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THE ORBITS OF THREE SPECTROSCOPIC BINARIES H.D. 2019, H.D. 10588 and H.D. 14688

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THE ORBIT OF THE SPECTROSCOPIC BINARY H.D. 2019

By JOHN F. HEARD

THE star H.D. 2019 ($\alpha\ 00^h\ 19.^m4$, $\delta + 30^\circ\ 49'$, vis. mag. 6. 8, type B9) was announced as a spectroscopic binary from seven plates taken at this observatory between 1935 and 1938,[1] using the 12½-inch camera of the one-prism spectrograph. Between 1945 and 1947, 32 additional plates were obtained with the 25-inch camera. An orbit has been computed from these 32 plates, the earlier plates serving only to fix the period.

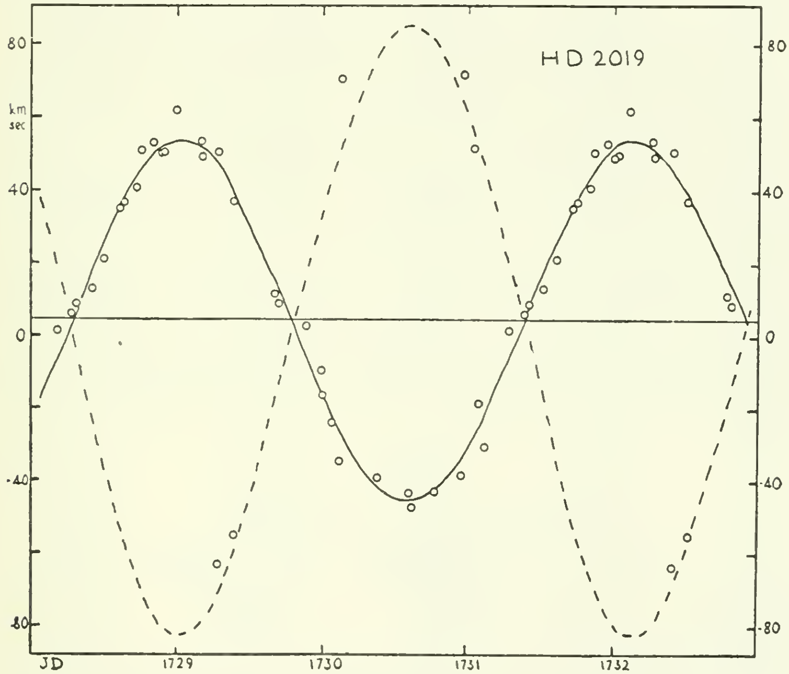

FIG. 1

The spectrum of H.D. 2019 is not of good quality for velocity measures, the lines being poor and few. Generally speaking, the lines measured were λ3933, 4101, 4128, 4130, 4340, 4481, and 4549A. Probable errors for the plates ranged from 2 to 4 km./sec. for the most part.

On five of the plates faint components to some of the lines were measured. These were presumed to be due to the secondary star,

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[1] *Pub. D.D.O.*, v. 1, no. 3, 1939.

a conclusion borne out by the accordance of the measures when later fitted to the orbit of the primary. That the components were not seen on more of the plates is attributed to their faintness which would mean that the density of the spectrum needed to be just right.

A preliminary circular orbit was used and differential corrections to the elements were computed by least squares using the method of Sterne.[2] In the solution twenty of the observations were combined in pairs to give twenty-two normal places which were weighted 1 or 2. Since the preliminary period was determined by the use of the early observations which were not used in the least-squares solution, no differential correction to the period was computed.

After the solution for the primary orbit was computed, the velocities attributed to the secondary star were examined. Regarding all the other elements as already fixed by the solution for the primary, a least-squares solution for the half-range of the secondary was made, weights being attributed to the five measures in proportion to the number of lines measured. From the value of K_2 so derived the mass ratio and the value of $(m_1 + m_2) \sin^3 i$ were derived.

The results are summarized in table I, and table II lists the individual times, phases, computed and observed velocities and residuals. Figure 1 shows the individual observations plotted with the final curves. The probable error for a single observation for the primary is ± 5.0 km./sec. and for the secondary ± 10.3 km./sec.

