THE MINIMUM MASSES OF SEVEN SPECTROSCOPIC BINARY STARS*

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DURING the spectroscopic survey of the Class B stars, brighter than magnitude 7.50, which was completed two years ago, at the Dominion Astrophysical Observatory, 117 new spectroscopic binaries were discovered. The spectra of 18 of these stars show double lines, and for these stars it is possible to determine the minimum masses of the components. The determination of the orbital elements and the masses of the more important systems is being undertaken by the author, who is also re-observing a few Class B stars to obtain the elements and masses of the secondary components of the systems.

Spectroscopic orbits have been completed this spring, for seven double-lines systems. The principal elements are given in Table I.

TABLE I—PRINCIPAL ORBITAL ELEMENTS OF SYSTEMS

Star	Types	m	P (days)	e	K_1	K_2
H.D. 57060	O7sfk—O7	4.90	4.39351	0.156	217	288
H.D. 39698	B3k —B5	5.89	7.8271	0.250	74	194
H.D. 29376	B3k —B5	6.89	2.2075	0.076	125	236
H.D. 218440	B3sk —B5	6.28	7.25105	0.376	88	147
H.D. 44701	B5n —B8n	6.58	1.19033	0.036	173	264
H.D. 208095	B7 —B9	6.1	17.3263	0.224	108	166
H.D. 57103	B8 —B8	5.61	2.25960	0.076	106	199

The spectral types range from O7 to B8. The short periods, small eccentricities and large amplitudes are typical of early type spectroscopic binaries.

Notes on the Systems

(1) The orbital elements for the brighter component of H.D. 57060 = 29 Canis Majoris, were derived by W. E. Harper, while at the Dominion Observatory, some 15 years ago. The faint lines

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of the secondary spectrum were not evident on his plates. The recent observations indicate that a small correction to his period is desirable.

(2) H.D. 39698—The binary nature of this star, suspected at the Yerkes Observatory was confirmed by the author. The faint secondary spectrum was measured on 7 plates, at times of maximum separation. The orbital elements were determined from 24 observations; 27 years, 1275 revolutions, separates the first Yerkes from the last Victoria observation. In addition to an interstellar calcium line, stellar calcium lines, oscillating in the same period and with the amplitude of the hydrogen and helium lines were observed. The star is, therefore, another example of those systems of Class B3, which exhibit the coexistence of stellar and interstellar calcium lines.

(3) H.D. 29376—This spectroscopic binary was discovered by the author. The orbital elements were determined from 27 observations. Like H.D. 39698, this is a B3k star, whose spectrum contains both stationary and oscillating calcium lines.

(4) H.D. 218440—S. L. Boothroyd published the orbit for the brighter component of this system in 1921. He reported the coexistence of stellar and interstellar calcium lines on 4 spectrograms. Spectrograms taken recently confirm his observations. The earlier plates were remeasured and the relative masses of the components deduced.

(5) H.D. 44701—This spectroscopic binary was discovered by the author. No difficulty was experienced in obtaining the short period. The orbital elements were determined from 32 observations.

(6) H.D. 208095—This star is the brighter component of the visual double Burnham 11323. 23 spectrograms were obtained from 1925-1928, on 12 of which the secondary spectrum was measured. The period is fairly long and the resulting masses are high for the spectral class. Five observations of the 7.0 mag. companion, Boss 5628, were obtained. The type is A0. The radial velocity is constant, -7.0 ± 1.2 km./sec. which is identical with the velocity of system of the brighter star. The proper motions of both stars are similar in amount and direction; $\mu=0''.018$ in $\psi=80°$. The relative positions have remained unchanged since the observations of F. G. W. Struve in 1832.

(7) H.D. 57103 = 19 Lyncis. An orbit for the brighter component was derived by W. E. Harper in 1918 while at the Dominion Observatory. Faint lines of the secondary star were observed on his plates. Recent observations show that his period has remained quite unchanged throughout the intervening years.

Mass Data

The mass data for these systems are given in Table II.

TABLE II—MASS DATA

Star	Types	$M \sin^3 i$	$m_1 \sin^3 i$	$m_2 \sin^3 i$	$\frac{m_2}{m_1}$
H.D. 57060	O7sfk – O7	56.5 ⊙	32.2 ⊙	24.3 ⊙	0.75
H.D. 39698	B3k – B5	14.2	10.3	3.9	0.38
H.D. 29376	B3k – B5	10.7	7.0	3.7	0.53
H.D. 218440	B3sk – B5	7.7	4.8	2.9	0.60
H.D. 44701	B5n – B8n	10.3	6.2	4.1	0.66
H.D. 208095	B7 – B9	34.4	20.8	13.6	0.65
H.D. 57103	B8 – B8	6.6	4.3	2.3	0.55

The masses of five of the systems are normal for double stars of this class. H.D. 208095, however, is considerably above the average for Class B8. H.D. 57060 is the third most massive system known, being exceeded by H.D. 698, B9sek, minimum mass M = 158 ⊙, and H.D. 47129, O8eK, minimum mass M = 139 ⊙, the former investigated by the author, and the latter by J. S. Plaskett.

Interstellar Calcium

The behavoiur of the calcium lines in these systems is an interesting feature. Stellar calcium Ca II, makes its marginal appearance at Class B2, is quite apparent at Class B3, and steadily increases in intensity throughout the B to G Classes, reaching a maximum in Class K. The lines of interstellar calcium which originate in the uniformly distributed cosmic cloud are superimposed upon the spectra of all distant stars. They are characterized by two properties (*a*) narrow quality, (*b*) stationary position. They have always been observed in the spectra of the distant O to B3 stars; found to coexist with the stellar calcium in the spectra of

seven spectroscopic binaries† of Classes B2 to B5; and have been observed in only one spectrum of later type than B5, that is, in the massive B9 star H.D. 698 investigated by the author.

In these systems, the stellar H and K lines are absent in the O7 star, H.D. 57060; faintly present in the B3 stars, H.D. 39698, H.D. 29376 and H.D. 218440; moderately strong in the B5 star, H.D. 44701; and prominent in the B7—B8 stars, H.D. 208096 and H.D. 57103. The interstellar lines are present in the spectra of the first four stars, but absent in the spectra of the last 3 stars which are too near to support them.

Thus we observe in H.D. 57060 a single calcium line of stationary position; in the three systems of Classes B5 to B8, double calcium lines which oscillate in the same period and with the same amplitude as the stellar lines; and in the three B3k systems, we have three components of the calcium lines; one, a strong narrow line of stationary position which originates in the tenuous intervening cosmic cloud, and two other components whose appearance and motions indicate that they arise in the atmospheres of the revolving stars.

The absolute magnitudes of four systems have been deduced from the intensities of the interstellar calcium lines. They are: H.D. 57060, −4.2; H.D. 39698, −3.4; H.D. 29376, −2.4; and H.D. 218440, −3.0.

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†Omicron Persei, B2k (Jordan); H.D. 218440, B3sk (Boothroyd); U Ophiuchi B5k, (Struve); H.D. 39698, B3k; H.D. 29376, B3k; H.D. 25833, B3k and H.D. 214240, B3k, by the author.