A DOUBLE-LINED CLASS B SPECTROSCOPIC BINARY SYSTEM

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THE star H.D. 214240 is situated at R.A. 22h 31.8m, Dec. +49° 33′, and is of visual magnitude 6.20, while the H.D. Catalogue gives the spectral type of this star as B3. It is one of the stars in the B-type programme under observation at Victoria. The binary nature of this star, not hitherto announced, was discovered by the writer.

Table I—Lines Measured in the Spectra

Primary (B2.5)	Secondary (B8)	"Stationary" Ca+
λAtom	λAtom	λAtom
3964 He	3964 He	3834 Ca+(K)
3970 Hε		3968 Ca+(H)
4009 He	4009 He	
4026 He	4026 He	
4070 H	4102 Hδ	
4072 H	4121 He	
4075 H	4128 Si II	
4102 Hδ	4131 Si II	
4121 He	4144 He	
4144 He	4267 C+	
4267 C+	4340 Hγ	
4340 Hγ	4388 He	
4388 He	4471 He	
4471 He	4481 Mg+	
4481 Mg+		
4713 He		
4861 Hβ		
4922 He		

Thirty-two spectra, obtained by different members of the observing staff, were employed in this orbit. After the approximate period of 10.91 days was selected, these were grouped into twentyone normal places. In the least-squares correction to the elements the equation of Lehmann-Filhés was used, involving six unknowns. The grouping of the normal equations from the observations was arranged so that a normal place included only a small number of revolutions, and thus the result is almost as rigid as if the individual observations had been treated separately. The normal places were weighted according to the number of plates in the normal place, each single plate being given weight unity.

As mentioned above, the H.D. Catalogue gave the spectral type of this star as B3, but as the oxygen triplet λλ4070, 4072 and 4075 was present on some of the plates, although showing faintly, the type of the primary seems somewhat earlier than B3 and has been classified as B2.5.

The lines measured in the spectra are shown in Table I.

The relative intensity of the spectral lines of the primary as compared with those of the secondary is about 3 to 1. Only at the nodes, where the separation is about 200 km. could the secondary be measured with any degree of accuracy. The Si II lines λλ4128 and 4131 were measured on several plates at the nodes, and the velocities of these lines agree well with those of the secondary spectrum which indicates that its type is B5 or later. Again the relative intensity of the helium line λ4471 to the mg. line λ4481 was used as a criterion of the type and a careful comparison of these lines on the micrometer engine showed them on the whole to be equal. In view of this, the secondary spectrum has been classified as B8. The lines in the spectrum are weak and difficult of measurement. The probable error of a single plate of weight unity is ±9.2 km. per second, while that of the primary, where the lines are fair, is ±3.2 km. per second. On account of the poor equality of the lines of the secondary spectrum the writer did not include it in the least-squares solution of the primary. However, corrections for K2 were obtained by accepting the elements from the primary solution and obtaining by least-squares the most probable correction for K2. The solution of the primary reduced Σpvv from 515 to 398, a reduction of approximately 23 per cent.

Figure 1 shows the individual velocities of the primary and secondary spectrum and those of the enhanced calcium lines plotted on the final velocity curve.

The mean velocity of the H and K lines of ionized calcium is -18.9 ± 0.3 km. per second, while the probable error of a measure is ± 1.6 km. The lines are good and, as the velocity indicates, do not oscillate with the star as shown on the figure. The component of the solar motion in the direction of this star is -11.8 km. per second, giving a residual velocity of -7.1 km. per second for the calcium cloud. Such differences between the velocity of calcium and the component of the solar motion are not unusual among the O- and early B-type stars as shown by Dr. Plaskett.[1]

