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RADIAL VELOCITIES OF B-TYPE STARS IN THE NEAREST ASSOCIATIONS*

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ABSTRACT

Radial velocities are given for 59 O- and B-type stars in the associations I Lac, I Ori, II Per, and in the Cas-Tau region, together with a few field stars They are based on 1040 spectrograms obtained with the 82-inch McDonald telescope in the years 1952–1956 The principal purpose of the program was, to obtain more complete information on the incidence of spectroscopic binaries in these groups. Orbital elements are given for eleven spectroscopic binaries for which no elements had been published previously. For all but two of these, the semiamplitude of the velocity variation lies between 10 and 40 km/sec. Knowledge of the spectroscopic binaries among the stars of spectral types B5 and earlier in the groups mentioned may now be regarded as nearly complete for objects with periods below 50 days and semiamplitudes K_1 exceeding 10 km/sec The results of this work serve for a statistical discussion of the properties of the binaries in stellar associations to be published separately.

I. INTRODUCTION

The present paper contains radial velocities of 59 O- and B-type stars in the nearest associations, based on 1040 plates collected with the 82-inch McDonald telescope in the years 1952–1956. The main purpose of this observational program was to arrive at more complete data on the incidence of spectroscopic binaries in these associations than was available in the literature. Such data are expected to be of basic importance for the study of the processes of star formation and of stellar evolution. For this purpose we wish to collect information on such items as the frequency with which single, double, and multiple stars are produced in the star-forming medium and the frequency distributions of the mass ratios and of the separations between the components among the double systems.

Earlier work, by various authors, had indicated that the incidence of duplicity and multiplicity among the massive stars is high. A recent, provisional, discussion of the data presently available (Blaauw 1961) has revealed that among the early B-type stars the majority are double or multiple, even if we limit the statistics to companions heavier than 1 solar mass. Among the O-type stars, single objects seem to be quite exceptional.

The data on spectroscopic binaries in existing catalogues suffer from selection effects which make them less suitable for the investigation of the distribution functions of the quantities just mentioned. This is a consequence of the larger chances of discovery for objects with large variations in the velocity and of the tendency of observers to select the extreme cases for further study. These latter objects are usually the ones with the larger amplitudes and the shorter periods. Yet, without more completeness of the material with regard to both these elements, no proper basis for the envisaged statistical investigation seemed to be present. The present observational program constituted an attempt to extend the lists of spectroscopic binaries in the selected associations to hitherto neglected and unknown cases.

We chose the nearest O associations for a variety of reasons: these associations contain the brighter stars and therefore are the least incompletely observed; their ages are approximately known, either from kinematic considerations or from the HR diagrams, and they therefore offer the possibility of relating the binary properties to age; and the

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binary statistics might be related to other properties of the group as a whole, like the internal velocity dispersion, the luminosity function, the total mass, etc. Interest in pursuing problems of this nature had been enhanced by results of an earlier investigation by one of the authors (A. B.), indicating a relation between the occurrence of duplicity among O and B stars and the space velocity and by preliminary observations with the McDonald telescope, which revealed a relatively large number of hitherto unknown spectroscopic binaries in the II Perseus association.

In the present paper, results are given for stars in the Cassiopeia-Taurus region and in the associations II Per, I Ori, I Lac, and for a small number of relatively bright field stars suspected of variability, selected when observing time permitted their inclusion in the program. A few faint late B stars in a small region of the II Perseus association were included for the study of their membership in this association. The stars in the Cassiopeia-Taurus region were chosen from the list of members of the Cassiopeia-Taurus group published by one of the authors (Blaauw 1956), their membership in this group being derived from their space distributions and proper motions. Modern data, including the present radial velocities, render the association of these stars doubtful, although the evidence is not conclusive. Doubts about the reality of the Cas-Tau aggregate as a group of common origin were expressed earlier by Petrie (1958). The properties of this group of stars will be discussed separately on the basis of up-to-date photometry and the new radial velocities. Observations of stars in the Scorpio-Centaurus association are being published elsewhere (van Hoof, Bertiau, and Deurinck 1963).

As a by-product, the program has produced improved data on the systemic velocities of the spectroscopic binaries and more accurate velocities of the single stars which had been suspected of velocity variations. These will allow an improved discussion of the internal motions in the various groups.

The present paper gives, apart from particulars about the observations: (*a*) the list of all velocities measured on the McDonald plates (see Table 3); (*b*) a compilation of the mean velocities, together with a comparison with Wilson's (1953) radial-velocity catalogue and with Petrie's (1958) results (see Table 1); and (*c*) a brief discussion of the individual spectroscopic binaries for which the period and orbital elements had not been determined earlier (see Sec. III and Table 2). For a number of these stars, we have included some recent observations made at the Dominion Astrophysical Observatory, Victoria, which Dr. R. M. Petrie has kindly put at our disposal. These are marked by crosses in the diagrams.

Discussions of the statistics of the orbital elements and of the statistics of duplicity and multiplicity will be published separately. Data concerning the periods and amplitudes for the stars in the groups Cas-Tau, II Per, I Ori, and I Lac are collected in Figure 1, in order to show that the additional material has indeed revealed many hitherto neglected objects with low amplitudes and long periods. Dots represent the objects that were already known and circles the stars for which data are added in the present paper and in the paper by Blaauw and van Hoof (1963) on the star HD 23625, a double-lined binary in the association II Perseus.

II. THE OBSERVATIONS

The observations were conducted by one of the authors (A. B.) in the years 1952, 1954, 1955, and 1956, with the 82-inch telescope of the McDonald Observatory. The observing sessions usually covered a period of the order of 1 month at a time, or two half-months during the bright of the moon, separated by a dark-moon period, which was used for other purposes. This arrangement permitted us to collect long series of observations on consecutive or nearly consecutive nights, which have proved to be particularly useful in detecting the character of the velocity variation for objects of small amplitude, i.e., amplitudes which only moderately exceed the observational errors. Examples of objects for which the character of the velocity variations would otherwise have been hard to detect are HD 24190 and HD 25799 in the association II Per. Observations covering only a few years naturally do not allow a very accurate determination of the periods of the binaries. However, they do suffice for the planned statistical study. We have also observed a few stars with well-established periods. This is the case, for example, with the binaries in I Lac, for which many very early observations exist and for which it seemed to be of some interest to check possible variations in the period or in the shape of the velocity-curve. These objects will also be discussed separately, but the McDonald observations are included in Table 3.

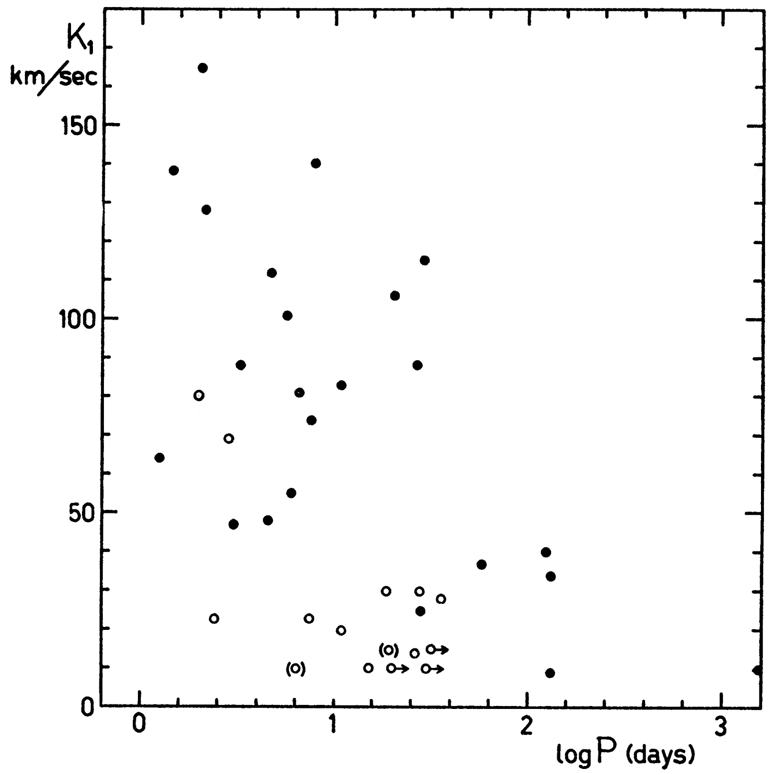

FIG. 1.—The (log P, K_1) diagram for the spectroscopic binaries of types B5 and earlier in the associations I Lac, I Ori, II Per, and the Cas-Tau group. *Open circles:* stars for which the elements were derived in the present program; *dots:* stars for which the elements were known previously.

The 1952 observations, denoted as the "CQ series," were obtained with the Cassegrain spectrograph equipped with two quartz prisms and a 500-mm-focal-length camera, providing a dispersion of about 40 A/mm at Hγ. All the later observations, denoted here as the "Cg series," were made with the D camera of the coudé grating spectrograph designed by W. A. Hiltner, giving a dispersion of 34 A/mm. Judging from the internal consistency of the measures, we find that the coudé arrangement has performed most satisfactorily, whereas the CQ spectrograms are of a lower quality. The constant-velocity star HD 24131 (in the II Per association) was frequently observed in the winter months, in order to check possible variations in the system of the radial velocities, and, for the same reason, HD 217811 (in the I Lac association) was frequently observed in the fall.

The individual observations are in Table 3. For each observation we give the series (CQ or Cg), the date expressed in Universal Time, the velocity and the number of lines used. At the bottom of the results for each star is the mean velocity and its internal probable error for stars with constant velocity and for objects of which the velocity shows small variations. Otherwise, the spectroscopic binary character is stated.

The lines measured are H12, H11, H10, λ 3819 (He I), H9, H8, λ 4026 (He I), Hδ, λ 4143 (He I), Hγ, λ 4387 (He I), λ 4471 (He I), and the K line, or part of these. The K line was mostly interstellar and was never used for the determination of the stellar velocity. In order to secure good definition of the cores of the strongest lines, we used, as a rule, rather strongly exposed spectrograms, although this meant sacrificing some metal lines. For the lines H12–H8 we originally used the laboratory wavelengths and, for the remaining lines, the empirical wavelengths recommended by Petrie (1953) on the basis of Victoria spectrograms. It then turned out that the velocities derived from some of the lines deviated systematically from the mean of all. H12 produced a systematic difference of −7.2 km/sec with respect to the mean of Hγ and Hδ. This is perhaps due to this line's position in a region of the spectrum where the continuum density of the background decreases rapidly toward the ultraviolet, causing the wavelength of minimum photographic density to be shifted somewhat to the ultraviolet with respect to the actual line center. Other lines also showed anomalies, particularly the line λ 4471 (He I), which gives systematic residuals up to −20 km/sec in some of the stars, whereas in others the adopted standard wavelength is correct. The deviations for this line are particularly noted in the spectroscopic binaries, where they are −11.7 km/sec, on the average. Another difficulty is that some of the lines are measured only in part of the stars.

We therefore proceeded as follows. For each star we computed from *all* spectrograms the *mean* systematic difference between the radial velocity derived from the lines Hγ, Hδ, H8, and H9 and that derived from all lines. Next, this mean difference was added to the mean velocity derived from all lines for each individual spectrogram. Thus radial velocities were obtained in a system defined only by the lines Hγ, Hδ, H8, and H9, whereas the use of all lines in determining the radial velocity tended to reduce the accidental error. Finally, we decided to apply a systematic correction of +3 km/sec to all velocities thus obtained, in order to reduce them to the revised system of Victoria (Petrie 1953), which is based on the lines λλ 3964–4471. This correction was computed in a comparison with all available Victoria velocities of stars in our material. Although there is admittedly something arbitrary in a procedure like this, we felt that, for most of the current problems for which the velocities will be used, such a reduction to a uniform system is to be preferred to the addition of an independent one.

The majority of the stars with broad lines, as well as spectroscopic binaries with small amplitudes, were measured independently by two different measures. In combining the measures of the two series, a curious effect was noticed which we have, so far, failed to account for. It appeared that one of the measurers (v.M.) tended to produce velocity-curves with amplitudes systematically smaller than those of the other measurers by amounts of up to 50 per cent, whereas the γ-velocities were nearly equal. His measures have been reduced to the system of the other observers.

Table 1 gives, in the fifth column, the mean radial velocity for stars with constant or only slightly variable velocity, as found from the McDonald observations only. For spectroscopic binaries with radial velocity-curves determined from the present observations the γ-velocity is given (see also Table 3). The sixth column, *n*, gives the numbers of McDonald spectrograms. The next two columns give the velocity according to Wilson's (1953) radial-velocity catalogue and Petrie's (1958) results for the Cas-Tau stars, insofar as his list overlaps with ours. The last column, "Remarks," gives references to (1) whether or not we consider the star to be a spectroscopic binary (marked "S.B."); (2) discussion of the star in Section III; (3) particulars about the elements of spectroscopic binaries in Table 2 (i.e., for objects for which no elements had been published previously); and (4) the diagrams with velocity-curves or with plots of the velocities against date.

