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THE ORBITS OF FOUR SPECTROSCOPIC BINARIES, H.D. 3264, H.D. 158013, H.D. 170829 and H.D. 201032

BY D. K. NORRIS, W. T. SHARP AND R. W. TANNER

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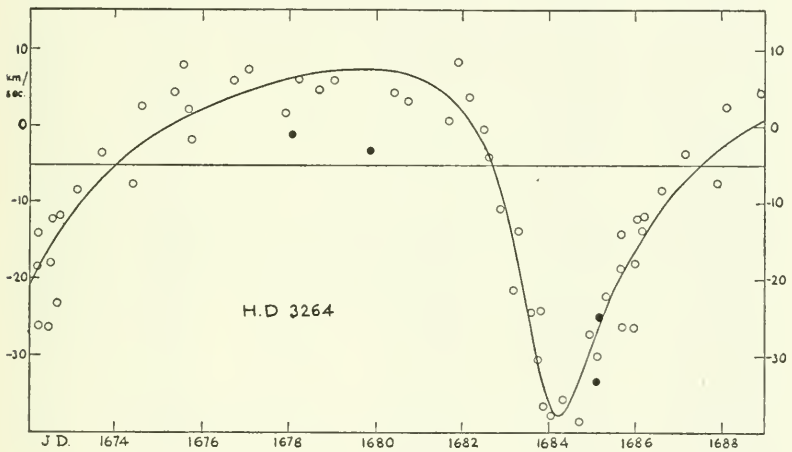
THE ORBIT OF THE SPECTROSCOPIC BINARY H.D. 3264

By William T. Sharp

THE star H.D. 3264, $\alpha(1900)\ 00^h30^m.7$, $\delta(1900)+48°00'$, vis. mag. 7.42, type B2, was found to have variable velocity in the course of the third radial-velocity programme at the David Dunlap Observatory.[1] Four plates taken with the $12\frac{1}{2}$-inch camera in the course of this programme between 1939 and 1941 showed a radial-velocity range of at least 30 km./sec. Further observation was undertaken in 1945 and completed in 1946, 43 plates being obtained with the 25-inch camera and one-prism spectrograph, giving a dispersion of about 33 A./mm. at Hγ. The information obtained from these plates is summarized in Table I. Weights were assigned to each



observation on the basis of the probable error of the measured radial velocity. The character of the spectral lines was generally good so that it was usually possible to measure ten or more lines on each plate with an average probable error of about 2 km./sec. The observations with the 25-inch camera were then grouped according to phase as indicated in the accompanying table to form twenty normal places of equal weight.

In Table I, V_o is the measured radial velocity, reduced to the sun and V_c is the radial velocity computed from the final orbital elements.

Preliminary elements were derived using R. K. Young's graphical method. A least-squares solution was carried through for T_o, e,

[1] *Pub. D.D.O.*, v. 1, no. 13, 1942.

