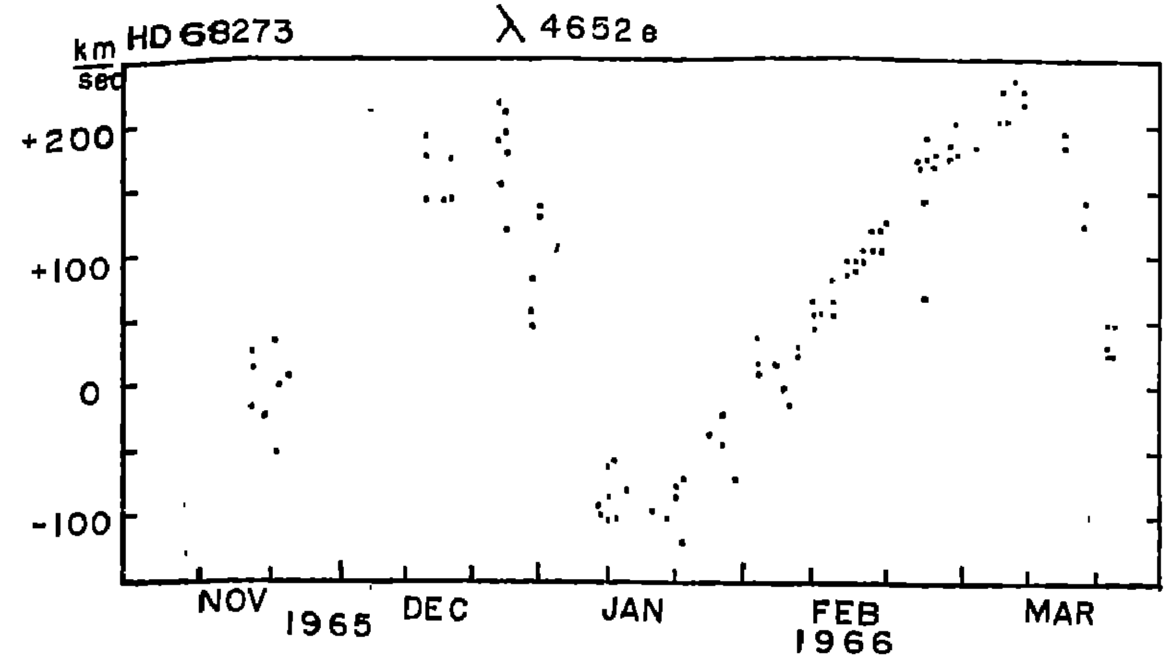

Figure 1:—Velocity variations of HD 68273—November 1965—March 1966

4652Å, covering the period November 1965 to March 1966. In combination with our velocity measures, we used a few values of velocities obtained by the Lick Observers from Chile. We also have utilized radial velocity measures of the absorption lines of the O star from a single high dispersion (6.7Å /mm) Coude spectrogram. This spectrogram was obtained by one of us with the Mount Stromlo 188 cm reflector through the courtesy of Director Bok and ANZAAS. The zero phase is assumed to be JD 2439128.25. The observations on two nights seem to rule out the possibility of a period close to a day. It is difficult at this stage to derive a more exact period of this system. Extended observations for some time will be necessary for a more correct spectroscopic determination of the period.

The observations of the emission lines 4686Å, 4652Å, 4441Å and the absorption line 4340Å grouped into 20 normal points are given in Table 2. Figure 2

TABLE 2

Velocity measures—normal points

No.	Mean phase	Mean Velocities			
		4686	4652	4441	4340
1	2	3	4	5	6
1	0.02	+101.20	+ 45.90	+ 19.10	− 64.00
2	0.10	− 39.80	− 88.60	−181.03	− 10.65