As regards the comparison with Petrie's results for the Cas-Tau stars, we note that, in

1963ApJ...137..791B

TABLE 1

SUMMARY OF RESULTS

Name	HD	m	Spectral Type	Radial Velocity (km/sec)	p.e.	n	Wilson Catalogue (km/sec)	Petrie (1958) Rad. Vel. (km/sec)	p.e.	Remarks
	1976	5.36	B5 IV	−18	±2	16	−12 c	− 7.1	±3.9 S.B.	S.B.; Sec. III, Table 2, Fig. 2
ξ Cas...	3901	4.85	B2 V	− 4.4	0 4	17	− 8 c	−13.3	3.1	
1 Per.	11241	5.49	B2 V	− 9.8	1.2	16	− 3 c	−10.9	2.3	S.B.?; Sec. III, Table 2, Fig. 3
35 Ari.	16908	4.58	B3 V	+ 7 4	1.3	11	+19 c	+ 6.0	1.9	
53 Ari.	19374	6.09	B2 V	+23 0	1.1	21	+28 c			Sec. III, Fig. 4
	20336	4.76	B2 Ve	+ 9.9	1.3	8	+20 c	+13.5	1.8	S.B.; Sec. III
τ Ari.	20756	5.17	B5 Vp:	+19.2	0.9	12	+14 c	+12.4	1.6	
	22951	5.04	B0.5 V	+28.2	0.9	14	+19 c			
	23060	7 46	B2 Vp	+28.5	0.9	8				
o Per.	23180	3.94	B1 III	+17 7		15	+18.5 a			S.B.; Sec. III, Fig. 5
	+31°645	9.2	B2:	+20.9	2.1	7				
29 Tau.	23466	5.36	B3 V	+17	2	16	+13 c	+16.3	2.5	S.B.; Sec. III, Table 2, Fig. 6
	23478	6.51	B3 IV	+16.4	1.1	16	+15 c			
	23840	8.45	B6	+14.2	2.8	6				
	24012	7.57	B5	+36.9	1.7	8				
	24131	5.73	B1 V	+16.4	0.8	28	+17.8 a			
	24190	7 41	B2 V	+27	2	52	+18 c			S.B.; Sec. III, Table 2, Fig. 7
	24321	8.79	B7	+21.6	3.3	7				
	24583	8.97	B6	+25.4	1.4	5				
	24640	5.48	B2 V	+17 7	0 7	22	+17 c			Sec. III
35 Eri.	25340	5.25	B5 V	+13.1	0.4	16	+16 c	+19.5	1.7	
	25799	6.87	B3 V	+24		63	+20 c			S.B.; Sec. III, Table 2, Fig. 8
48 Per.	25940	4.03	B3 Vp	− 0 7	1.1	9	+ 3 0 b	− 1.2	2.6	
	27192	5.54	B2 IV	−21.4	2.4	9	−18 d	−15.8	2.0	
μ Eri.	30211	4.18	B5 IV	+23	2	19	+ 7 d	+10.5	2.1 S.B.	S.B., Sec. III, Table 2, Fig. 9
105 Tau.	32991	5.95	B2 Vp	+10.5	2.3	12	+25 c	+20.4	2.7 S.B.	S.B.?; Sec. III
	34748	6.30	B1.5 V	+32.6	1.5	20	+19 c			
ρ Aur	34759	5.12	B5 V	+19	2	12	+ 5 c	+21.1	4.9	S.B.; Sec. III, Table 2, Fig. 10
	35532	6.18	B2 V	+32.0	3.3	6	+31.4 b			S.B.?; Sec. III, Table 2
	35588	6.15	B3 V	+17	4	21	−24 c			S.B.; Sec. III, Table 2, Fig. 11

TABLE 1—*Continued*

Name	HD	*m*	Spectral Type	Radial Velocity (km/sec)	p.e.	*n*	Wilson Catalogue (km/sec)	Petrie (1958) Rad. Vel. (km/sec)	p.e.	Remarks
ρ Aur	35792	7.2	B3 V	+24.9	0.6	20	. . . . .			
	36936	7.52	B5	+18.7	1.2	19				S.B.?; Sec. III, Table 2
	36982	8.45	B1.5 Vp	+36.1	1.2	12				
	37017	6.54	B1.5 V	+32	2	19	+29 c			S.B.; Sec. III, Table 2, Fig. 12
	37321	7 08	B3 V	+22.5	0.9	17				S.B.?; Sec. III
	37367	6.00	B2 V	+25.9	1.2	15	+30 d	+19 6	2.9 S.B.	S.B.; Sec. III, Table 2
57 Ori.	39698	5.89	B2 V			6	+ 7.2 b		S.B.	S.B.; Sec. III
	40005	6.91	B3 V	+35	4	13	+32 d			S.B.; Sec. III, Table 2, Fig. 13
69 Ori.	42545	4.92	B5 V	+22.4	1.5	17	+22 c	+12.5	2.9	S.B.?; Sec. III, Table 2, Fig. 14
ξ Ori.	42560	4.35	B3 V	+40.3	0.8	14	+24 d			
	54224	6.38	B3	+ 4.5	5.5	2				
	65041	7.04	B2 V	−13	4	7	− 9 c			S.B.; Sec. III, Table 2, Fig. 15
	65875	6.43	B3 Vp	+50.3	1.9	7	+33 d			S.B.?; Sec. III
	209961	6.16	B2 V			29	−17.8 a			S.B., Sec. III
	212883	6.39	B2 V	− 9.5	0.8	7	− 6.5 b			
	214240	6.20	B3 V			47	−15.3 a			S.B.; Sec. III
	214432	7 4	B3 V	− 5.3	0.7	14				
	214652	6.67	B2:V			20	−12.6 a			S.B.; Sec. III
10 Lac.	214680	4.91	O9 V	− 9.3	0.9	20	− 9 7 a			
	216092	8.1	B1.V	+ 0.6	0.7	10				
14 Lac.	216200	5.84	B3 IV	−18.0	3.6	8	−14 c			S.B.?; Sec. III
	216534	8.0	B3 V	−76.8	3.1	7				
	216684	7.8	B3 V	− 6.1	1.8	12				S.B.?
	216851	7.68	B3 V:n	− 8.5	2.3	11	−20.1 b			
	217543	6.39	B3	−16.8	0.6	35	−16 c			Sec. III
	217811	6.32	B2 V	− 8.5	0.4	44	− 8.3 b			
	218325	8.0	B3 V	−18.9	0.9	30				
	218407	6.56	B2 V			42	−15.1 b			S.B.; Sec. III
	218674	6.53	B3 IV	−16.0	1.1	44	− 4 c			S.B.?; Sec. III, Fig. 16

TABLE 2

SPECTROSCOPIC BINARIES FOR WHICH NO ELEMENTS WERE PREVIOUSLY PUBLISHED

Name	HD	MK	γ (km/sec)	K_1 (km/sec)	e	ω	Period (days)	Figure No.	Remarks
	1976	B5 IV	−18	30	0.2	140°	27.8	2	
1 Per	11241	2 V	− 9	10	.45	90	15.6:	3	Binary character needs confirmation
29 Tau.	23466	3 V	+17	23	.0		2.4079	6	
	24190	2 V	+27	14	.1	120	26.1	7	
	25799	3 V	+24	20	.2	130	10.67	8	Erratic changes in velocity-curve
μ Eri.	30211	5 IV	+23	23	.39	125	7.330	9	
ρ Aur.	34759	5 V	+19	28	.0		35.5	10	
	35588	3 V	+17	69	.05	270	2.885	11	
	36936	5		10:			>20		Binary character needs confirmation
	37017	1.5 V	+32	30	.3	110	18.65	12	
	37367	2 V		9:			6.5?		Binary character needs confirmation
	40005	3 V	+35	77	.0		3.306	13	
69 Ori.	42545	5 V		15:			19?	14	Binary character needs confirmation
	65041	2 V	−13	34	0.30	320	2.826	15	
	218674	3 IV		10:			>30	16	Binary character needs confirmation

general, there is good agreement; our conclusions differ from his mainly in that we assign spectroscopic binary character to the stars HD 23466 (29 Tau) and HD 34759 (ρ Aur), whereas Petrie did not.

III. REMARKS CONCERNING INDIVIDUAL OBJECTS

HD 1976.—No period of this spectroscopic binary was known. From the McDonald observations, covering two sessions in November and December, 1956, a period of 27.8 days has been found. In Figure 2, the velocities are plotted against phase in this period. The two sessions are represented by dots (November, 1956) and triangles (December, 1956), respectively. Phases were computed with the formula

$$\text{Phase} = (27.8)^{-1}\ (\text{JD} - 2435000)\ .$$

Victoria observations of 1956 and 1957 are represented by crosses. The estimated uncertainty in the period does not exceed 1 day. An attempt to improve upon it by means of the old Victoria observations of 1924 to 1927 was not successful. The elements were estimated by means of standard curves, with the results given in Table 2. The drawn curve in Figure 2 corresponds to these elements.

TABLE 3

McDONALD RADIAL VELOCITIES

Star (HD No.)	Series	U.T.	Radial Velocity km/sec	n
1976	Cg	1956 Nov. 18.116	+ 7	7
		19.099	+ 11	7
		20.176	+ 12	7
		22.133	+ 1	7
		26.118	- 24	7
		27.161	- 24	7
		Dec. 12.087	- 9	7
		13.056	+ 4	7
		14.113	+ 5	7
		15.036	+ 4	7
		16.083	+ 4	7
		17.086	+ 3	7
		23.056	- 12	7
		24.093	- 16	7
		25.057	- 34	7
		26.051	- 40	7
			spectr. binary	
3901	Cg	1956 Nov. 17.112	- 6	7
		18.130	- 4	7
		19.112	- 6	7
		20.189	- 5	7
		22.144	- 5	7
		26.131	- 4	7
		27.169	+ 4	7
		Dec. 12.100	- 5	7
		13.065	- 5	7
		14.123	- 5	7
		15.058	- 4	7
		16.093	- 4	7
		17.097	- 9	7
		23.068	- 2	7
		24.103	- 1	7
		25.068	- 6	7
		26.062	- 8	7
			- 4.4 ± 0.4	
11241	Cg	1956 Nov. 17.123	+ 3	9
		18.145	- 3	10
		19.125	- 18	10
		20.203	- 18	9
		22.158	- 13	10
		26.144	- 16	10
		Dec. 12.113	- 12	11
		13.076	- 7	11
		14.130	- 5	11
		15.068	- 3	11
		16.103	- 11	11
		17.106	- 1	11
		23.082	- 17	10
		24.114	- 15	9
		25.078	- 8	11
		26.073	- 13	11
			- 9.8 ± 1.2 variable	
16908	Cg	1956 Nov. 19.150	- 5	12
		Dec. 12.125	+ 3	12
		13.086	+ 5	12
		14.137	+ 8	11
		15.077	+ 4	12
		16.113	+ 7	12
		17.116	+ 17	12
		23.095	+ 8	12
		24.125	+ 3	11
		25.089	+ 21	12
		26.101	+ 10	12
			+ 7.4 ± 1.3	
19374	Cg	1956 Nov. 14.264	+ 15	12
		16.245	+ 19	12
		17.138	+ 14	12
		18.161	+ 16	12
		19.162	+ 18	12
19374 (cont.)	Cg	1956 Nov. 20.229	+ 9	11
		25.305	+ 30	12
		26.165	+ 20	12
		27.180	+ 29	12
		Dec. 12.138	+ 30	12
		13.095	+ 25	12
		14.147	+ 26	12
		15.088	+ 18	11
		16.127	+ 29	12
		17.129	+ 21	12
		21.266	+ 33	12
		23.110	+ 21	12
		24.139	+ 32	12
		25.101	+ 27	12
		26.113	+ 27	11
		27.122	+ 25	12
			+ 23.0 ± 1.1	
20336	Cg	1956 Nov. 16.285	+ 9	7
		19.138	+ 15	7
		Dec. 14.299	+ 12	7
		15.110	+ 16	7
		16.250	+ 7	7
		17.191	+ 13	7
		25.123	+ 3	7
		26.092	+ 4	7
			+ 9.9 ± 1.3	
20756	Cg	1956 Nov. 19.177	+ 17	12
		26.300	+ 23	12
		Dec. 12.153	+ 14	12
		13.233	+ 25	12
		14.157	+ 24	12
		15.100	+ 13	12
		16.142	+ 12	12
		17.150	+ 19	12

TABLE 3 - continued

Star (HD No.)	Series	U.T.	Radial Velocity km/sec	n
20756 (cont.)	Cg	1956 Dec. 23.126	+ 24	12
		24.156	+ 19	12
		25.113	+ 21	12
		27.137	+ 19	12
			+ 19.2 ± 0.9	
22951	Cg	1954 Sept. 16.426	+ 35	11
		18.422	+ 25	11
		20.397	+ 21	11
		20.406	+ 31	11
		21.349	+ 31	9
		21.356	+ 34	8
		22.379	+ 25	11
		22.387	+ 20	11
		23.398	+ 32	11
		23.406	+ 29	11
		24.399	+ 27	11
		26.394	+ 33	10
		27.479	+ 26	11
		30.390	+ 26	11
			+ 28.2 ± 0.9	
23060	Cg	1955 Nov. 3.474	+ 24	12
		5.397	+ 34	12
		6.278	+ 27	12
		7.377	+ 29	12
		Dec. 3.274	+ 34	12
		6.190	+ 26	11
		7.192	+ 27	11
		9.299	+ 27	12
			+ 28.5 ± 0.9	
23180	Cg	1954 Sept. 15.390	+ 27	9
		15.399	+ 21	10
		16.414	+ 118	10