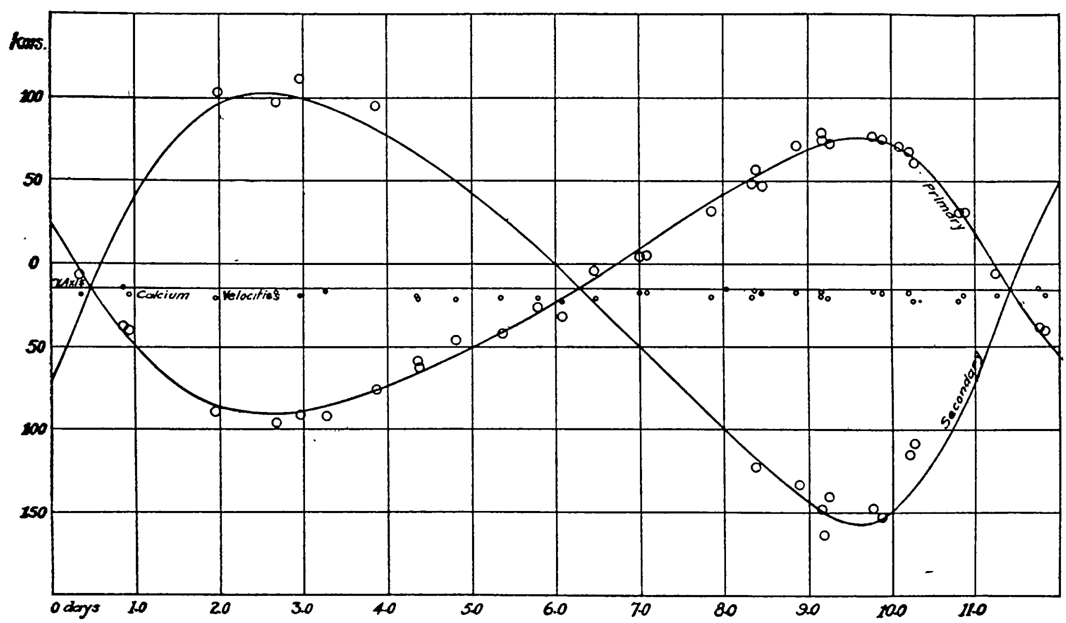

Fig 1—Velocity Curves of H.D. 214240.

The values of the preliminary and final elements are given in Table II.

Considering the spectral type of H.D. 214240 as B2.5 for the primary and interpolating from Fowler and Milne's[2] scale, a temperature of 17,500° K. has been assigned to it. The spectral lines of the brighter component of the star under discussion have been compared with those of u Herculis, a B3 star whose photometric orbit[3] has been obtained and whose density is given as 0.097 for the primary. The spectra of the primaries of these two stars are very similar in appearance and the stars are not unlike in mass, u Herculis being 7.5 times the mass of the sun while the minimum mass of H.D. 214240 is 6.01 times the sun, while if the inclination is assumed to be the average value the mass would be 9.25 times the sun. Considering a temperature of 17,500° K mentioned above a surface brightness by Hertzsprung's method[4] of −3.24 magnitudes, 19.76 times the sun, has been computed. On account of the high eccentricity of H.D. 214240, viz., 0.253, the star has probably had a considerable advance in its evolutionary stage and it seems reasonable to assume that its density is of the order 0.10. With surface brightness of −3.24 magnitudes compared with the sun and a minimum mass of 6.01 times the sun, the

TABLE II—ELEMENTS OF H.D. 214240

Element	Preliminary	Final
P = Period..............	10.91 days	10.9114 ±0.00126 days
e = Eccentricity.........	0.25	0.253 ±0.012
K_1 = Semi-amp. prim.....	85 km.	83.27 ±0.93 km.
K_2 = Semi-amp. sec.......	124 km.	129.44 ±3.59 km.
γ = Velocity of system...	−15.12	−15.28 ±0.70 km.
ω_1 = Longitude of apse....	65°	67°.54 ±2°.97
ω_2 = Longitude of apse....	245°	247°.54 ±2°.97
T = Time of periastron...	J.D. 2,424,340.478	J.D. 2,424,340.5415 ±0.0937
$a_1 \sin i$ = Semi axis maj. prim..		12,088,000 km.
$a_2 \sin i$ = Semi axis maj. sec...		18,789,000 km.
$m_1 \sin^3 i$ = Mass primary......		6.01$\odot$
$m_2 \sin^3 i$ = Mass secondary....		3.87$\odot$

absolute magnitude is calculated as −1.86 for a density of 0.05, −1.35 for a density of 0.10 and −1.06 for a density of 0.15. The difference of magnitude between a star of mass 6.01 and one of 3.87 times the sun by Eddington's method[5] is 0.71 magnitudes. We have, therefore, two stars of a total visual magnitude of 6.20 differing by 0.71 magnitudes from which is obtained a magnitude of 6.65 for the brighter and 7.36 for the fainter.

By the use of the fundamental equation showing the relation between absolute and apparent magnitude

$$M = m + 5 + 5 \log \pi$$

the parallax is computed as 0″.00251 or 1,300 light years. However, if we consider the average inclination of the orbital plane for

H.D. 214240, $\sin^3 i = 0.65$, the masses become 9.25 and 5.95 times the sun, which, for the density, temperature and surface brightness mentioned above, give a parallax of 0″.00217 or 1,500 light years. So the star under discussion appears to be at least 1,300 light years distant and in all probability nearer 1,500.

On the relationship between mass and luminosity by Eddington,[5] after applying the temperature term $-2 \log_{10} Te/5200$, the bolometric absolute magnitude for H.D. 214240 is computed as −2.34 and, after applying the correction for visual magnitudes of +1.50, the visual magnitude becomes −0.84 against −1.35 by the luminosity method. The visual magnitude of −0.84 corresponds to a density of 0.2. From the above assumptions and computations, together with the discussion on H.D. 191201[6] and some recent work on H.D. 1337,[7] both made at this Observatory, it would appear that Eddington's theory gives a magnitude somewhat too small for the higher temperature stars, such as the one discussed in this paper. Complete details will appear in a publication of the Dominion Astrophysical Observatory now in press.

REFERENCES

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[6]H.D. 191201, Pub. D.A.O. *III*, No. 11.
[7]H.D. 1337, Pub. D.A.O. *III*, 275.