TABLE 2—*Contd.*

1	2	3	4	5	6
3	0.12	− 61.30	− 72.09	−163.90	+ 13.63
4	0.17	− 77.16	− 38.92	−162.99	+ 39.92
5	0.24	−109.80	− 80.20	−217.26	− 31.90
6	0.29	− 83.09	− 89.62	−114.46	+ 33.96
7	0.34	− 38.25	− 76.75	−173.60	+ 9.36
8	0.44	− 25.00	+ 27.35	− 89.50	+ 21.93
9	0.46	− 8.07	+ 31.33	−130.45	+ 30.65
10	0.48	+ 23.64	+ 39.21	− 47.99	+ 40.47
11	0.53	+ 51.86	+ 74.11	− 27.99	+ 20.35
12	0.57	+114.33	+107.04	+ 71.37	− 27.23
13	0.62	+137.90	+139.75	+108.27	+ 17.65
14	0.68	+175.02	+180.45	+115.17	− 48.83
15	0.71	+183.34	+188.18	+135.56	− 86.12
16	0.75	+217.82	+198.61	+105.63	− 61.07
17	0.80	+214.40	+197.45	+143.51	− 56.43
18	0.87	+206.09	+208.46	+152.74	− 59.81
19	0.91	+201.70	+187.30	+114.30	− 40.96
20	0.95	+180.52	+123.61	+ 94.25	− 34.53

contains the plots of radial velocities of λ4441, λ4652 and λ4686. The plots of radial velocities show that the orbits are near-circular. Hence Sterne's method was utilized to solve for the elements. These elements were treated again as preliminary values in the case of 4686Å and 4652Å and final elements calculated by the method of Lehman-Filhes. The elements derived from the three emission lines are given in Table 3.

TABLE 3

	HeII 4686Å	CIII complex 4652Å	CIV 4441Å
γ (km/sec)	+63.9±2.4	+59.9±3.0	−26.5±11.4
K (km/sec)	163.7±3.5	153.5±4.4	196.7±15.4
e	0.16±.02	0.17±.03	0.13±.08
ω	96°±8°	87°±.9°	78°±43°

In the derivation of a velocity from a measurement of the CIII emission complex, we have assumed a wavelength of 4652.0Å as the mean wavelength of the band and the shifts from this arbitrary value denote the velocities. While this prevents the assignment of an exact value for the systemic velocity as inferred from measures of this line, it is useful in providing a set of parameters that define the orbital motion.