TABLE I

J.D. 242–243	Vo km./sec.	Phase from final T	Normal place	Vc km./sec.	Vo–Vc km./sec.
9508.848	−03.5	9.44	..	+07.8	−11.3
9878.802	−26.0	1.28	..	−27.0	+ 1.0
9905.697	−35.0	1.17	..	−28.7	− 6.3
0249.772	−01.0	7.64	..	+06.6	− 7.6
1678.882	−01.9	5.332	1	+01.7	− 3.6
1683.867	+03.5	10.317	2	+07.1	− 3.6
1684.819	+00.8	11.269	2	+04.1	− 3.3
1686.861	−42.0	13.311	3	−32.2	− 9.8
1687.853	−40.5	0.799	11	−34.6	− 5.9
1688.848	−27.5	1.794	8	−19.9	− 7.6
1694.831	+06.7	7.777	5	+06.8	− 0.1
1701.822	−26.1	1.264	4	−27.2	+ 1.1
1702.820	−12.2	2.262	6	−14.8	+ 2.6
1703.797	−03.8	3.239	6	−07.3	+ 3.5
1705.812	+02.3	5.254	10	+01.5	+ 0.8
1706.876	+06.2	6.318	10	+04.3	+ 1.9
1708.803	+05.0	8.245	5	+07.4	− 2.4
1715.826	−14.9	1.764	8	−20.3	+ 5.4
1728.773	−31.5	1.207	4	−28.1	− 3.4
1732.708	+08.4	5.142	1	+01.1	+ 7.3
1747.683	+07.9	6.613	7	+04.9	+ 3.0
1756.696	−12.9	2.122	9	−16.2	+ 3.3
1783.600	−27.7	2.018	9	−17.4	−10.3
1791.586	+04.7	10.004	2	+07.5	− 2.8
1802.529	+01.8	7.443	7	+06.4	− 4.6
1808.488	−25.1	13.402	3	−34.6	+ 9.5
1812.512	−07.9	3.992	1	−05.6	− 2.3
1822.496	−37.6	0.402	11	−39.2	+ 1.6
2046.786	+06.3	8.628	12	+07.7	− 1.4
2053.729	−18.0	2.067	13	−16.8	− 1.2
2053.860	−24.2	2.198	13	−16.0	− 8.2
2066.589	−23.2	1.423	14	−24.8	+ 1.6
2066.913	−19.5	1.747	14	−20.5	+ 1.0
2067.841	−08.9	2.675	17	−11.2	+ 2.3
2076.619	+08.9	11.453	15	+03.0	+ 5.9
2076.920	+04.0	11.754	15	+00.6	+ 3.4
2077.916	−22.5	12.750	20	−15.8	− 6.7
2078.631	−38.3	13.465	16	−35.9	− 2.4
2078.782	−39.8	0.112	18	−38.4	− 1.4
2079.703	−28.5	1.033	18	−30.9	+ 2.4
2083.615	+14.7	4.945	17	+00.5	+14.2
2090.835	−04.3	12.165	19	−04.1	− 0.2
2091.516	−14.3	12.846	20	−18.5	+ 4.2
2091.812	−25.5	13.142	16	−27.4	+ 1.9
2109.849	+02.7	4.171	17	−02.5	+ 5.2
2117.760	−00.4	12.082	19	−03.0	+ 2.6
2131.642	−11.3	12.460	20	−09.2	− 2.1

ω, γ, and K. In view of the confirmatory evidence of the $12\frac{1}{2}$-inch camera observations and the high eccentricity, it was not considered necessary to correct the period. The preliminary and final elements obtained are given in Table II below; the errors given are mean errors except in the case of the period where the error is estimated from graphical considerations. The values of V_o-V_c given for the individual plates in Table I seem reasonable in view of the quality of the observational material and the mean errors of the orbital elements. For the normal places, $\Sigma(V_o\text{-}V_c)^2$ was reduced by the least-squares solution from 243 to 156.

TABLE II

Orbital Elements of H.D. 3264

Element		Preliminary	Final	
Period	P	13.504 days	13.504 days	$\pm$ 0.003
Eccentricity	e	0.46	0.507	$\pm$ 0.035
Angle of periastron	ω	160°	152°.35	$\pm$ 6°.8
Periastron passage	T	J.D. 2431673.58	J.D. 2431673.550	$\pm$ 0.25
Velocity of system	γ	− 5.6 km./sec.	− 5.15 km./sec.	$\pm$ 0.61
Semi-amplitude	K	24 km./sec.	23.65 km./sec.	$\pm$ 1.16
$a \sin i$			3.8×10^5 km.	
$\frac{m_2^3 \sin^3 i}{(m_1+m_2)^2}$			0.000012 ⊙	