Star (HD No.)	Series	U.T.	Radial Velocity km/sec	n
23180 (cont.)	Cg	1954 Sept. 16.420	+ 121	10
		17.390	+ 27	10
		18.428	- 87	8
		18.433	- 65	9
		20.421	+ 89	7
		21.367	+ 74	10
		22.395	- 32	10
		22.401	- 43	10
		23.413	- 51	9
		23.418	- 43	9
		24.406	+ 47	10
		30.397	+ 59	10
			spectr. binary	
BD +31°645	Cg	1955 Feb. 10.151	+ 21	9
		13.131	+ 34	9
		15.143	+ 17	10
		Nov. 2.333	+ 11	12
		4.378	+ 17	12
		Dec. 7.303	+ 29	12
		8.167	+ 17	12
			+ 20.9 ± 2.1	
23466	Cg	1956 Nov. 14.285	- 8	7
		16.267	- 1	9
		17.348	+ 27	10
		18.279	+ 18	10
		19.323	+ 1	10
		26.315	- 3	10
		27.253	+ 31	10
		Dec. 13.284	- 6	10
		14.323	+ 36	9
		15.285	- 2	10
		16.154	+ 11	10
		23.243	+ 11	10
		24.265	+ 40	9

Star (HD No.)	Series	U.T.	Radial Velocity km/sec	n
23466 (cont.)	Cg	1956 Dec. 25.272	- 2	9
		26.224	+ 39	9
		27.262	+ 15	10
			spectr. binary	
23478	Cg	1954 Sept. 10.444	+ 22	7
		13.421	+ 16	7
		14.419	+ 13	7
		15.369	+ 9	7
		16.381	+ 6	7
		17.312	+ 11	7
		17.476	+ 14	7
		18.479	+ 13	7
		19.480	+ 12	7
		22.461	+ 26	7
		23.493	+ 19	7
		24.440	+ 22	7
		26.442	+ 22	7
		27.442	+ 20	7
		30.322	+ 23	7
		30.457	+ 15	7
			+ 16.4 ± 1.1	
23840	Cg	1955 Feb. 16.228	+ 20	7
		Nov. 2.417	+ 9	7
		4.269	+ 7	7
		1956 Nov. 17.220	+ 20	7
		19.227	+ 4	7
		Dec. 14.188	+ 25	7
			+ 14.2 ± 2.8	
24012	Cg	1955 Feb. 6.296	+ 26	7
		12.260	+ 41	7
		14.162	+ 43	7

TABLE 3 - continued

Star (HD No.)	Series	U.T.	Radial Velocity km/sec	n
24012 (cont.)	Cg	1955 Feb. 16.153	+ 42	7
		18.217	+ 31	7
		Nov. 5.428	+ 42	7
		6.397	+ 33	7
		7.487	+ 37	7
			+ 36.9 ± 1.7	
24131	Cg	1955 Feb. 6.252	+ 16	12
		8.150	+ 21	12
		9.190	+ 14	9
		10.085	+ 14	11
		10.210	+ 22	10
		12.151	+ 25	12
		13.202	+ 22	10
		14.140	+ 9	11
		15.200	+ 27	9
		16.176	+ 16	10
		16.194	+ 23	9
		Nov. 3.393	+ 13	12
		1956 Nov. 14.157	+ 9	12
		16.170	+ 15	12
		17.168	+ 22	12
		18.182	+ 7	12
		19.257	+ 21	12
		26.208	+ 17	12
		27.192	+ 12	12
		Dec. 12.188	+ 20	12
		13.269	+ 10	12
		14.235	+ 20	12
		15.153	+ 13	12
		16.180	+ 20	12
		23.151	+ 15	12
		24.171	+ 9	12
		25.154	+ 12	12
		26.188	+ 14	12
			+ 16.4 ± 0.8	
24190	Cg	1954 Sept. 8.441	+ 9	8
		9.455	+ 19	8
		10.416	+ 8	7
		15.458	+ 19	8
		17.412	+ 29	7
		18.453	+ 15	8
		19.362	+ 32	7
		20.477	+ 44	8
		21.383	+ 31	8
		23.343	+ 40	8
		23.467	+ 38	8
		24.374	+ 31	7
		25.351	+ 39	7
		25.440	+ 35	8
		28.368	+ 40	8
		30.422	+ 26	8
		1955 Feb. 8.127	+ 32	9
		9.219	+ 35	9
		12.121	+ 22	7
		14.117	+ 13	8
		22.118	+ 28	9
		23.208	+ 34	9
		24.179	+ 30	8
		25.124	+ 42	7
		28.099	+ 43	9
		Nov. 3.353	+ 12	9
		5.334	+ 15	9
		6.314	+ 19	9
		7.419	+ 12	9
		Dec. 3.354	+ 13	9
		4.285	+ 25	9
		6.401	+ 31	9
		8.366	+ 33	9
		9.336	+ 34	9
		1956 Nov. 14.183	+ 35	12
		16.206	+ 42	12
		17.184	+ 44	12
24190 (cont.)	Cg	1956 Nov. 18.201	+ 36	12
		19.274	+ 32	12
		20.284	+ 22	12
		23.269	+ 19	12
		26.230	+ 25	12
		27.237	+ 25	12
		Dec. 12.207	+ 37	12
		14.252	+ 43	11
		15.168	+ 43	12
		16.198	+ 34	12
		23.173	+ 16	12
		24.192	+ 9	11
		25.170	+ 18	12
		26.145	+ 1	12
		27.165	+ 23	12
			spectr. binary	
24321	Cg	1955 Feb. 15.235	+ 18	7
		Nov. 2.471	+ 19	7
		4.319	+ 5	7
		1956 Nov. 17.292	+ 11	7
		Dec. 12.244	+ 28	7
		15.200	+ 31	7
		27.199	+ 39	7
			+ 21.6 ± 3.3	
24583	Cg	1955 Nov. 5.465	+ 20	6
		Dec. 3.404	+ 25	7
		1956 Dec. 15.250	+ 26	7
		25.213	+ 33	7
		26.184	+ 23	7
			+ 25.4 ± 1.4	
24640	Cg	1954 Sept. 7.458	+ 11	11
		8.422	+ 13	12

TABLE 3 – continued

Star (HD No.)	Series	U.T.	Radial Velocity km/sec	n
24640 (cont.)	Cg	1954 Sept. 9.396	+ 18	11
		10.345	+ 21	11
		11.410	+ 16	11
		12.451	+ 21	12
		13.449	+ 13	11
		14.441	+ 19	9
		15.479	+ 15	11
		16.401	+ 25	11
		17.372	+ 24	10
		18.411	+ 14	11
		19.428	+ 8	10
		20.388	+ 13	10
		21.404	+ 32	9
		22.412	+ 17	10
		23.388	+ 17	10
		24.344	+ 17	11
		25.417	+ 16	10
		26.383	+ 23	9
		27.465	+ 17	10
		30.376	+ 19	12
			+ 17.7 ± 0.7	
25340	Cg	1956 Nov. 14.300	+ 11	7
		17.359	+ 11	7
		18.292	+ 13	7
		19.338	+ 15	7
		26.328	+ 11	7
		27.265	+ 14	7
		Dec. 13.297	+ 15	7
		14.334	+ 18	7
		15.297	+ 16	7
		16.166	+ 11	7
		17.252	+ 11	7
		23.261	+ 13	7
		24.282	+ 12	7
		25.285	+ 15	7
		26.237	+ 10	7
		27.275	+ 13	7
			+ 13.1 ± 0.4	
25799	Cg	1954 Sept. 8.399	+ 53	7
		10.368	+ 27	7
		11.432	+ 9	7
		12.427	+ 2	7
		13.474	+ 5	7
		14.378	+ 9	7
		15.421	+ 23	7
		16.454	+ 40	7
		18.356	+ 31	7
		19.401	+ 40	7
		20.442	+ 30	7
		23.437	+ 1	7
		24.317	+ 9	7
		24.468	+ 6	7
		25.394	+ 16	7
		26.358	+ 19	7
		26.477	+ 32	7
		27.398	+ 27	7
		28.335	+ 37	7
		30.353	+ 45	7
		1955 Feb. 6.203	+ 19	7
		7.114	+ 17	7
		8.087	+ 17	7
		8.240	+ 16	7
		9.103	+ 14	7
		9.153	+ 31	7
		11.073	+ 22	7
		12.082	+ 19	7
		12.208	+ 51	7
		13.225	+ 54	7
		14.082	+ 57	7
		14.219	+ 50	7
		15.070	+ 45	7
		20.101	+ 10	7
		21.099	+ 14	7
		23.242	+ 51	7
		25.178	+ 38	7
25799 (cont.)	Cg	1955 Nov. 3.428	+ 17	7
		5.355	+ 17	7
		6.351	+ 17	7
		7.445	+ 50	7
		Dec. 3.316	+ 17	7
		4.322	+ 12	7
		6.128	+ 7	7
		7.145	+ 6	7
		8.100	+ 15	7
		9.152	+ 19	7
		9.374	+ 52	7
		1956 Nov. 14.222	+ 13	7
		17.327	+ 26	7
		18.231	+ 37	7
		19.299	+ 42	7
		20.311	+ 11	7
		22.312	+ 2	7
		26.269	+ 28	7
		27.214	+ 49	7
		Dec. 12.286	+ 9	7
		14.278	+ 15	7
		16.227	+ 27	7
		23.211	+ 32	7
		24.218	+ 21	7
		25.253	+ 27	7
		27.238	+ 36	7
			spectr. binary	
25940	Cg	1956 Nov. 16.300	- 1	7
		18.317	+ 15	7
		23.288	- 2	7
		27.276	- 1	7
		Dec. 14.305	- 6	7
		15.131	- 4	7
		16.261	- 1	7
		17.206	+ 1	7
		25.131	- 7	7
			- 0.7 ± 1.1	

TABLE 3 - continued

Star (HD No.)	Series	U.T.	Radial Velocity km/sec	n
27192	Cg	1956 Nov. 16.314	0	7
		18.329	- 20	7
		23.300	- 17	7
		27.287	- 17	7
		Dec. 14.312	- 30	7
		15.123	- 27	7
		16.270	- 17	7
		17.219	- 27	7
		25.141	- 38	7
			- 21.4 ± 2.4 variable	
30211	Cg	1956 Nov. 14.311	+ 7	8
		16.368	+ 30	10
		17.368	+ 40	9
		18.303	+ 31	10
		19.350	+ 28	11
		25.319	+ 42	11
		26.339	+ 37	11
		27.312	- 3	11
		Dec. 13.307	+ 6	11
		14.344	+ 21	11
		15.306	+ 30	11
		16.310	+ 41	11
		17.262	+ 39	11
		21.278	+ 11	11
		23.275	+ 33	11
		24.295	+ 42	11
		25.296	+ 35	10
		26.247	+ 33	11
		27.285	0	11
			spectr. binary	
32991	Cg	1955 Feb. 8.289	0	8
		1956 Nov. 14.326	+ 6	9
32991 (cont.)	Cg	1956 Nov. 16.349	- 6	10
		17.513	+ 19	6
		18.361	+ 7	10
		27.302	+ 24	10
		Dec. 13.318	+ 5	10
		15.316	+ 26	10
		16.298	+ 3	9
		23.290	+ 20	10
		24.244	+ 17	9
		26.260	+ 5	10
			+ 10.5 ± 2.3 variable	
34748	Cg	1956 Nov. 14.345	+ 25	9
		17.446	+ 33	9
		18.400	+ 20	9
		19.370	+ 34	9
		20.340	+ 14	9
		22.346	+ 21	9
		25.334	+ 33	9
		26.353	+ 46	9
		27.325	+ 25	9
		Dec. 13.338	+ 48	9
		14.352	+ 34	9
		15.334	+ 37	9
		16.324	+ 35	9
		17.277	+ 30	9
		21.289	+ 44	9
		23.312	+ 17	9
		24.308	+ 35	9
		25.308	+ 49	9
		26.307	+ 37	9
		27.295	+ 34	9
			+ 32.6 ± 1.5	
34759	Cg	1956 Nov. 14.487	+ 28	7
		16.331	+ 19	10
		18.345	+ 10	10
		22.512	- 6	10
		27.469	- 6	10
		Dec. 13.485	+ 53	10
		14.490	+ 48	10
		15.481	+ 41	10
		17.234	+ 39	10
		21.429	+ 30	9
		26.440	- 2	9
		27.457	+ 1	9
			spectr. binary	
35532	Cg	1955 Feb. 9.284	+ 20	7
		14.251	+ 20	7
		15.290	+ 30	7
		16.268	+ 44	7
		17.130	+ 41	7
		19.143	+ 37	7
			+ 32.0 ± 3.3 variable	
35588	Cg	1956 Nov. 14.364	+ 76	11
		17.464	+ 59	11
		18.422	- 43	10
		19.389	+ 45	11
		20.358	+ 57	11
		22.365	+ 43	11
		25.351	+ 68	11
		26.371	+ 27	10
		27.341	- 44	11
		Dec. 12.314	+ 22	11
		13.355	+ 68	11