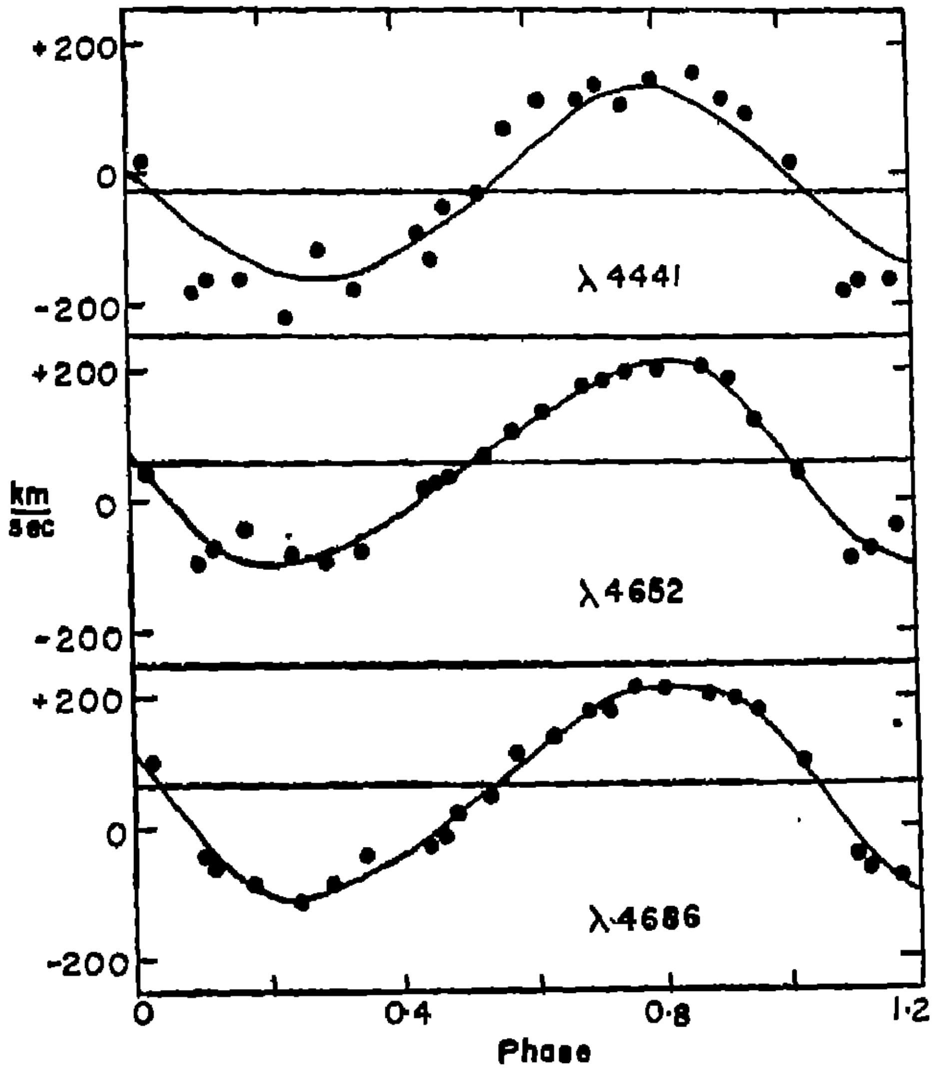

Figure 2.—The Radial velocity curves of HD 68273 for the emission lines.

The measures of the hydrogen absorption line at 4340Å are utilized to study the orbit of the O star. A large scatter of the measures, together with the relatively smaller amplitude in velocity of the more massive O star, made it difficult for us to carry through an independent analysis of the orbit. We have, therefore, solved for the values of γ and K which give the best theoretical fit for the observed points. The final elements derived from the velocity measures of 4340Å are as follows:

$\gamma = -18.0 \pm 1.80$ km/sec.

$K = 43.1 \pm 2.6$ km/sec.

$e = 0.17$

Discussion

The orbital elements obtained for all the three emission lines are remarkably similar. This result can be contrasted with HD 214419, CQ Cephei, where according to Bappu *et al* (1967), there is a considerable difference in the orbital characteristics, denoted by the velocity curves of NIV 4058 and HeII 4686. A disparity exists only in the values of K, with CIV 4441 having the largest value of 196 km/sec. and the 4652Å complex having a value of 154 km/sec. The large amplitude in the velocity curve of CIV 4441 seems certainly to originate from an apparent shift to the violet at some phases caused by the absorption line on the long wavelength side.

In the case of HeII 4686, Sahade (1958) has shown that at certain phases a narrow emission is seen superposed on the broad emission feature of 4686°A. Sahade has interpreted this feature as due to material streaming from the Wolf-Rayet star through the inner Lagrangian point. The presence of this narrow feature is likely to upset within a small limit, the value of the semi-amplitude of the velocity curve. It could also affect the value of the derived systemic velocity, though, if it is seen at more phases than a restricted range, it is quite probable that the effect will be nullified.

We have, therefore, preferred using the value of K derived from 4652Å, since it is least likely to be affected by possible distortions that are usually present in Wolf-Rayet systems. In fact, 4652Å may have proved also to be unsuitable for this purpose, were it not for the fact that a violet edge, normally seen associated with this line in most WC spectra, is totally absent in HD 68273, as was pointed out first by Smith (1955).

Along with the measures of the H-gamma line, we have made measures of the absorption line HeII 4200 as well as the hydrogen line at 4100Å. The helium absorption line is seen only weakly in the spectra and hence the helium contribution to the overall absorption of the Balmer series is not likely to be greater than 20 to 30 per cent. In the reduction of velocity measures of 4340 we have assumed that it has the wavelength of the hydrogen gamma line and have ignored possible contamination by the corresponding member of the Pickering series. In doing so, the results will be affected, if at all, in the value of the systemic velocity without altering K. Figure 3 contains plots of radial velocities measured in the absorption lines 4340°A., 4200Å and 4101Å. If the velocity curve of 4340Å is made to pass through the points of the absorption lines 4200Å and 4100Å, and systemic velocities derived, then one finds the velocity of 4200Å to be about 62