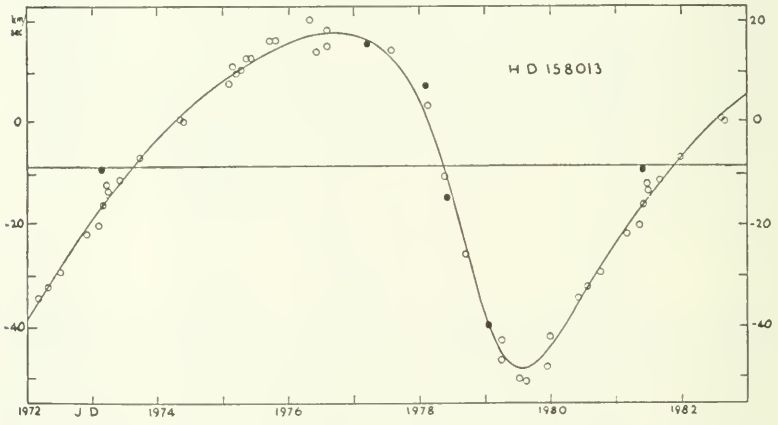
The individual observations are plotted on the graph in figure 1, with $12\frac{1}{2}$-inch camera plates shown as solid circles on the curve.

Measures of the velocity from the K-line of ionized calcium indicated that this originated in interstellar space. From 26 plates this velocity was found to be − 12.7 ± 1.5 km./sec. Of this velocity the component of the solar motion was − 6 km./sec., leaving a residual velocity of − 7 ± 1.5 km./sec. On the assumption that this velocity was due to galactic rotation and that the interstellar material was uniformly distributed, an estimate of the distance of the star was made. Taking A = + 0.017 km./sec./parsec, $l_o = 331°$, $l = 88°$, $b = -13°$ this distance was found to be 1100 parsecs. Neglecting interstellar absorption, this gives for the absolute magnitude the reasonable value − 2.8.

THE ORBIT OF THE SPECTROSCOPIC BINARY H.D. 158013

By D. K. Norris

H.D. 158013, $\alpha(1900)$ $17^h21^m.7$, $\delta(1900)+57°05'$, vis. mag. 6.55, type A2, was announced as a binary from five plates taken at this observatory during 1939-1941.[1] These plates were taken with the $12\frac{1}{2}$-inch camera giving a dispersion of 66A./mm. at Hγ. Thirty-four plates were taken during 1946-1947 with the 25-inch camera, giving 33A./mm. By using the early plates, the period was well determined; the other plates were grouped according to phase into 22 observational equations. Weights (1, 2) were assigned according to the number of plates. Table III gives the data from the plates.



The preliminary elements were determined graphically using R. K. Young's method. Final elements were derived using T. E. Sterne's form of least-squares solution. These elements are given in Table IV. The probable error of a single plate is 1.3 km./sec. The individual observations are plotted on the graph; the early observations are indicated by solid circles.

[1] *Pub. D.D.O.*, v. 1, no. 13, 1942.

TABLE III

J.D. 242-243	V_o km./sec.	Phase from final T	V km./sec.	V_o–V_c km./sec.
9382.834	−40.3	0.053	−40.3	0.0
9759.823	+07.0	7.332	+06.9	+0.1
9817.660	−15.0	7.653	−11.7	−3.3
9824.658	+15.3	6.437	+15.8	−0.5
0132.822	−09.5	2.395	−16.8	+7.3
1971.785	−42.7	0.998	−45.2	+2.5
1975.752	+15.9	4.996	+14.0	+1.9
1980.754	−29.8	1.754	−29.4	−0.4
2027.674	−10.8	7.595	−09.5	−1.3
2340.760	−43.3	0.258	−46.5	+3.2
2362.763	+17.8	5.829	+17.7	+0.1
2363.731	+13.9	6.798	+12.9	+1.0
2365.663	−50.9	0.513	−49.6	−1.3
2367.621	−12.5	2.469	−15.8	+3.3
2367.812	−11.7	2.666	−12.4	+0.7
2368.774	+00.1	3.627	+01.4	−1.3
2369.736	+12.4	4.588	+11.3	+1.1
2370.829	+13.6	5.681	+17.6	−4.0
2386.651	+16.1	5.065	+14.7	+1.4
2390.756	−48.6	0.957	−46.1	−2.5
2392.764	−07.0	2.970	−07.0	0.0
2395.624	+14.7	5.829	+17.7	−3.0
2397.716	−26.4	7.916	−25.2	−1.2
2398.630	−51.4	0.620	−49.7	−1.7
2399.585	−32.8	1.573	−32.8	0.0
2401.606	+00.3	3.594	+01.2	−0.9
2402.689	+12.6	4.679	+12.0	+0.6
2403.578	+20.1	5.566	+17.3	+2.8
2407.645	−34.9	1.417	−36.5	+1.6
2408.574	−20.6	2.345	−17.9	−2.7
2408.646	−16.5	2.419	−16.5	0.0
2408.728	−13.7	2.502	−15.4	+1.7
2410.565	+07.5	4.334	+08.9	−1.4
2410.613	+10.8	4.383	+09.5	+1.3
2410.672	+09.5	4.440	+09.9	−0.4
2410.742	+10.3	4.514	+10.6	−0.3
2413.580	+03.1	7.349	+00.7	+2.4
2414.681	−47.3	0.234	−46.3	−1.0
2416.605	−22.4	2.156	−21.4	−1.0