TABLE 3 - continued

Star (HD No.)	Series	U.T.	Radial Velocity km/sec	n
35588 (cont.)	Cg	1956 Dec. 14.363	- 56	11
		15.350	+ 35	11
		16.346	+ 56	11
		17.295	- 55	11
		21.316	+ 78	11
		23.331	- 52	11
		24.324	+ 78	10
		25.326	+ 19	10
		26.323	- 36	10
		27.310	+ 88	11
			spectr. binary	
35792	Cg	1956 Nov. 14.383	+ 26	12
		17.478	+ 23	12
		18.440	+ 23	11
		19.408	+ 18	12
		20.375	+ 23	12
		22.384	+ 23	12
		25.369	+ 24	9
		26.386	+ 31	8
		27.357	+ 27	11
		Dec. 13.369	+ 18	10
		14.375	+ 26	11
		15.366	+ 23	10
		17.314	+ 22	11
		21.303	+ 31	10
		22.428	+ 29	11
		23.350	+ 30	11
		24.341	+ 22	11
		25.341	+ 31	10
		26.341	+ 24	12
		27.331	+ 24	12
			+ 24.9 ± 0.6	

Star (HD No.)	Series	U.T.	Radial Velocity km/sec	n
36936	Cg	1956 Nov. 14.403	+ 19	7
		17.381	+ 24	7
		18.484	+ 32	7
		19.425	+ 20	7
		20.393	+ 17	7
		22.407	+ 21	7
		25.391	+ 24	6
		26.406	+ 19	7
		27.375	+ 28	7
		Dec. 13.385	+ 32	7
		14.390	+ 15	7
		15.384	+ 25	6
		17.334	+ 15	7
		21.331	+ 14	7
		23.370	+ 9	7
		24.362	+ 6	7
		25.379	+ 9	7
		26.363	+ 14	7
		27.349	+ 13	7
			+ 18.7 ± 1.2 variable	
36982	Cg	1956 Nov. 14.428	+ 29	8
		17.406	+ 41	8
		19.463	+ 30	7
		22.473	+ 48	8
		27.413	+ 39	8
		Dec. 13.448	+ 37	8
		14.449	+ 34	8
		15.452	+ 31	7
		17.411	+ 34	8
		21.385	+ 31	7
		24.439	+ 45	7
		25.434	+ 34	6
			+ 36.1 ± 1.2	

Star (HDNo.)	Series	U.T.	Radial Velocity km/sec	n
37017	Cg	1955 Dec. 6.460	+ 67	10
		1956 Nov. 14.452	+ 24	9
		17.429	+ 32	11
		18.503	+ 40	11
		19.440	+ 47	8
		20.412	+ 43	10
		22.426	+ 55	11
		25.414	+ 59	11
		26.427	+ 42	9
		27.391	+ 28	11
		Dec. 13.402	+ 50	11
		14.405	+ 52	10
		15.402	+ 45	11
		17.356	+ 4	10
		21.347	+ 9	11
		24.383	+ 29	11
		25.359	+ 38	11
		26.388	+ 42	10
		27.368	+ 51	11
			spectr. binary	
37321	Cg	1956 Nov. 14.469	+ 26	12
		17.495	+ 27	11
		18.461	+ 29	11
		22.446	+ 28	11
		26.454	+ 29	12
		27.436	+ 22	12
		Dec. 13.420	+ 20	12
		14.421	+ 23	12
		15.422	+ 26	12
		17.376	+ 27	12
		20.395	+ 6	12
		21.363	+ 16	12
		22.403	+ 19	12
		24.404	+ 22	9
		25.400	+ 23	10

TABLE 3 - continued

Star (HD No.)	Series	U.T.	Radial Velocity km/sec	n
37321 (cont.)	Cg	1956 Dec. 26.415	+ 19	10
		27.388	+ 20	10
			+ 22.5 ± 0.9 variable?	
37367	Cg	1955 Feb. 12.295	+ 20	12
		14.270	+ 36	12
		16.289	+ 30	12
		17.151	+ 23	12
		18.257	+ 19	12
		19.162	+ 28	12
		1956 Nov. 14.503	+ 21	12
		22.497	+ 23	12
		27.456	+ 24	12
		Dec. 13.474	+ 25	12
		14.476	+ 35	12
		17.448	+ 32	12
		21.413	+ 34	12
		22.452	+ 16	12
		26.278	+ 23	12
			+ 25.9 ± 1.2 spectr. binary	
39698	Cg	1955 Feb. 8.315	- 53	12
		14.288	+ 22	12
		16.308	- 30	12
		17.172	- 30	12
		18.281	+ 25	12
		20.256	+ 99	12
			spectr. binary	
40005	Cg	1955 Feb. 9.325	+ 108	10
		12.314	+ 122	9
		14.317	- 18	9
		15.315	+ 104	9
		16.124	+ 75	10
		18.310	+ 64	10
		19.181	+ 101	10
		20.172	- 22	9
		21.185	+ 7	9
		22.168	+ 105	10
		23.294	+ 3	9
		25.224	+ 92	7
		28.185	+ 64	10
			spectr. binary	
42545	Cg	1955 Feb. 6.346	+ 33	7
		8.334	+ 13	7
		16.090	+ 5	7
		16.097	+ 17	7
		17.057	+ 16	7
		17.065	+ 27	7
		18.164	+ 21	7
		18.172	+ 19	7
		19.110	+ 32	7
		19.117	+ 28	7
		20.215	+ 22	7
		21.232	+ 26	7
		23.262	+ 28	7
		23.269	+ 34	7
		25.201	+ 18	7
		27.212	+ 30	7
		27.229	+ 11	7
			+ 22.4 ± 1.5 variable	
42560	Cg	1955 Feb. 6.359	+ 38	8
		16.104	+ 36	7
		16.109	+ 45	9
		17.072	+ 40	9
		17.078	+ 42	9
		18.179	+ 40	9
		18.183	+ 43	9
		19.124	+ 41	9
		19.129	+ 46	9
		20.232	+ 41	9
		21.247	+ 33	9
		22.190	+ 37	9
		23.276	+ 49	9
		25.209	+ 33	9
			+ 40.3 ± 0.8	
54224	Cg	1955 Dec. 3.494	- 2	12
		4.494	+ 11	12
			+ 4.5 ± 5.5	
65041	Cg	1956 Dec. 17.488	- 32	12
		21.480	+ 26	12
		22.499	- 20	12
		24.505	+ 26	12
		25.497	- 28	12
		26.497	- 39	12
		27.516	+ 26	12
			spectr. binary	
65875	Cg	1956 Dec. 17.466	+ 49	9
		21.454	+ 47	10
		22.472	+ 48	10
		24.477	+ 47	11

TABLE 3 - continued

Star (HD No.)	Series	U.T.	Radial Velocity km/sec	n
65875 (cont.)	Cg	1956 Dec. 25.469	+ 53	10
		26.472	+ 67	11
		27.490	+ 41	10
			+ 50.3 ± 1.9	
209961	Cg	1954 Sept. 2.367	+ 94	9
		2.383	+ 70	11
		3.126	+ 1	11
		4.100	- 52	11
		5.167	+ 39	11
		6.260	- 65	11
		7.112	+ 102	10
		7.375	+ 20	11
		8.103	- 139	10
		9.155	+ 114	10
		9.376	+ 94	9
		10.098	- 133	11
		10.304	- 140	11
		11.188	+ 99	10
		12.106	- 92	10
		12.362	- 141	11
		13.106	+ 33	11
		14.089	- 24	11
		15.096	- 10	10
		16.133	+ 7	11
		17.102	- 54	10
		18.127	+ 63	10
		19.268	- 68	11
		22.135	+ 114	10
		23.223	- 142	11
		24.124	+ 68	9
		25.203	- 104	11
		26.175	+ 41	11
		29.131	+ 23	11
			spectr. binary	

Star (HD No.)	Series	U.T.	Radial Velocity km/sec	n
212883	CQ	1952 July 17.345	- 10	14
		18.353	- 8	14
	Cg	1956 Nov. 16.045	- 8	12
		18.043	- 9	12
		22.034	- 13	12
		Dec. 16.034	- 13	12
		24.036	- 5	12
			- 9.5 ± 0.8	
214240	CQ	1952 July 17.365	+ 3	12
		18.367	- 65	12
		19.351	- 100	12
		20.373	- 94	12
		21.365	- 71	12
		22.343	- 32	12
		22.405	- 35	12
		23.336	- 19	12
		24.331	+ 3	12
		25.344	+ 32	12
		26.331	+ 68	12
		27.329	+ 67	12
		28.318	+ 10	12
		29.443	- 81	11
		30.401	- 99	11
		31.335	- 66	10
		Aug. 2.326	- 32	12
		3.370	- 17	12
		4.290	- 1	12
		5.467	+ 54	10
		6.401	+ 75	11
		7.467	+ 68	11
		8.476	- 18	12
	Cg	1954 Sept. 2.400	- 90	11
		2.412	- 88	11
		3.156	- 83	11

Star (HD No.)	Series	U.T.	Radial Velocity km/sec	n
214240 (cont.)	Cg	1954 Sept. 4.127	- 74	11
		5.194	- 40	11
		6.295	- 9	10
		7.185	+ 2	11
		8.162	+ 26	11
		9.210	+ 74	11
		10.144	+ 90	10
		11.208	+ 39	11
		12.159	- 35	11
		13.140	- 90	11
		14.117	- 93	11
		15.116	- 76	9
		16.166	- 33	11
		17.133	- 19	9
		18.151	+ 3	11
		21.250	+ 84	7
		22.165	+ 33	9
		24.146	- 87	9
		25.225	- 86	10
		26.202	- 63	9
		30.197	+ 38	9
			spectr. binary	
214432	CQ	1952 July 17.461	- 9	10
		24.426	- 4	10
		27.368	- 2	9
		30.442	- 1	9
		Aug. 1.460	+ 1	9
		7.378	- 12	10
		8.453	- 1	10
	Cg	1955 Nov. 3.073	- 5	11
		4.060	- 4	11
		5.067	- 6	12
		6.063	- 11	10

TABLE 3 - continued

Star (HD No.)	Series	U.T.	Radial Velocity km/sec	n
214432 (cont.)	Cg	1955 Nov. 7.067	- 1	12
		1956 Nov. 17.047	- 6	12
		22.055	- 9	12
			- 5.3 ± 0.7	
214652	Cg	1954 Sept. 3.221	+ 51	11
		4.216	- 2	11
		5.122	- 77	10
		5.272	- 65	11
		5.460	- 20	11
		6.175	- 39	11
		7.146	+ 31	11
		7.418	- 30	11
		8.132	+ 30	10
		8.358	+ 43	11
		9.178	- 23	11
		10.122	- 78	11
		10.327	- 60	11
		11.382	- 71	11
		12.131	+ 54	11
		12.390	- 16	11
		13.228	+ 53	11
		14.195	- 31	11
		15.193	- 79	11
		16.254	- 46	11
			spectr. binary	
214680	CQ	1952 July 18.380	- 12	7
		18.473	- 15	7
		19.336	- 19	7
		20.357	- 14	7
		20.471	- 3	7
		21.344	- 10	7
		22.353	- 9	7
214680 (cont.)	CQ	1952 July 22.416	- 18	7
		23.347	- 14	7
		24.342	- 14	7
		25.412	- 2	7
		26.388	- 3	7
		27.399	- 2	7
		28.403	- 5	7
		29.428	- 12	7
		30.469	- 10	7
		Aug. 3.308	+ 1	7
		5.378	- 8	7
		6.412	- 9	7
		7.351	- 8	7
			- 9.3 ± 0.9	
216092	CQ	1952 July 18.411	- 11	7
		24.376	+ 3	7
		28.365	- 5	7
		Aug. 2.451	+ 15	7
		6.339	- 4	7
		8.322	- 1	7
	Cg	1955 Nov. 2.132	+ 6	7
		4.087	+ 2	7
		5.139	+ 7	7
		6.118	- 9	7
			+ 0.6 ± 0.7	
216200	CQ	1952 July 17.385	+ 14	10
		18.467	- 13	10
	Cg	1955 Nov. 3.109	- 33	7
		1956 Nov. 16.066	+ 4	7
		17.059	- 18	7
		19.036	- 37	7
		22.100	- 24	7
		27.022	- 18	7
			- 18.0 ± 3.6 variable	
216534	CQ	1952 July 19.394	- 62	10
		25.381	- 85	10
		29.332	- 74	10
		Aug. 3.258	- 65	10
		5.419	- 71	10
		7.431	- 73	10
	Cg	1955 Nov. 4.119	- 92	10
			- 76.8 ± 3.1	
216684	CQ	1952 July 20.414	- 10	11
		25.438	+ 5	9
		27.452	+ 8	11
		Aug. 2.389	0	9
		5.340	- 6	11
		8.410	+ 4	10
	Cg	1955 Nov. 2.213	- 4	12
		4.170	- 8	12
		6.150	- 3	12
		7.140	- 5	12
		1956 Nov. 17.073	- 12	12
		22.080	- 24	12
			- 6.1 ± 1.8 variable?	
216851	CQ	1952 July 22.378	- 12	7
		26.362	- 31	7
		28.435	+ 14	7
		Aug. 1.411	+ 5	7
		6.283	- 6	7
		10.356	+ 12	7
	Cg	1955 Nov. 3.149	- 13	7
		4.197	- 8	7
		6.185	- 15	7
		1956 Nov. 16.090	- 11	7
		18.066	- 9	6
			- 8.5 ± 2.3	