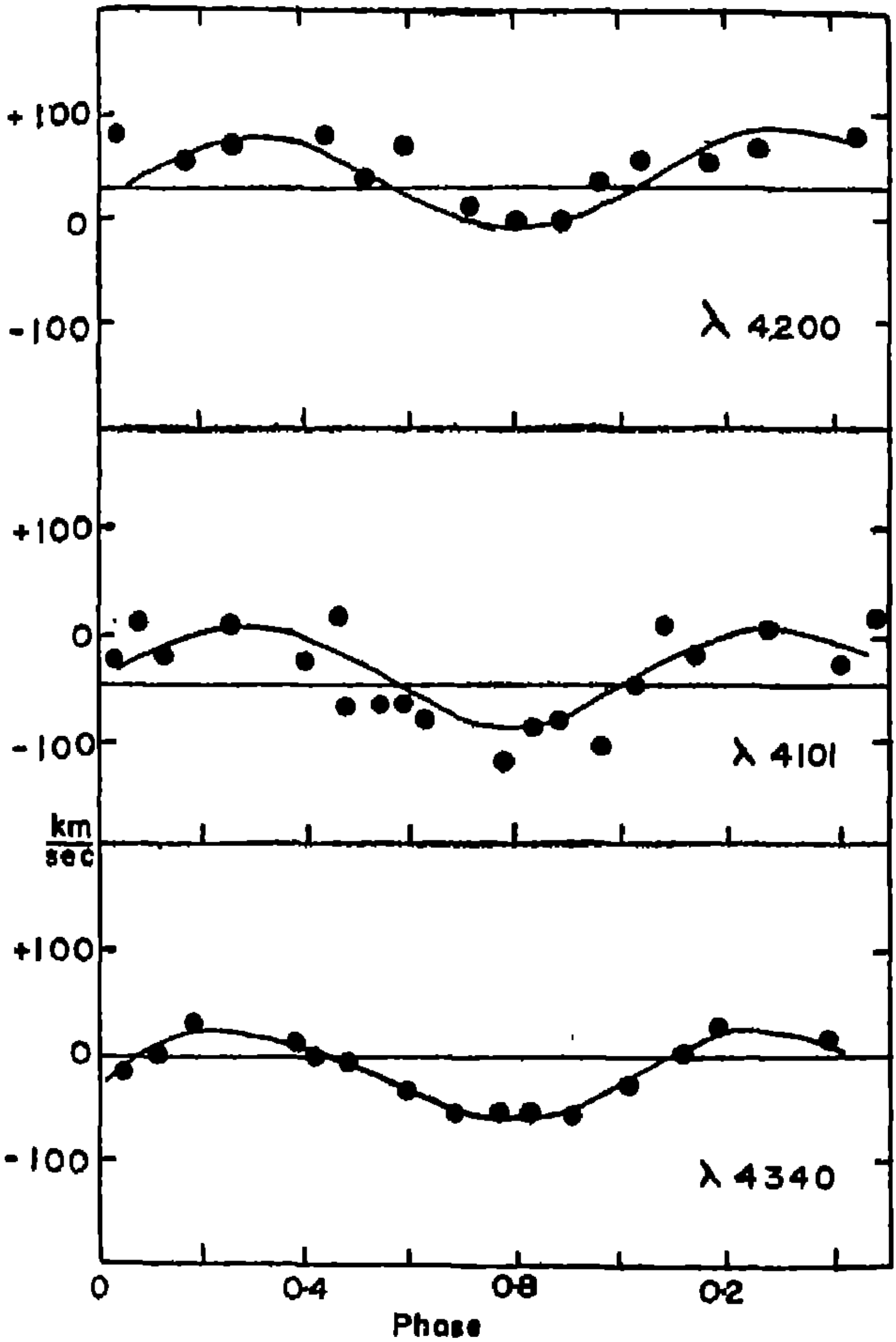

Figure 3.—The Radial velocity curves of HD 68273 for the absorption lines.

km/sec. more positive than 4340Å. This raises the question whether the discrepancy thus observed is due to our neglect of the HeII contribution towards the wavelength of the absorption feature at 4340Å. If it were so, and if HeII has contributed appreciably, then the mean wavelength would be shifted more to the violet causing thereby the occurrence of a value of systemic velocity that is more negative than what we have measured. Hence, we feel justified that the wavelength of the absorption feature at 4340Å is correctly taken, if one assigns to it the wavelength of the hydrogen-gamma line. An explanation of the more positive value of the systemic velocity from HeII 4200 is its likely contamination with 4200Å emission originating from the Wolf-Rayet atmosphere. The plots of the velocity measures of the absorption feature at 4101Å, when fitted with the theoretical curve for 4340Å, shows a systemic velocity very much more negative than 4340Å. Clearly, the wavelength used for this absorption feature is not correct and the absorption is the sum total of the effect of, not only the hydrogen-delta line, but also, of some other ions that have a transition near about this wavelength. An examination of the spectra shows that this line is broad and intense, upsetting the decrement of the Balmer series at this particular wavelength.