TABLE IV

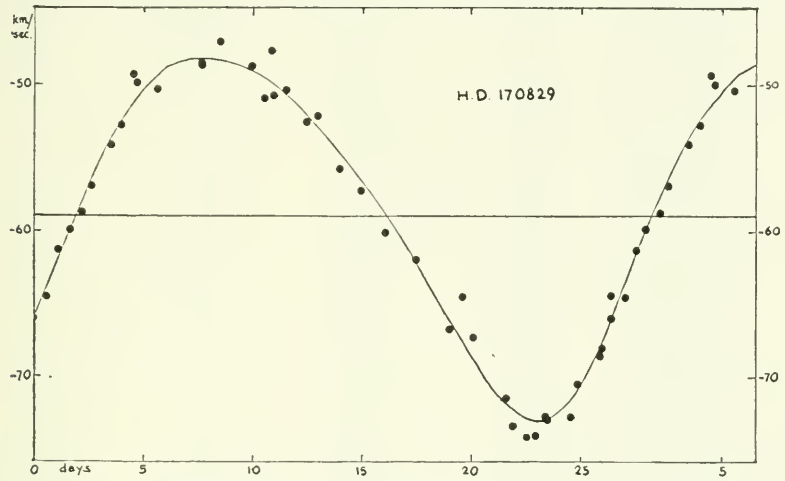
ORBITAL ELEMENTS OF H.D. 158013

Element	Preliminary	Final	P.E.
Period	8.2159 days	8.2159	
Eccentricity	0.33	0.333	± 0.009
Angle of periastron	140°	132°.1	$\pm 2°.1$
Periastron passage	J.D. 2431979.130	2431979.003	± 0.049
Velocity of system	−8.53 km./sec.	−8.427	± 0.523
Semi-amplitude	33.6 km./sec.	33.931	± 0.356
$a \sin i$		3.62×10^6km.	
$\frac{m_2^3 \sin^3 i}{(m_1+m_2)^2}$		$0.0280\ \odot$	

THE ORBIT OF THE SPECTROSCOPIC BINARY H.D. 170829

By D. K. Norris

THE star H.D. 170829, $\alpha 18^h26^m.4$, $\delta + 20°46'(1900)$, vis. mag. 6.59, spectral class G5, showed a variable radial velocity on four plates obtained at this observatory in 1942-43.[1] A long run of plates was taken in 1945, and a few plates in each of 1946 and 1947 to improve the period and eliminate the possibility of a short period.



The orbit is based on 39 plates with 33A./mm. dispersion at Hγ listed in Table V. One weak plate with a large error of measurement was rejected. The observations cover nearly 60 revolutions; the period best assembling them is 26.39 days.

By trial, preliminary elements of $\omega = 235°$, $e = 0.17$, $\gamma = -58.9$ km./sec., K = 12.85 km./sec., T = J.D. 2430574. 662 were found. The plates were grouped into 25 normal places and the usual least-squares solution carried out, reducing the sum of the squares of the residuals from 56 to 33.