TABLE 3 – continued

Star (HD No.)	Series	U.T.	Radial Velocity km/sec	n
217543	CQ	1952 July 19.471	- 13	7
		20.453	- 13	7
		21.422	- 3	7
	Cg	1954 Sept. 4.244	- 15	7
		5.297	- 17	7
		6.411	- 12	7
		7.258	- 15	7
		9.275	- 24	7
		10.211	- 20	7
		12.239	- 21	7
		13.262	- 17	7
		14.222	- 16	7
		15.221	- 18	7
		17.210	- 22	7
		18.101	- 11	7
		18.312	- 20	7
		19.207	- 34	7
		21.118	- 13	7
		22.097	- 25	7
		23.179	- 16	7
		24.099	- 17	7
		24.283	- 17	7
		25.179	- 23	7
		26.149	- 19	7
		26.290	- 9	7
		27.271	- 21	7
		28.236	- 21	7
		30.266	- 19	7
		1955 Dec. 6.069	- 8	7
		7.077	- 10	7
		1956 Nov. 18.084	- 10	7
		19.052	- 13	7
		26.035	- 12	7
		Dec. 16.052	- 18	7
		25.041	- 16	7
			- 16.8 ± 0.6	

Star (HD No.)	Series	U.T.	Radial Velocity km/sec	n
217811	Cg	1954 Sept. 2.251	- 9	12
		2.431	- 5	12
		3.175	- 14	12
		4.162	- 9	12
		5.219	- 13	12
		6.378	- 6	12
		7.204	- 9	12
		8.181	- 12	12
		9.228	- 17	12
		10.162	- 5	12
		11.234	- 10	12
		12.184	- 17	12
		13.165	- 9	12
		14.140	- 8	12
		15.140	- 11	12
		16.301	- 19	12
		17.242	- 9	12
		18.289	- 5	12
		19.296	- 8	12
		20.339	- 6	12
		21.331	- 7	12
		23.201	- 9	12
		23.270	- 9	12
		24.167	- 14	12
		25.249	- 8	12
		26.229	- 13	12
		27.301	- 12	12
		28.207	- 6	12
		30.222	- 13	12
		1955 Nov. 2.090	- 3	12
		4.146	- 6	12
		5.095	- 7	12
		6.089	- 4	12
		7.103	- 14	12
		Dec. 3.171	+ 1	12
		6.094	- 7	12
		7.107	- 3	12
		8.070	- 7	12
		9.079	0	12

Star (HD No.)	Series	U.T.	Radial Velocity km/sec	n
217811 (cont.)	Cg	1956 Nov. 14.131	- 9	12
		19.067	- 1	12
		26.056	- 3	12
		Dec. 12.048	- 8	12
		24.057	- 9	12
			- 8.5 ± 0.4	
218325	CQ	1952 July 22.447	- 1	8
		26.417	- 27	8
		31.294	- 33	8
		Aug. 3.447	- 30	8
		7.312	- 28	7
	Cg	1954 Sept. 3.262	- 18	8
		4.320	- 14	8
		5.379	- 25	8
		7.297	- 16	7
		8.292	- 2	7
		9.341	- 13	7
		10.246	- 18	8
		12.275	- 18	8
		13.301	- 23	7
		14.259	- 8	8
		15.261	- 13	8
		18.219	- 14	7
		19.164	- 18	8
		21.292	- 14	8
		22.292	- 15	8
		23.112	- 18	8
		23.304	- 32	8
		24.199	- 22	7
		25.149	- 24	8
		26.114	- 13	8
		27.199	- 23	7
		28.146	- 22	8
		29.097	- 21	8
		1955 Nov. 4.226	- 30	8
		6.226	- 27	7
			- 18.9 ± 0.9	

TABLE 3 - continued

Star (HD No.)	Series	U.T.	Radial Velocity km/sec	n
218407	CQ	1952 July 17.432	- 72	11
		18.451	+ 59	10
		19.429	+ 8	11
		21.395	+ 34	11
		23.444	- 91	11
		24.458	- 6	11
		25.475	+ 59	11
		26.453	- 31	11
		28.473	+ 60	11
		29.288	+ 10	11
		29.463	+ 10	11
		Aug. 1.367	+ 40	11
		2.295	- 68	11
		3.397	0	10
		5.269	- 14	11
		6.381	- 89	11
		7.269	+ 55	11
		8.368	+ 19	11
		11.456	+ 34	11
	Cg	1954 Sept. 2.469	- 90	9
		3.196	- 48	10
		4.188	+ 59	10
		5.244	+ 2	10
		6.326	- 81	10
		7.231	+ 57	10
		8.205	+ 32	9
		9.249	- 116	10
		10.186	+ 14	9
		11.260	+ 42	10
		12.212	- 56	10
		13.188	- 36	10
		14.165	+ 61	10
		15.167	+ 3	10
		16.206	- 108	10
		17.172	+ 34	10
		18.178	+ 23	10
		19.237	- 104	10
		22.197	- 49	10
		24.231	+ 61	9
218407 (cont.)	Cg	1954 Sept. 25.279	- 13	10
		26.258	- 104	10
		1955 Nov. 2.245	+ 71	10
			spectr. binary	
218674	CQ	1952 July 17.400	- 19	7
		19.456	- 3	7
		27.415	- 41	7
		29.417	- 14	7
		Aug. 2.348	- 26	7
	Cg	1954 Sept. 4.272	- 27	7
		5.427	- 17	7
		6.209	- 29	7
		7.340	- 18	7
		8.251	- 20	7
		9.298	- 12	7
		10.281	- 22	7
		12.337	- 17	7
		14.294	- 7	7
		15.306	- 23	7
		18.264	- 21	7
		19.119	- 9	7
		20.138	- 10	7
		20.365	- 3	7
		21.212	- 9	7
		22.221	- 14	7
		23.152	- 4	7
		23.247	- 3	7
		24.258	- 17	7
		25.112	- 1	7
		25.310	+ 1	7
		27.239	+ 5	7
		28.265	- 13	7
		30.244	+ 1	7
		1956 Nov. 13.127	- 28	7
		16.118	- 22	7
		17.091	- 20	7
218674 (cont.)	Cg	1956 Nov. 18.100	- 17	7
		19.083	- 16	7
		22.118	- 15	7
		25.098	- 26	7
		26.074	- 17	7
		27.123	- 34	7
		Dec. 12.069	- 48	7
		14.100	- 23	7
		16.069	- 15	7
		23.033	- 10	7
		24.077	- 12	7
		26.035	- 23	7
			- 16.0 ± 1.1 variable	

HD 11241.—The observations suggest a period of 15.6 days. Figure 3 shows the McDonald observations for November (*dots*) and December (*triangles*) of 1956, plotted against phase in this period; this phase is computed with the formula

$$\text{Phase} = (15.6)^{-1}\ (\text{JD} - 2435000)\ .$$

Victoria observations of January, 1957, are represented by crosses. The drawn curve corresponds to the elements given in Table 2. The binary nature requires confirmation.

HD 19374 = 53 Arietis.—This is a runaway star from the I Ori association (Blaauw 1956). Münch and Flather (1957) have found evidence for β Canis Majoris variability of this star, with a period of about 4 hours and a range near 5 km/sec. The mean velocity found by these authors was about +23 km/sec on September 21, 1956 (9 observations), and about +22 km/sec on October 20 and 21, 1956 (17 observations). The McDonald

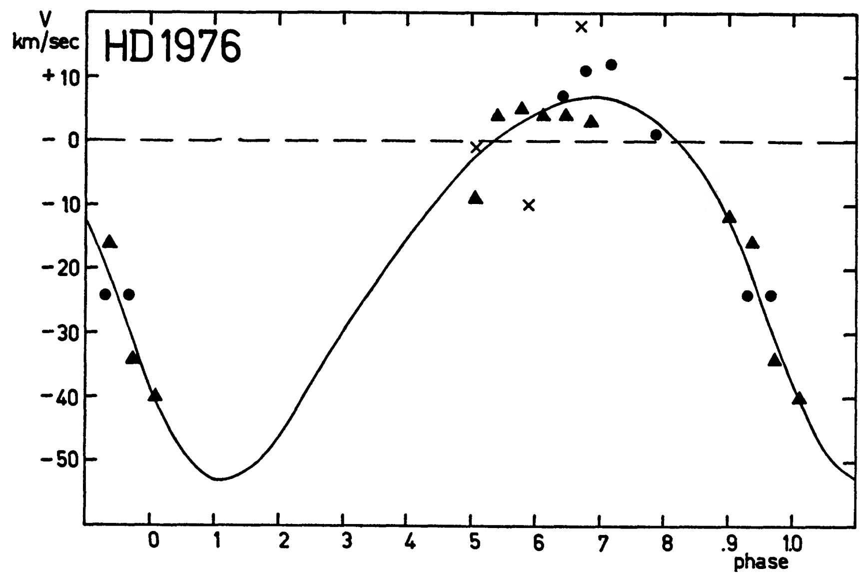

FIG. 2.—Radial velocity-curve of HD 1976 (period 27.8 days). *Dots:* McDonald observations of November 18–27, 1956; *triangles*: McDonald observations of December 12–26, 1956; *crosses:* Victoria observations of February, 1956, to January, 1957.

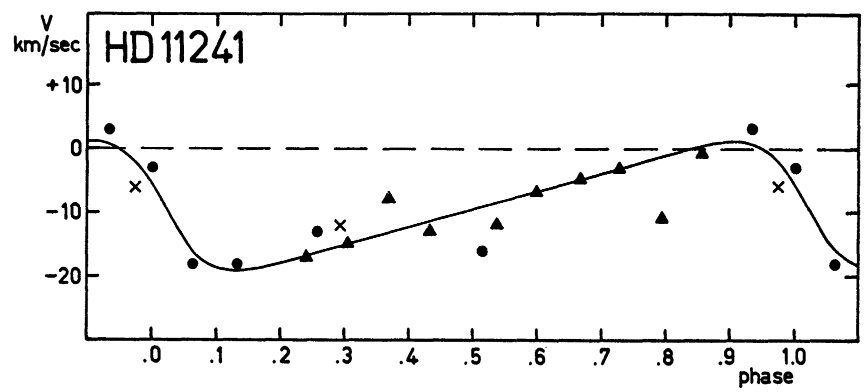

FIG. 3.—Radial velocity-curve of 1 Per ≡ HD 11241 (period 15.6 days?). *Dots:* McDonald observations of November 17–26, 1956; *triangles:* McDonald observations of December 12–26, 1956; *crosses:* Victoria observations of January, 1957.

observations do not allow a new investigation of this short-period, low-range variability. There is, however, evidence of a long-period variation, as shown in Figure 4. If this is of a periodic nature, the period probably exceeds 40 days.

HD 20336.—According to Slettebak and Howard (1955), this star's velocity varies with a period of 4–5 years. Long-period variation is also indicated by early Michigan observations.

HD 23180 = *o Per.*—The McDonald observations of this well-known spectroscopic binary are in agreement with the earlier ones by Jordan (1910) and with the Victoria material for the years 1926–1938 discussed by Lynds (1960), except for the fact that we find $K_1 = 90$ km/sec, whereas Jordan and Lynds find 112 km/sec and 109 km/sec, respectively. The difference may be due to the fact that we did not separately measure the lines of both components, whereas Jordan and Lynds did. The McDonald plates show the presence of a violet companion to some of the lines at high positive velocities, but it cannot be measured as a separate feature.