TABLE I

ORBITAL ELEMENTS FOR H.D. 2019

		Preliminary	*Final*	*P.E.*
Period	P	$3^d.11276$	$3^d.11276$	
Eccentricity	e	0	0.026	± .015
Angle of periastron	ω		339°	± 35°
Velocity of system	γ	+ 5.0 km./sec.	+ 4.76 km./sec.	± 0.92
Epoch of mean longitude	To	J.D. 2431732.178	J.D. 2431732.152	± 0.008
Date of periastron	T		J.D. 2431731.970	
Semi-amplitude, primary	K_1	82 km./sec.	79.6 km./sec.	± 1.35
Semi-amplitude, secondary	K_2		134.7 km./sec.	± 4.7
$a_1 \sin i$			3.41×10^6 km.	
$a_2 \sin i$			5.76×10^6 km.	
$\frac{m_1}{m_2}$			1.69	± 0.07
$(m_1 + m_2) \sin^3 i$			1.70 ⊙	

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[2] *Proc. Nat. Acad. Sc.*, v. 27, no. 3, 1941.

TABLE II

J.D.	*Vo* km./sec.	*Phase from final T*	*Vc* km./sec.	*Vo-Vc* km./sec.
2428770.805	+ 82.4*	2.183	+ 90.7	− 8.3
2431733.717	− 69.3	1.747	− 72.9	+ 3.6
1746.655	− 29.2	2.234	− 39.6	+10.4
1751.683	+ 3.8	1.037	− 9.2	+13.0
1756.657	+ 59.0	2.898	+ 60.8	− 1.8
1757.690	+ 18.4	0.819	+ 25.0	− 6.6
1764.633	− 62.2	1.536	− 67.0	+ 4.8
1765.618	+ 9.6	2.521	+ 3.6	+ 6.0
1790.567	+ 13.8	2.568	+ 11.3	+ 2.5
1812.474	+ 20.5	2.685	+ 30.3	− 9.8
2067.801	+ 33.9	2.766	+ 42.8	− 8.9
2078.765	− 54.8	1.279	− 42.8	−12.0
	+113*		+ 85.4	+27.6
2079.754	− 48.8	2.264	− 35.6	−13.2
2386.868	− 38.3	1.219	− 35.3	− 3.0
2390.866	− 61.3	2.104	− 54.6	− 6.7
	+115*		+105.2	+ 9.8
2395.832	+ 13.8	0.844	+ 21.2	− 7.4
2399.876	− 75.8	1.776	− 72.8	− 3.0
2404.867	+ 59.3	0.541	+ 63.7	− 4.4
	− 88*		− 94.9	+ 6.9
2407.878	+ 80.9	0.439	+ 74.2	+ 6.7
	−102*		−112.6	+10.6
2409.875	+ 2.4	2.436	− 10.2	+12.6
2421.805	− 69.2	1.915	− 68.8	− 0.4
2425.869	+ 56.2	2.867	+ 57.0	− 0.8
2428.682	+ 13.9	2.568	+ 11.3	+ 2.5
2432.760	+ 78.0	0.319	+ 82.5	− 4.5
2435.760	+ 86.0	0.306	+ 83.1	+ 2.9
2441.822	+ 99.2	0.143	+ 86.1	+13.1
2444.778	+ 84.7	3.099	+ 80.1	+ 4.6
2467.726	− 15.4	1.143	− 24.9	+ 9.5
2469.597	+ 81.2	3.016	+ 73.5	+ 7.7
2469.730	+ 78.4	0.036	+ 82.9	− 4.5
2470.842	− 25.6	1.149	− 25.7	+ 0.1
2472.677	+ 64.5	2.983	+ 70.4	− 5.9
2472.861	+ 78.8	0.054	+ 83.8	− 5.0

*Secondary spectrum

THE ORBIT OF THE SPECTROSCOPIC BINARY H.D. 10588

By Ruth J. Northcott

THE star H.D. 10588, $\alpha(1900)\ 01^{h}38^{m}.2$, $\delta(1900)\ 31^{\circ}43'$, vis. mag. 6.42, type G5, was announced as a binary from six plates taken at this observatory during 1936-1938.[1] Thirty-nine spectrograms were taken between the dates 1945 and 1947; these forty-five plates have been made the basis of a least-squares solution for the orbital elements. The early plates were taken with the one-prism spectrograph and the 12½-inch camera giving a dispersion of 66 A./mm. at Hγ; the rest of the plates were taken with the 25-inch camera giving 33 A./mm. at Hγ. The data from the plates are given in table III.