The final elements and their probable errors are:

P 26.390 days
K 12.42 ±0.18 km./sec.
γ − 58.96 ± 0.28 km./sec.
ω 222° ± 5°
e 0.176 ± 0.014
T_0 J.D. 2430557.26 ± 0.07; T J.D. 2430573.532
$a \sin i$ 4.44 ± .06 × 10^6km.
Mass function 0.0050 ⊙
Probable error of a single plate ± 0.78 km./sec.

[1] *Pub. D.D.O.*, v. 1, no. 16, 1945.

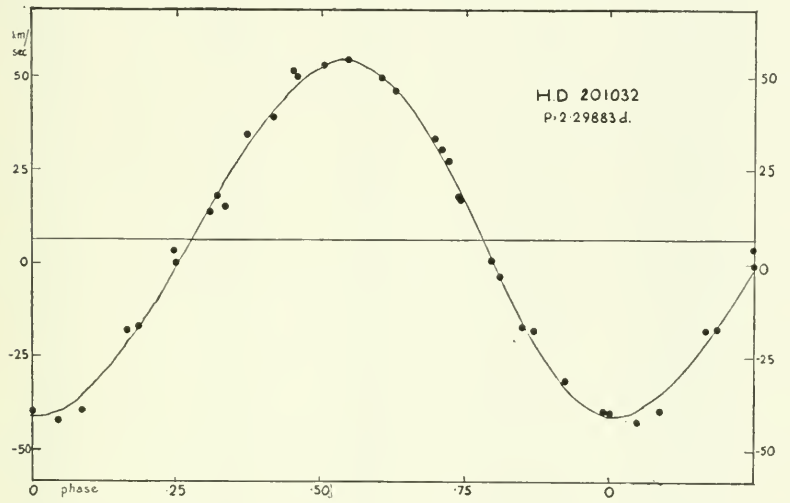
TABLE V

J.D.	V_o km./sec.	Phase from final T	V_c km./sec.	V_o—V_c km./sec.
243 0574.662	−66.0	1.110	−66.0	+0.0
0624.534	−73.0	24.592	−72.9	−0.1
0951.593	−48.6	8.581	−48.2	−0.4
0996.508	−68.0	0.816	−67.5	−0.5
1614.790	−47.6	12.028	−49.9	+2.3
1628.718	−70.5	25.956	−70.9	+0.4
1629.765	−68.5	0.613	−67.8	−0.7
1633.749	−54.1	4.597	−53.6	−0.5
1640.752	−50.9	11.600	−49.5	−1.4
1647.707	−62.0	18.555	−62.2	+0.2
1653.665	−72.7	24.513	−72.9	+0.2
1656.597	−64.4	1.055	−66.2	+1.8
1660.614	−52.7	5.027	−52.4	−0.3
1666.599	−48.8	11.057	−49.0	+0.2
1667.672	−50.8	12.130	−50.0	−0.8
1669.616	−52.0	14.074	−52.7	+0.7
1670.598	−55.8	15.056	−54.5	−1.3
1671.585	−57.2	16.043	−56.4	−0.8
1672.646	−60.1	17.104	−58.7	−1.4
1676.635	−67.2	21.093	−68.4	+1.2
1678.568	−73.3	23.026	−72.2	−1.1
1679.603	−74.0	24.061	−73.0	−1.0
1683.665	−64.5	1.733	−63.6	−0.9
1684.638	−59.8	2.706	−59.8	−0.0
1687.553	−49.3	5.625	−51.2	+1.9
1688.653	−50.4	12.619	−50.6	+0.2
1690.662	−48.5	8.730	−48.2	−0.3
1691.565	−47.0	9.633	−48.2	+1.2
1694.551	−50.4	12.619	−49.4	−1.0
1695.544	−52.6	13.612	−52.0	−0.6
1702.609	−64.5	20.677	−67.6	+3.1
1704.590	−71.4	22.658	−71.7	+0.3
1705.572	−74.1	23.640	−72.8	−1.3
1707.556	−72.8	25.624	−71.6	−1.2
1710.546	−61.2	2.224	−61.7	+0.5
1711.605	−58.7	3.283	−57.7	−1.0
1728.567	−66.7	20.245	−66.5	−0.2
2028.727	−56.9	3.725	−56.2	−0.7
2083.555	−49.9	5.773	−50.9	+1.0