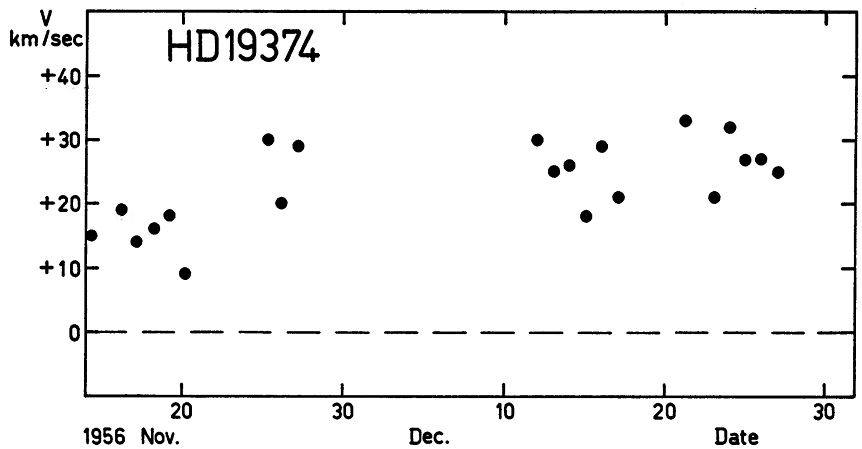

FIG. 4.—Radial velocities of 53 Ari ≡ HD 19374. See also the remarks in Sec III

Muller, Walraven, and Woltjer (1956) published Leiden observations of the years 1948 and 1949. Their value $K_1 = 112$ km/sec agrees well with Jordan's and Lynds's. The γ-velocity adopted by these authors is determined by means of a comparison with ζ Persei; they arrive at $\gamma = +14$ km/sec ± 3 (p.e.), whereas the γ-velocities found by Jordan, Lynds, and the present authors are +18.5, +19.8, and +17.7 km/sec, respectively. Jones (1960), in a discussion of Herstmonceux observations of 1958 and 1959, finds $K_1 = 93$ km/sec $\pm$ 4 (p.e.) and $\gamma = +14$ km/sec $\pm$ 3 (p.e.). This author also used ζ Persei as a standard.

Figure 5 shows the McDonald observations plotted against phase in the period of 4.419167 days, which satisfies all the observations available at present. Phases were computed with the formula

$$\text{Phase} = (4.419167)^{-1}\,(\text{JD} - 2435000.810).$$

The last term in this expression differs a whole multiple of the period from the value used by Jones. The drawn curve corresponds to the elements $\gamma = +17.7$ km/sec, $K_1 = 90$ km/sec, and $e = 0$.

HD 23466.—A period of 2.42 days was indicated by the McDonald observations, and this could be improved by considering the Lick observations from 1918 to 1924. The adopted period is 2.4079 $\pm$ 0.0004 days. However, the accuracy is not yet sufficient to bridge the time interval between the Lick and McDonald material for further improvement of the period.

Figure 6 shows the McDonald observations for November (*dots*) and December (*triangles*), 1956, plotted against phases computed with

$$\text{Phase} = (2.4079)^{-1}\,(\text{JD} - 2435000)\,.$$

Victoria observations of 1956 and 1957 are represented by crosses. The elements were estimated by means of standard curves, with the results given in Table 2. The drawn curve represents these elements.

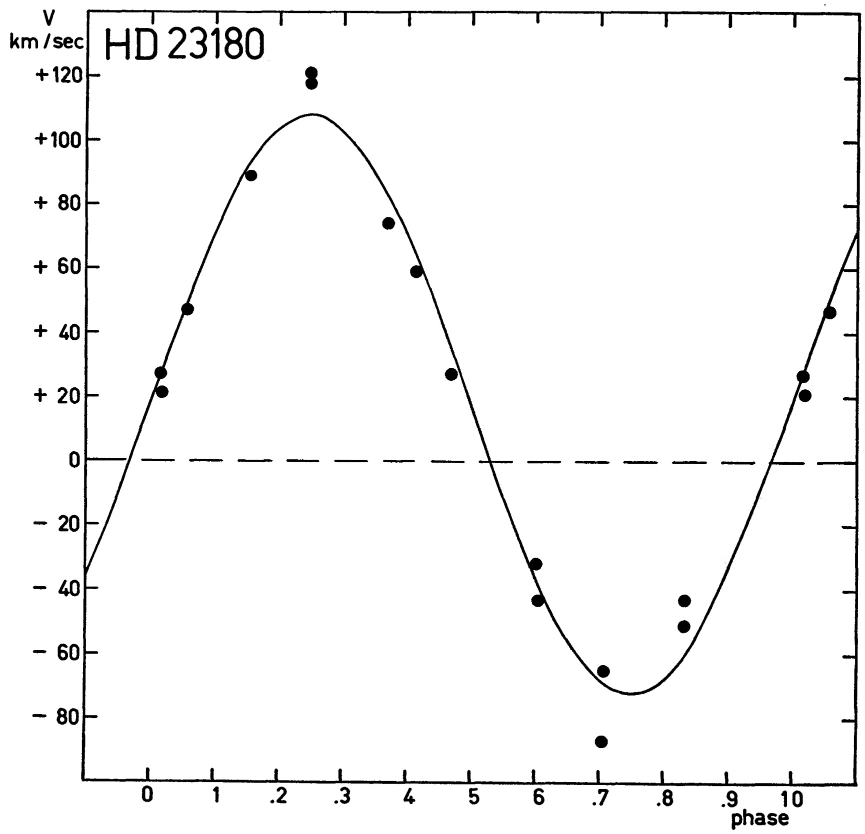

FIG. 5.—Radial velocity-curve of *o* Per ≡ HD 23180. The drawn curve corresponds to the previously known elements; dots are the McDonald observations. The period is 4.419167 days.

HD 24190.—Although the amplitude of the velocity variation is small and the errors of measurement large as a consequence of the broad lines, the period of approximately 26.1 days appears well established. In Figure 7, *a*, the velocities are plotted against phase with discrimination of four observing sessions: September, 1954 (*dots*); February, 1955 (*triangles*); November–December, 1955 (*circles*); and November–December, 1956 (*open triangles*). Figure 7, *b*, gives mean values for groups of five to eight observations arranged according to phase. The phases were computed with the formula

$$\text{Phase} = (26.1)^{-1}\,(\text{JD} - 2400000)\,.$$

The drawn curve corresponds to the elements given in Table 2.

HD 24640.—For this star, Jones (1960) suspected β CMa type variation with a

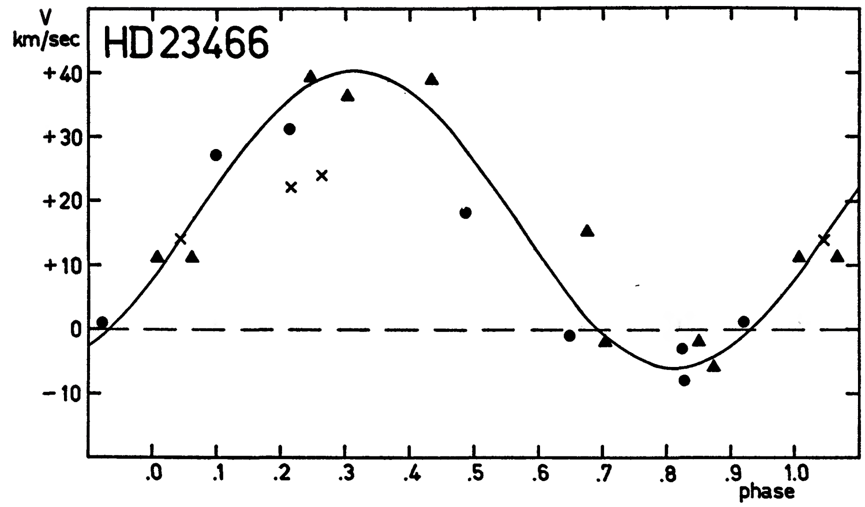

FIG. 6.—Radial velocity-curve of 29 Tau ≡ HD 23466 (period 2.4079 days). *Dots:* McDonald observations of November 14–27, 1956; *triangles:* McDonald observations of December 13–27, 1956; *crosses:* Victoria observations of January, 1957.

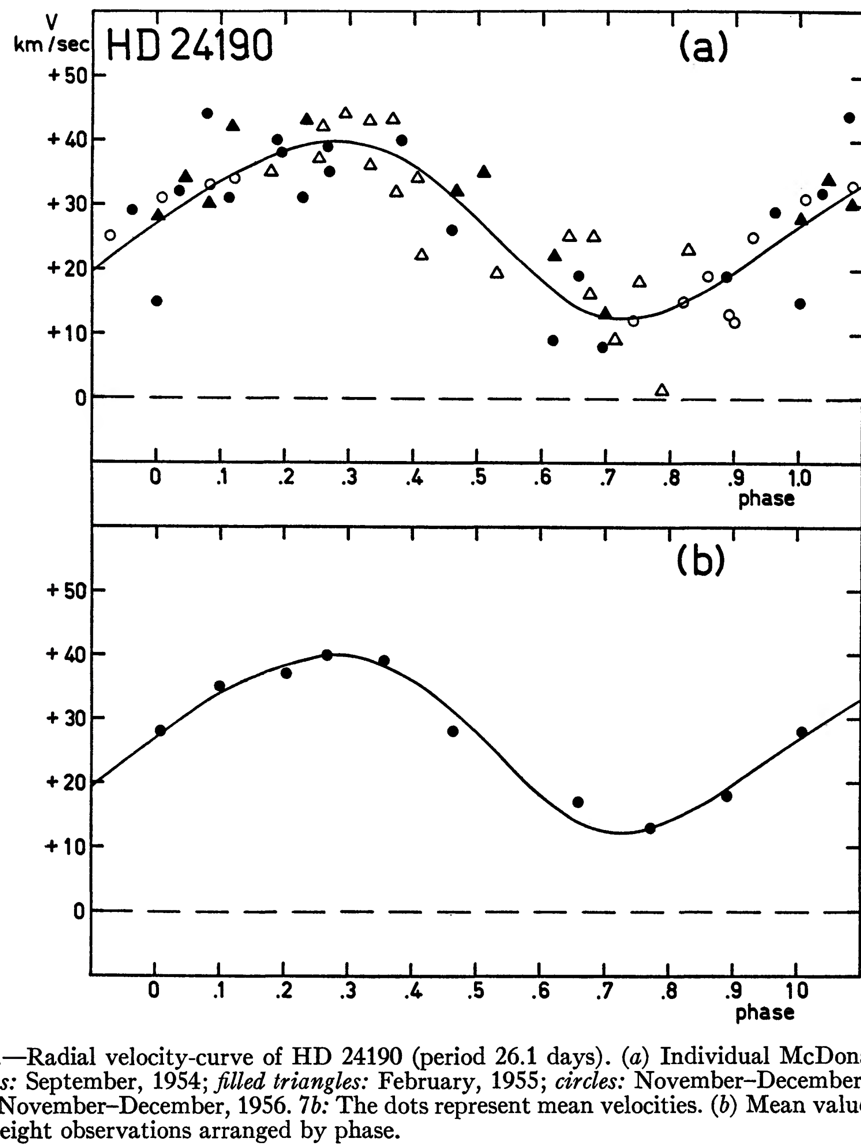

FIG. 7.—Radial velocity-curve of HD 24190 (period 26.1 days). (*a*) Individual McDonald observations: *Dots:* September, 1954; *filled triangles:* February, 1955; *circles:* November–December, 1955; *open triangles:* November–December, 1956. 7*b:* The dots represent mean velocities. (*b*) Mean values for groups of five to eight observations arranged by phase.

period of 0.13169 day and different velocity-curves for different cycles. Our observations do not permit us to check this kind of variability.

HD 25799.—This star was observed during the four sessions September, 1954, February, 1955, November–December, 1955, and November and December, 1956. The measures, which are based on the hydrogen lines exclusively, are plotted against Julian Days in the Figure 8, *a*, *b*, *c*, *d*, *e*. They reveal a period of between 10 and 11 days. However, the shape of the velocity-curve shows large fluctuations. These considerably exceed the errors of measurement, which are of the order of ± 4.5 km/sec per plate for each of the observing sessions. The drawn line in the diagrams corresponds to the elements given in Table 2. These elements fit the first observing session satisfactorily.

The observations of February, 1955, suggest a distortion of this velocity-curve in such a way that (*a*) the γ-velocity lies about 10 km/sec higher and (*b*) a sudden increase in the measured velocities takes place about halfway up the rising branch. A similar discontinuity on the rising branch is indicated in the observations of November and December, 1955 (Fig. 8, *c*). Large random deviations occur in the observing session of November–December, 1956.

The adopted period of 10.67 days has been obtained in the following way: (1) A period of about 10.5 days follows from the September, 1954, session. (2) If we consider the interval of time elapsed between the discontinuities on the rising branch of the sessions February, 1955, and November–December, 1955, then we find that the period must have been about 10.7 days. (3) The adopted period is a compromise between these two; it leaves much to be desired with regard to the fitting of the November–December, 1956, observations. This last session, considered separately, would be somewhat better represented by a shorter period—for instance, about 9.5 days.

The velocity-curve of this star exhibits in a remarkably strong manner the influence of gas currents in this binary system, of the nature of those described by Struve (1950) for SX Cas. However, these currents reveal themselves with a greatly varying degree of intensity, being modest in the first observing session and very pronounced in the sessions of February, 1955, and November–December, 1955.

According to Martin (1939), the star is an eclipsing variable with a relatively short minimum of 0.11 mag. depth. Additional photometric observations are desirable.