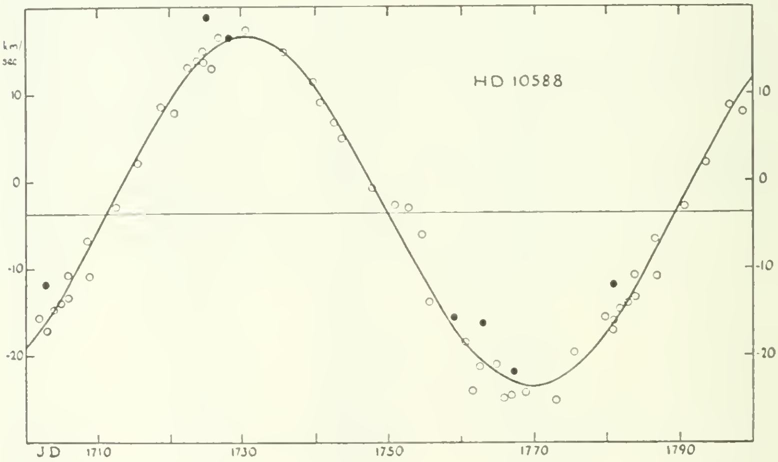

Fig. 2

The observations were grouped into 33 observational equations; in no case did the observations to be grouped differ in time by more than one revolution. Weights (1, 2, 3) were assigned according to the number of plates.

The preliminary elements were derived using R. K. Young's graphical method. A circular orbit was found to fit the observations reasonably well. Final elements were derived using T. E. Sterne's form of least-squares solution for very small eccentricities. All six elements were included in the solution. The observations were

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[1] *Pub. D.D.O.*, v. 1, no. 3, 1939.

TABLE III

J.D. 242-243	*Vo* km./sec.	*Phase from final T*	*Vc* km./sec.	*Vo-Vc* km./sec.
8412.820	− 21.9	36.585	− 23.0	+ 1.1
8763.842	+ 16.7	75.578	+ 16.4	+ 0.3
8794.798	− 15.6	28.526	− 16.9	+ 1.3
8838.674	+ 19.1	72.402	+ 14.6	+ 4.5
8894.490	− 11.9	50.211	− 16.3	+ 4.4
9188.716	− 16.3	32.408	− 20.7	+ 4.4
1687.897	− 25.1	35.355	− 22.6	− 2.5
1688.891	− 24.7	36.349	− 23.0	− 1.7
1694.883	− 25.2	42.341	− 22.8	− 2.4
1701.853	− 15.8	49.311	− 17.4	+ 1.6
1702.865	− 16.2	50.323	− 16.2	0.0
1703.842	− 14.6	51.300	− 15.0	+ 0.4
1704.868	− 14.0	52.326	− 13.6	− 0.4
1705.838	− 13.4	53.306	− 12.2	− 1.2
1708.835	− 11.0	56.293	− 07.7	− 3.3
1739.749	+ 11.5	9.200	+ 11.4	+ 0.1
1780.651	− 17.1	50.102	− 16.5	− 0.6
1786.639	− 06.5	56.090	− 08.0	+ 1.5
1793.614	+ 02.3	63.065	− 03.1	− 0.8
1802.575	+ 15.0	72.026	+ 14.3	+ 0.7
1840.506	− 21.4	31.950	− 20.3	− 1.1
2059.902	− 00.8	17.324	− 00.2	− 0.6
2062.869	− 05.5	20.291	− 05.0	− 0.5
2064.874	− 05.1	22.296	− 08.2	− 3.1
2076.835	− 21.8	34.257	− 21.8	0.0
2113.809	+ 13.9	71.231	+ 13.6	+ 0.3
2114.801	+ 13.8	72.223	+ 14.6	− 0.8
2115.759	+ 13.0	73.181	+ 14.0	− 1.0
2116.754	+ 16.7	74.176	+ 15.8	+ 0.9
2120.731	+ 17.5	0.146	+ 16.9	+ 0.6
2125.724	+ 15.1	5.139	+ 15.1	0.0
2144.675	− 10.0	24.090	− 11.0	+ 1.0
2145.665	− 13.9	25.080	− 12.4	− 1.5
2165.590	− 19.7	45.005	− 21.4	+ 1.7
2173.707	− 10.7	53.122	− 12.5	+ 1.8
2190.552	+ 13.4	69.967	+ 12.4	+ 1.0
2228.509	− 18.5	29.916	− 18.4	− 0.1
2229.498	− 24.2	30.905	− 19.4	− 4.8
2392.856	− 24.9	38.249	− 23.4	− 1.5
2414.740	− 02.9	60.133	− 01.6	− 1.3
2420.897	+ 08.8	66.290	+ 04.8	+ 4.0
2422.836	+ 08.1	68.229	+ 10.4	− 2.3
2442.774	+ 09.1	10.159	+ 10.3	− 1.2
2444.858	+ 06.8	12.243	+ 07.5	− 0.7
2445.809	+ 05.0	13.194	+ 06.2	− 1.2