THE ORBIT OF SPECTROSCOPIC BINARY H.D. 201032

By R. W. Tanner

THE star H.D. 201032, $\alpha 21^h02^m.0$, $\delta + 62°59'$ (1900), vis. mag. 7.26, type A5, was found to have a variable radial velocity on five plates secured here in 1940-41.[1] These plates were taken with the $12\frac{1}{2}$-inch camera, giving a dispersion of about 66 A./mm. at Hγ.



Eight more observations with the 25-inch camera, giving 33 A./mm. in 1945-46 suggested a short period, and the velocity curve was filled in by a run of 25-inch camera plates in September and October, 1947. The orbit is based on 29 plates, including the five $12\frac{1}{2}$-inch plates, as given in Table VI.

About fifteen or twenty lines were measured on each plate, the error of measurement being from one to two km./sec., judged from the internal agreement of the measures.

The period best assembling the observations is 2.29883 days. The observations cover more than 1100 revolutions, and the error in the period is estimated at ± .00005 days. Several check plates eliminate any possibility of an alternative period.

The orbit is nearly circular, and preliminary elements chosen were $T_o = $ J.D. 2431708.9, $K = 49$ km./sec., $\gamma = 6$ km./sec. A least-squares solution by Sterne's method made rather large changes in

[1] *Pub. D.D.O.*, v. 1, no. 13, 1942.

TABLE VI

J.D.	V_o km./sec.	Phase from T_o	V_c km./sec.	V_o–V_c km./sec.
2429858.729	+30.9	.178	+29.0	+1.9
9947.469	+13.7	.781	+14.6	−0.9
2430239.749	+51.5	.923	+47.0	+4.5
0287.558	+ 3.7	.721	− 1.7	+5.4
0324.510	+17.8	.795	+18.4	−0.6
1707.657	−39.4	.478	−40.7	+1.3
2012.816	+17.0	.213	+18.2	−1.2
2013.847	−17.0	.662	−16.6	−0.4
2015.825	−42.5	.526	−39.2	−3.3
2025.865	+39.2	.891	+41.3	−2.1
2033.790	−18.3	.338	−20.8	+2.4
2035.788	+17.7	.207	+20.4	−2.7
2118.510	+27.2	.191	+25.2	+2.0
2432.662	+34.4	.848	+31.8	+2.6
2434.680	− 0.1	.726	− 0.3	+0.2
2435.695	+33.4	.167	+32.1	+1.3
2436.610	−39.3	.565	−35.1	−4.2
2436.785	−18.1	.642	−21.3	+3.2
2437.782	+49.8	.075	+51.0	−1.2
2438.665	−38.9	.459	−40.2	+1.3
2441.771	+15.1	.811	+22.5	−7.4
2444.740	+46.2	.102	+47.0	−0.8
2446.648	+49.9	.932	+48.3	+1.6
2446.749	+52.8	.976	+53.1	−0.3
2453.749	+54.3	.021	+54.6	−0.3
2454.601	−31.2	.392	−32.6	+1.4
2456.642	− 4.4	.279	− 3.5	−0.9
2456.731	−17.1	.318	−15.3	−1.8
2463.506	+ 0.9	.265	+ 1.1	−0.2

the elements, necessitating a second solution with preliminary elements: T_o = J.D. 2431708.88, K = 47.65 km./sec., γ = 6.52 km./sec. The final elements with their mean errors are:

P 2.29883 ± .00005 days
K 47.68 ± .81 km./sec.
γ +6.59 ± .54 km./sec.
e 0.047 ± .016
ω 81° ± 19°
To J.D. 2431708.879 ± .005; T J.D. 2431709.396
$a \sin i$ 1.50×10^6 km.
Mass function 0.026 $\odot$
Mean error single plate ± 2.84 km./sec.