HD 30211.—A period of 7.330 days is found from the McDonald 1956 observations; these are shown in Figure 9, represented by dots (November) and triangles (December). Phases were computed with

$$\text{Phase} = (7.330)^{-1}\ (\text{JD} - 2430000)\ .$$

Victoria observations of January, 1957, are represented by crosses. The drawn curve corresponds to the elements given in Table 2. These elements were determined by Irwin's (1952) method, which is especially suited for objects with high eccentricity. The accuracy of the period as determined from our observations does not allow us to bridge the interval between these observations and older Lick and Victoria data and thus to improve the period.

HD 32991.—The McDonald observations definitely confirm earlier evidence for variable velocity, but no period could be established yet.

HD 34759.—Although the McDonald observations appear to cover only the descending branch of the velocity-curve, they allow a fairly accurate estimate of the elements of this spectroscopic binary; the period is found to be 35.5 days ± 0.5 (p.e.). The observations are plotted in Figure 10. Dots represent those of November, 1956, triangles those of December, 1956. Phases were computed with the formula

$$\text{Phase} = (35.5)^{-1}\ (\text{JD} - 2430000).$$

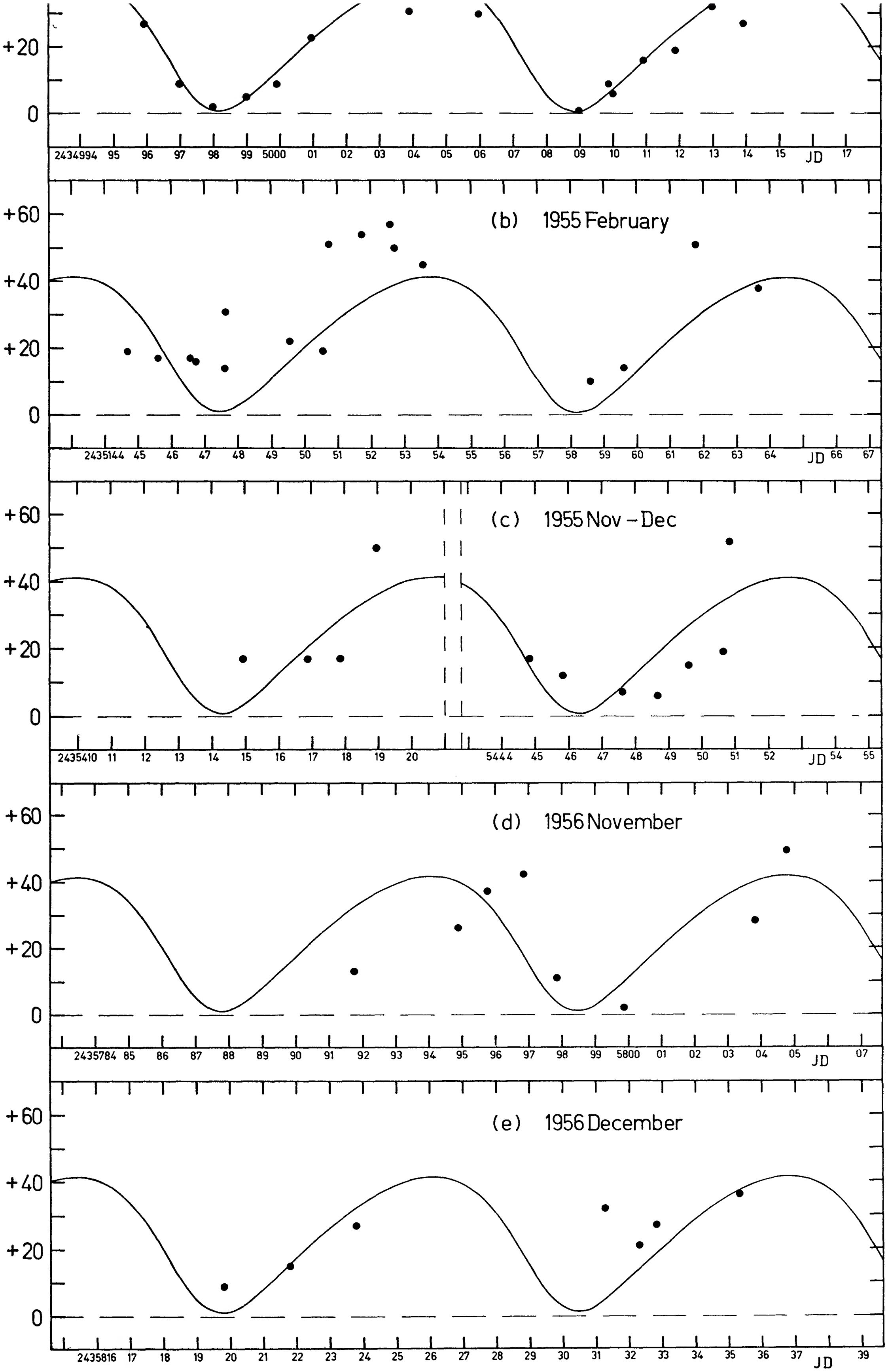

FIG. 8.—Radial velocities of HD 25799. McDonald observations plotted against date for the five observing sessions: September, 1954, February, 1955, November–December, 1955, November, 1956, December, 1956 The drawn curve represents a period of 10 67 days (see also Sec III)

Victoria observations of January, 1957, are represented by crosses. The drawn curve corresponds to the elements given in Table 2. These elements were estimated by means of standard curves.

HD 35532.—The systematic run of the six radial velocities suggests variability with a range of about 25 km/sec and a period exceeding 5 days.

HD 35588.—A period of 2.885 days ±0.003 (p.e.) is found from the McDonald observations. Earlier observations do not allow us to improve this period. Figure 11 shows

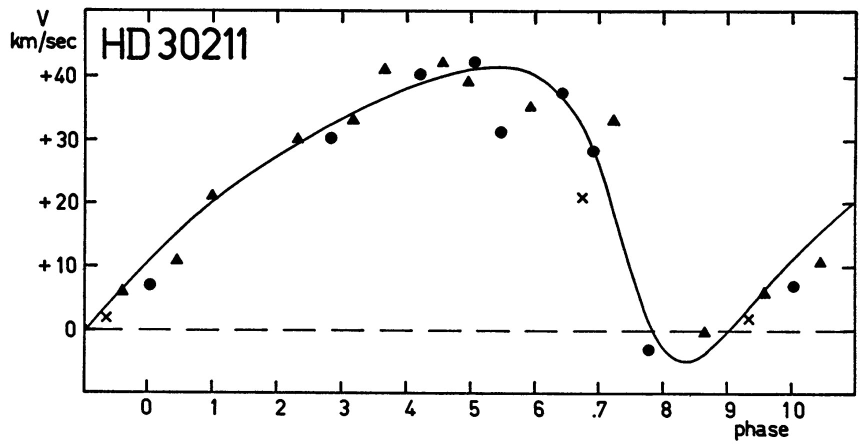

FIG. 9 —Radial velocity-curve of μ Eri ≡ HD 30211 (period 7.330 days). *Dots*: McDonald observations of November 14–27, 1956; *triangles:* McDonald observations of December 13–27, 1956; *crosses:* Victoria observations of January, 1957.

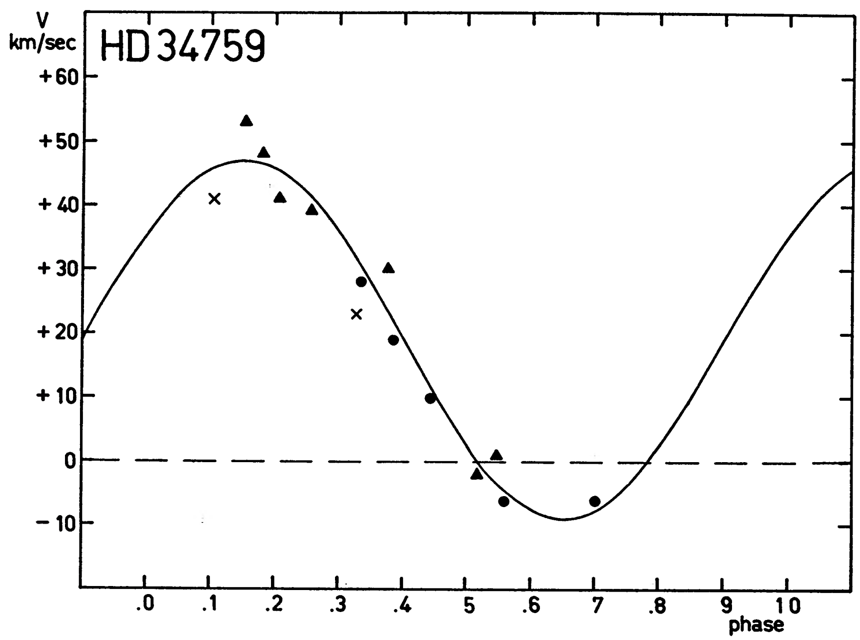

FIG. 10.—Radial velocity-curve of ρ Aur ≡ HD 34759 (period 35 5 days). *Dots:* McDonald observations of November 14–27, 1956; *triangles:* McDonald observations of December 13–27, 1956; *crosses:* Victoria observations of January, 1957.

the McDonald observations for November, 1956 (*dots*), and December, 1956 (*triangles*), plotted against phases computed with

$$\text{Phase} = (2.885)^{-1}\,(\text{JD} - 2435000)\ .$$

The drawn curve corresponds to the elements given in Table 2.

HD 36936.—A plot of our observations against date suggest a change in the velocity from about +20 km/sec around December 15, 1956, to +10 km/sec around December 25, 1956, and a period of at least 20 days.

HD 37017.—A period of 18.65 days ±0.08 (p.e.) has been found from the McDonald observations. It was determined in a first approximation from the November and December, 1956, observations only. The single observation of December, 1955, served to

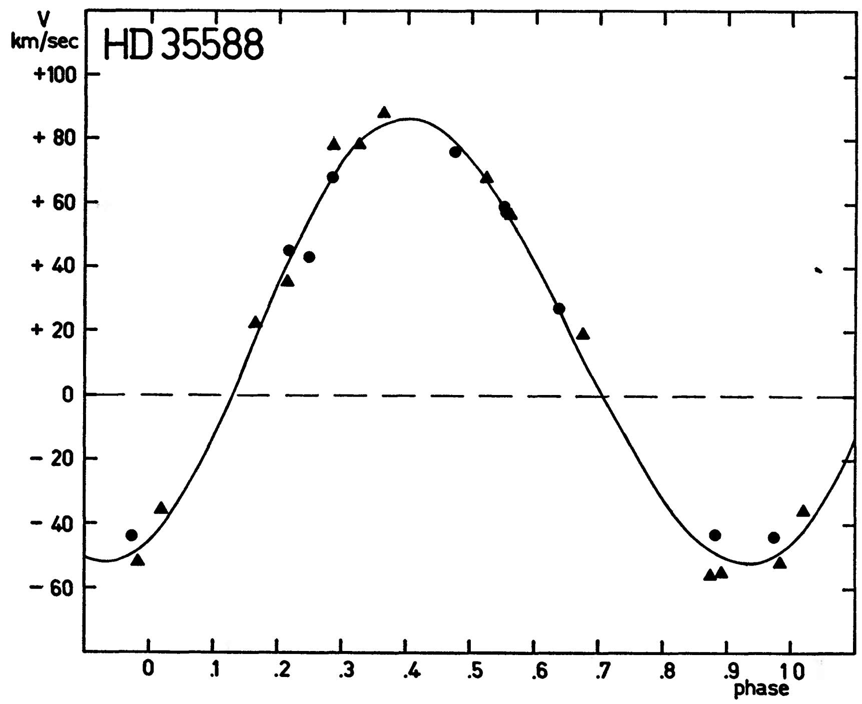

FIG. 11.—Radial velocity-curve of HD 35588 (period 2.885 days). *Dots:* McDonald observations of November 14–27, 1956; *triangles:* McDonald observations of December 12–27, 1956.

improve upon the accuracy, this observation falling at maximum velocity, whereas the intervening lapse of time of 1 year could be easily bridged as to the number of cycles. The 1955 observation is marked by a circle in Figure 12. In this figure, the McDonald observations are plotted against phase computed with the formula

$$\text{Phase} = (18.65)^{-1}\,(\text{JD} - 2435000)\ .$$

The drawn curve represents the elements given in Table 2. These elements also satisfactorily represent earlier Victoria observations of 1924–1928.

HD 37321.—The systematically larger velocity of November, 1956, around +27 km/sec, compared with the mean value of +20 km/sec of December, 1956, suggests long-period variability.

HD 37367.—The McDonald observations leave little doubt as to the spectroscopic binary character, thus confirming Petrie's (1958) suspicion. There are indications of a period of 6.5 days, but this could not be definitely established. The semiamplitude K_1 is about 9 km/sec.