tested for a fictitious period by the method of R. W. Tanner.[2] Reduction of Σpv^2 was from 240 to 176. The following table IV gives the preliminary and final elements obtained.

The individual observations are shown in figure 2. The probable error of a single plate is 1.4 km./sec.

TABLE IV

ORBITAL ELEMENTS OF H.D. 10588

		Preliminary	Final	P. E.
Period	P	77.98 days	78.0073	± 0.0128
Eccentricity	e	0	0.0173	± 0.0104
Angle of periastron	ω		359°.40	±28.34
Periastron passage	T		J.D. 2431730.549	± 0.160
Velocity of system	γ	−03.5 km./sec.	−03.654	± 0.188
Semi-amplitude	K	21.5 km./sec.	20.142	± 0.270
$a \sin i$			2.160×10^7 km.	
$\frac{m_2^3 \sin^3 i}{(m_1 + m_2)^2}$			0.0662 ⊙	
Absolute magnitude M (spectroscopic)			+2.0	
Spectroscopic parallax			0″.013	

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[2] *Comm. D.D.O.*, no. 16, 1948.

THE ORBIT OF THE SPECTROSCOPIC BINARY H.D. 14688

By John F. Heard

THE star H.D. 14688 (α 02^{h}17^m.1, δ + 16°24′, vis. mag. 7.8, type A1s) was announced as a spectroscopic binary from five plates taken at this observatory between 1935 and 1938.[1] The plates were taken with the 12½-inch camera of the one-prism spectrograph. During 1945 and 1946, 27 additional plates have been obtained with the 25-inch camera which gives a dispersion of about 33 A./mm. at Hγ. From these latter plates an orbit has been computed. The earlier plates were used to fix the period but were not otherwise used in the solution.