It is necessary at this stage to be able to determine the spectral type of the O companion. The single high dispersion blue spectrogram obtained at Mount Stromlo shows no trace of MgII 4481 and OIII 3960. Also HeI 4387 is seen marginally. Hence the spectral type is earlier than O8 and closer to O7. The ratios $\frac{4542}{4471}=0.4$; $\frac{4542}{4340}=0.2$ and $\frac{3819}{3813}=0.25$ make it earlier than O8, but later than O7. Hence a spectral type of O7.5 seems best to adopt. The Balmer series are seen on the high dispersion plate until H16 with certainty.

In Table 4 we give the values of $m_{O7.5} \sin^3 i$ and $m_W \sin^3 i$ based on the mass, ratios determined from the hydrogen-gamma line and each of the other three emission lines used. Since K is an important quantity in the evaluation of the masses,

TABLE 4

Values of $m_o \sin^3 i$ and $m_W \sin^3 i$

HD 68273	HeII 4686	CIII 4652 Complex	CIV 4441
$m_o \sin^3 i$	54.9	46.3	89.8
$m_W \sin^3 i$	14.5	13.0	19.7

we have to use that value which is the most dependable from the results we have on the three emission lines. It has been pointed out before that CIV 4441 is the least reliable of the three. The presence of emission from the inner Lagrangian point superimposed on the normal 4686Å profile and the absence of a violet edge for the emission complex 4652Å make the latter, despite the wavelength uncertainty, more dependable than the other for an evaluation of the masses. Proceeding on this reasoning, we find that the values of $M_O \sin^3 i$ and $M_W \sin^3 i$ as 46.3 and 13.0 solar masses are in the range of values, obtained for equivalent spectral types.

There are very few well determined masses of the O stars available in the literature. The values obtained in this study are in good agreement with those listed by Allen (1963) and can provide an independent estimate of the mass of an O7.5 star, if the inclination of the orbit can be evaluated with certainty. The masses derived on the assumption of $\sin^3 i = 1$ come within the range of values that we know to be valid for the Wolf-Rayet stars and the O stars. However, the detection of emission near the inner Lagrangian point at almost all phases would necessarily imply that the inclination has a value of 70° or smaller. If this is true, then not only would the chances of an eclipse be ruled out, but the lower limits to the masses of the W and O star would be 14 and 48 solar masses respectively. While this would make the Wolf-Rayet star the most massive of the very small number we know of, the mass of the O star would make it intermediate between those found among the O dwarfs and O subgiants. It is obvious that much of this speculation can be eliminated, if a light curve is avilable for the system.

As indicated earlier, HD, 68273 has long been known for the variations in its spectra. The Kodaikanal Observations cover over 3 cycles of the star and a feature that is most strikingly seen is the variation in the absorption of HeI 3889. This has been reported earlier by Smith, who observed a displaced absorption component of this line on a few nights during 1953 and also on a few nights during 1954. Due to the fact that the star has never been subjected to a systematic study before, it has always been assumed that the occurrence of displaced HeI 3889 absorption is sporadic in nature. Our observations of the system show that the violet edges are seen on two cycles chiefly between phases 2 days and 30 days. This fact seems to suggest that the displaced absorption of HeI 3889 can be observed only in a selected range of phases of the binary system. However, we must point out that in the second of the 3 continuous cycles we have observed at Kodaikanal, no displaced absorption was seen even though we had good coverage of the star over a range of phase from 2 days to 35 days. It seems likely that this displaced absorption originates from material flow with a velocity of about 1500 km/sec.in the vicinity of the inner Lagrangian point from the advancing hemisphere of the Wolf-Rayet star. The gas streams are visible from phase 2 days to atmost 40 days. However, it is not necessary that, in every cycle over this phase range, the displaced absorption be present. We believe that the gas streaming giving rise to the intense and displaced HeI absorption 3889Å is sporadic. Sahade's findings in 4686Å emission also seem to support such a conclusion. With a period of 78.5 days, the phases at which Smith observed displaced 3889Å have been 18 days in 1953 and 33 days in 1954.

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