HD 39698.—The McDonald observations fit very well the period of 7.825 days derived earlier from Victoria observations by Pearce (1932). In combining these with earlier Yerkes observations, Pearce arrived at a period of 7.8271 days. This, however, cannot be reconciled with the McDonald results when combined with Victoria. We adopt the period of 7.8251 days ± 0.0002 (p.e.). The early Yerkes observation marked as "good" in Pearce's paper does not contradict this. For the approximate orbital elements we refer to Pearce's paper, although they were derived there with a somewhat different period.

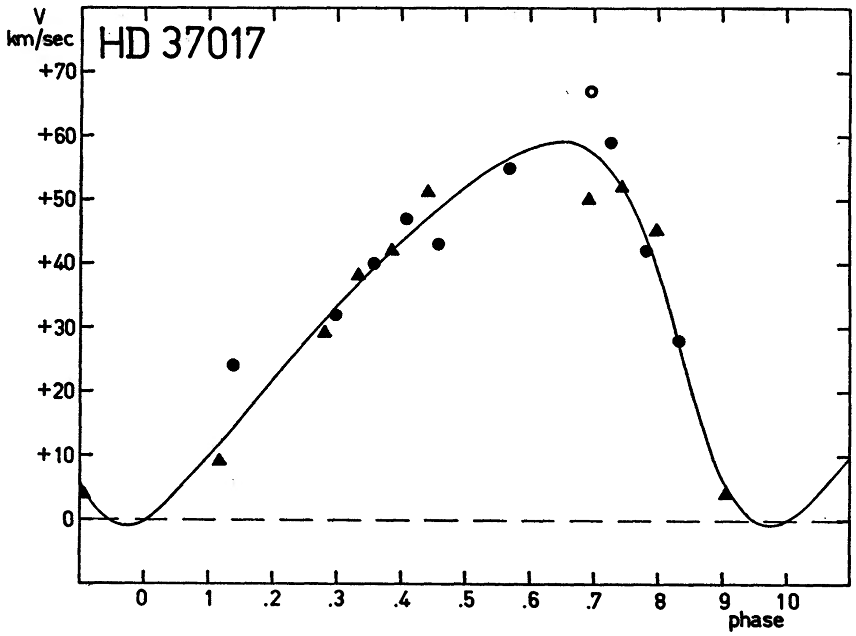

FIG. 12.—Radial velocity-curve of HD 37017 (period 18 65 days). *Circle:* McDonald observation of December 6, 1955; *dots:* McDonald observations of November 14–27, 1956; *triangles:* McDonald observations of December 13–27, 1956.

HD 40005.—A period of 3.306 days ± 0.030 (p.e.) is found from the McDonald observations. Earlier Victoria observations of 1925–1943, which revealed the binary nature of this star, are too much scattered in time to allow an improvement of this period. The McDonald observations are plotted against phase in Figure 13. Phases were computed with the formula

$$\text{Phase} = (3.306)^{-1} (\text{JD} - 2435000) .$$

The drawn curve corresponds to the elements given in Table 2.

HD 42545.—The variability of the velocity is clearly shown by the plot of the McDonald observations for February, 1955, in Figure 14. These suggest a period of 19 days. The compilation of earlier observations at other observatories (Wilson 1953) also indicated variability. The semiamplitude K_1 is probably about 15 km/sec.

HD 65041.—Although the number of McDonald observations (7) of this star is rather limited, they allow establishment of the period of about 2.8 days, with a possible error not exceeding 0.2 days. In Figure 15, the McDonald velocities are plotted against phase. The latter were computed with the formula

$$\text{Phase} = (2.826)^{-1} (\text{JD} - 2435000) .$$

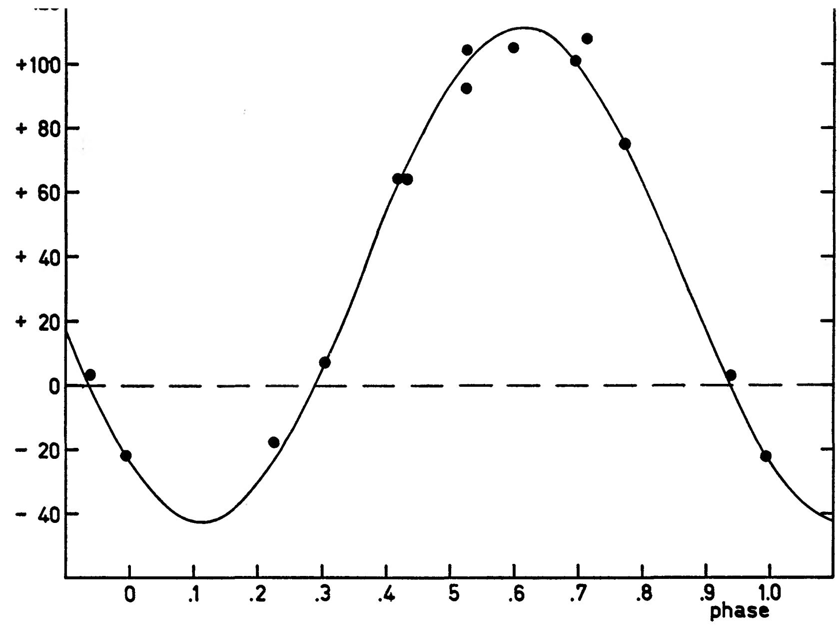

FIG. 13.—Radial velocity of HD 40005 (period 3.306 days). All observations were made in February, 1955.

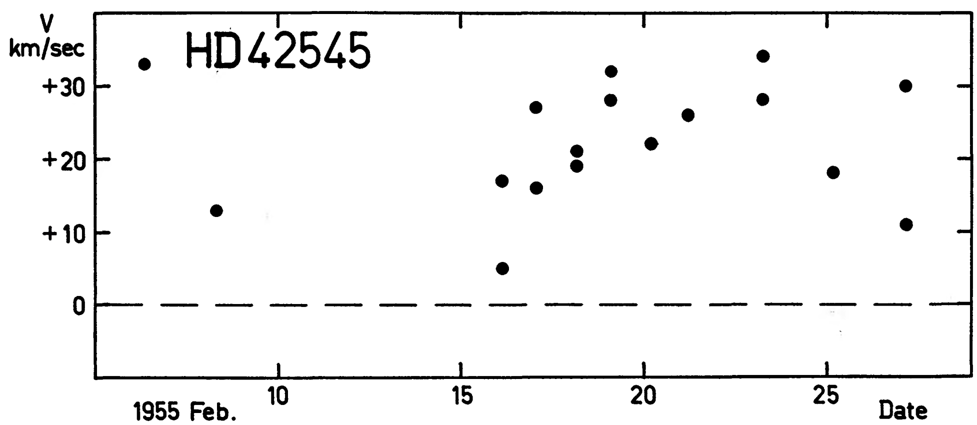

FIG. 14.—Radial velocities of 69 Ori ≡ HD 42545 during the month of February, 1955

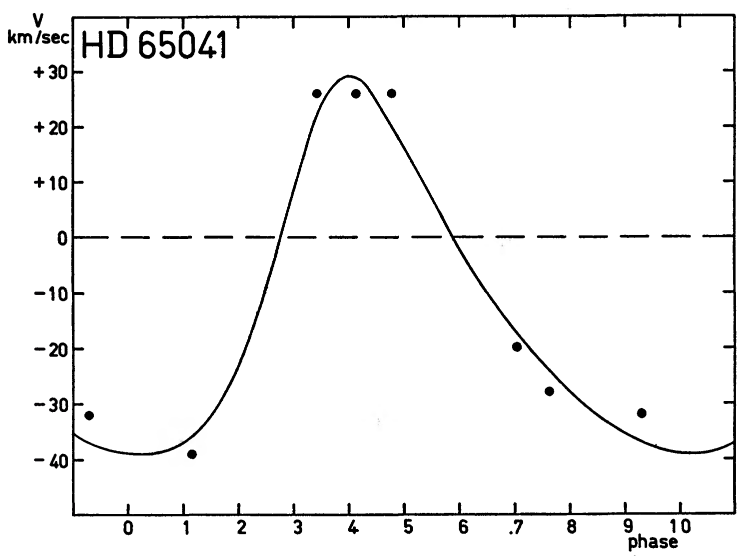

FIG. 15.—Radial veloctiy-curve of HD 65041 (period 2.826 days). All observations were made in December, 1956.

The value of the reciprocal period used here will be explained below. The drawn curve corresponds to the elements given in Table 2.

Eleven Victoria observations between March, 1924, and May, 1927, are given by Plaskett and Pearce (1931). Six of these were obtained between March 2 and May 9, 1927. From these, we find a most likely period of 2.83 days or a less likely one of 2.71 days. A further improvement is obtained by also including the still earlier Victoria observations, and, from this, the value of 2.826 ± 0.011 (p.e.) results. It appears doubtful whether the shape of the velocity-curve for the Victoria observations is the same as that found from the McDonald observations. This, however, is not surprising, considering the rather short period of apsidal motion to be expected for a star of this type and orbital period. For the star HD 218407, for instance, which has a period of 3.337 days, the apsidal motion has a period of 190 years (Struve, Huang, and Zebergs 1959). Both

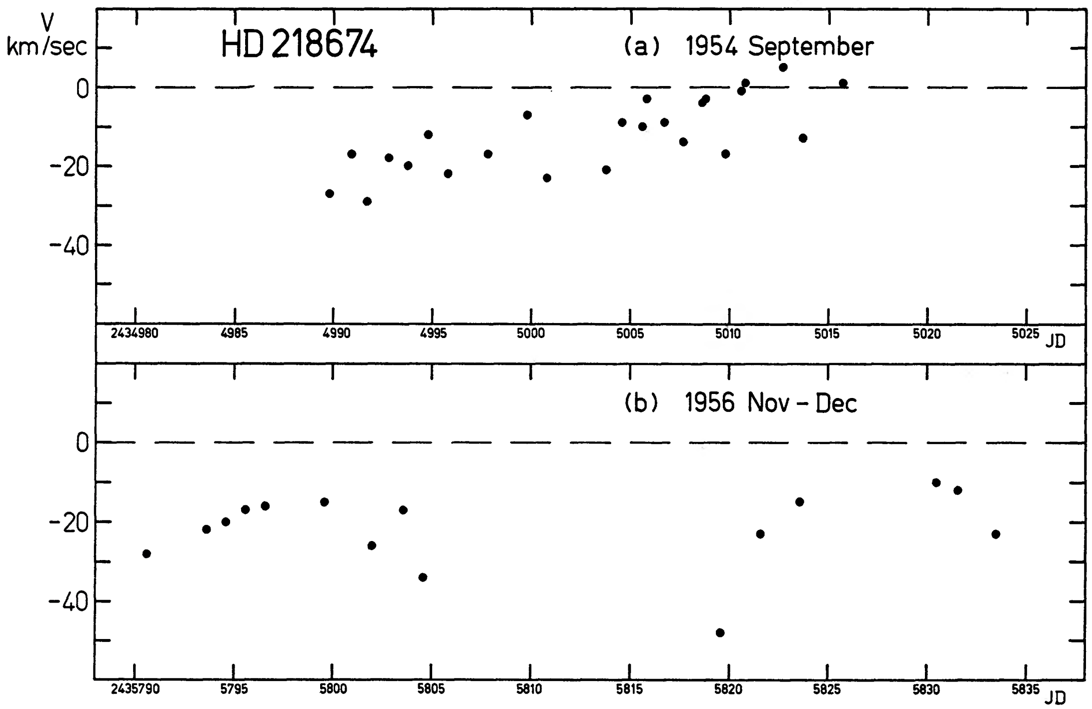

FIG. 16 —Radial velocities of HD 218674. McDonald observations plotted against date for the observing sessions September, 1954, and November–December, 1956.

HD 65041 and HD 218407 have MK type B2 V, and the elements of the two systems are approximately the same. An apsidal period of about 160 years is to be expected for HD 65041. It would be interesting to check this by means of further observations.

HD 65875.—Early Victoria observations of 1924–1926 (Plaskett and Pearce 1931) suggest a spectroscopic binary character. The McDonald velocities are rather constant, but they do not seem to contradict the Victoria results, in view of the short interval of time covered by our observations. If the Victoria interpretation is accepted, the period of the star must be of the order of several weeks or more.

HD 209961.—The McDonald observations of this known spectroscopic binary in the I Lacerta association will be discussed elsewhere.

HD 214240.—The McDonald observations of this known spectroscopic binary in the I Lacerta association will be discussed elsewhere.

HD 214652.—The McDonald observations of this known spectroscopic binary in the I Lacerta association will be discussed elsewhere.

HD 216200.—The McDonald observations suggest a variable velocity, but this is not indicated by four Victoria observations of 1925–1926.

HD 217543.—The extensive series of McDonald observations does not confirm the variability in velocity suggested by the early Victoria observations (Pearce and Petrie 1951).

HD 218407.—The McDonald observations of this known spectroscopic binary in the I Lacerta association will be discussed elsewhere.

HD 218674.—The McDonald observations show the velocity to be variable, with a period of at least 1 month and a total range of at least 20 km/sec. They are plotted against date in Figure 16, *a* (September, 1954) and *b* (November–December, 1956).

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