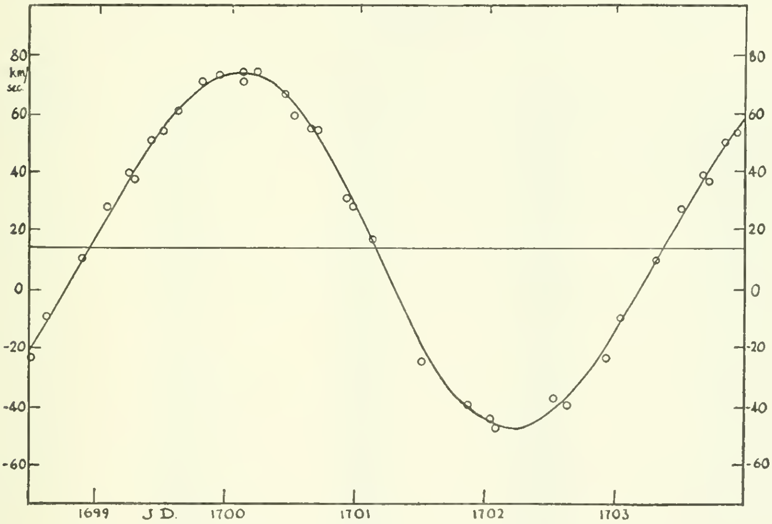

Fig. 3

The spectrum of H.D. 14688 is of very good quality for measuring, the lines being numerous and sharp. Between 27 and 41 lines were measured on each plate. The probable errors of the velocities from inter-agreement among the lines ranged from 0.6 to 1.2 km./sec. An apparent variation in the intensity of the line 4226 reported earlier[1] was not confirmed on the plates of greater dispersion, and no other peculiarities of the spectrum were noticed.

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[1] *Pub. D.D.O.*, v. 1, no. 3, 1939.

TABLE V

ORBITAL ELEMENTS FOR H.D. 14688

	Preliminary	*Final*	P. E.
Period . . . . P	4.37140 days	4.37140 days	
Eccentricity . . . . e	0.05	0.047	± .007
Angle of Periastron . . . . ω	90°	90°.00	±7.45
Velocity of system . . . . γ	+13.7 km./sec.	+13.86 km./sec.	± .47
Semi-amplitude . . . . K	59.5 km./sec.	59.54 km./sec.	± .38
Epoch of mean longitude . . . T_0	J.D. 2431704.404	J.D. 2431704.406	± .005
Date of periastron . . . . T	J.D. 2431705.497	J.D. 2431705.498	
$a \sin i$		3,574,000 km.	
$\frac{m_2^3 \sin^3 i}{(m_1 + m_2)^2}$		0.092 ⊙	

TABLE VI

J.D. 243	*Vo* km./sec.	*Phase from final T*	*Vc* km./sec.	*Vo-Vc* km./sec.
1701.881	−37.3	0.754	−40.9	+3.6
1702.885	−22.2	1.758	−18.3	−3.9
1703.884	+53.3	2.757	+54.7	−1.4
1704.896	+59.1	3.769	+61.9	−2.8
1705.874	−23.7	0.376	−19.3	−4.4
1708.853	+73.5	3.355	+73.4	+0.1
1728.831	−38.4	1.476	−34.3	−4.1
1745.728	−43.1	0.887	−44.4	+1.3
1746.717	− 8.4	1.876	− 9.4	+1.0
1747.708	+60.0	2.867	+60.6	−0.6
1748.742	+53.8	3.901	+53.9	−0.1
1751.718	+39.2	2.506	+38.2	+1.0
1755.725	+10.7	2.141	+10.2	+0.5
1757.756	+30.8	4.172	+32.3	−1.5
1763.703	−34.9	1.376	−38.7	+3.8
1764.659	+28.0	2.332	+25.0	+3.0
1765.689	+70.7	3.362	+73.4	−2.7
1766.690	+17.9	4.363	+14.7	+3.2
1791.635	+71.1	3.080	+69.3	+1.8
1795.578	+50.4	2.652	+48.2	+2.2
1805.637	+52.4	3.968	+49.1	+3.3
1813.590	+71.8	3.178	+71.7	+0.1
1831.583	+66.4	3.685	+66.0	+0.4
1836.483	+28.1	4.214	+28.5	−0.4
1837.583	−45.7	0.943	−45.2	−0.5
1843.536	+36.2	2.524	+39.5	−3.3
1844.478	+73.6	3.466	+72.5	+1.1

A preliminary orbit was determined by the graphical method of R. K. Young and a least-squares solution was made using 19 normal places. Since the eccentricity is small, the method of Sterne was used in the least-squares solution, that is, a differential correction was computed for T_0, the date at which the mean longitude $\omega + M$ is zero. Both T_0 and the corresponding T, time of periastron passage, are shown in table V, which lists the preliminary and final elements and their probable errors. The period was not included in the least-squares solution since it was possible to fix it with considerable accuracy by use of the earlier observations.

Table VI lists the individual times, phases, computed and observed velocities and residuals.

Figure 3 shows the individual observations plotted with the final curve. The probable error of a single observation is ± 1.6 km./sec.