THE ORBIT OF THE SPECTROSCOPIC BINARY 29 UW CANIS MAJORIS*

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ABSTRACT

The orbital elements of 29 UW Canis Majoris have not undergone a significant change since Harper's observations of 1915–1917 at Ottawa. The lines of the fainter component of the system give a value of K_2 that is appreciably smaller than K_1. The absorption lines of this component are much stronger when its velocity is negative (phases near 3.4 days) than when its velocity is positive (phases near 0.9 day). This effect is especially pronounced in the case of the line He I 5876 but is also present for He I 4472. The fainter component cannot be observed in the other absorption lines of the spectrum in the photographic region.

A new orbit has been derived from measurements of the radial velocities on forty-five spectrograms obtained with the coudé spectrograph of the 100-inch telescope and with the Cassegrain spectrograph of the 60-inch telescope, both at the Mount Wilson Observatory. The dispersions in the photographic region were 10 A/mm for the coudé spectrograms and 20 A/mm for the Cassegrain spectrograms. Table 1 lists the wave lengths of the star lines. Table 2 gives the radial velocities obtained from the absorption lines and from the emission lines of N III and He II. The results from the H absorption lines are listed separately, since they are blended with He II absorption lines. The orbital elements are listed in Table 3, together with the orbital elements obtained by other observers. The only significant change in the elements is that of γ, which may be due to the presence of a distant companion in the system. The earlier orbits were obtained by Harper (1920) at Ottawa in 1915–1917, by Pearce (1932) at Victoria in 1927–1928, and by Struve and Sherman (1941) at the McDonald Observatory in 1940. A short series of spectrograms made at the Yerkes Observatory in 1931–1935 was discussed by Luyten and Ebbighausen (1935). Their orbital elements agree closely with those of Harper and Pearce.

TABLE 1

WAVE LENGTHS OF STAR LINES

Wave Length	Element	Remarks	Wave Length	Element	Remarks
3797 90	H10		4340 47	Hγ	
3819 64	He I		4471 51	He I	
3835 39	H9		4541 59	He II	
3933 66	Ca II	Interstellar	4634 16	N III	Emission
3968 47	Ca II	Interstellar	4640 64	N III	Emission
4026 22	He I		4685 68	He II	Emission
4088 86	Si IV		5875 634	He I	
4097 31	N III		5889 953	Na I	Interstellar
4101 74	Hδ		5895 923	Na I	Interstellar
4199 95	He II, N III				

* The spectrograms used in this investigation were obtained by O. Struve and J Sahade as guest investigators at the Mount Wilson Observatory.

TABLE 2

RADIAL VELOCITIES OF 29 CANIS MAJORIS FROM LINES IN REGION λλ 3700–4700

Date	U T	Phase (days)	Radial Velocity from Absorption Lines (km/sec)		Radial Velocity from Emission Lines (km/sec)	
			All except H	H	N III	He II
1957						
Oct. 4	11^h58^m	1 23	−197	−177	−146	−143
	12 47	1 26	−190	−187	−168	−155
5	12 26	2 25	− 50	− 48	. .	. . .
Nov. 6	10 08	3 40	+241	+257	+260	+290
	11 02	3 44	+239	+242	+273	+300
	13 00	3 52	+258	+262	+274	+302
7	10 48	0 04	+ 84	+ 91	+228	+258
	11 42	0 07	+ 74	+ 79	+251	+237
8	9 40	0 99	−149	−150	−162	− 89
	11 28	1 06	−159	−150	−187	−146
	12 28	1 10	−162	−154	−154	−112
9	12 02*	2 09	−109	− 96		. .
	13 02*	2 13	−100	− 71		− 29
10	10 52*	3 04	+161	+168	+233	+225
	12 00*	3 08	+169	+176	+221	+252
11	9 28*	3 98	+204	+220	+340	+61 +346
	10 26*	4 02	+206	+189	+341	+329
	12 38*	4 11	+209	+185	+338	+344
Dec. 11	7 13	3 13	+186	+194	+242	+246
	7 52	3 16	+193	+212	+256	+259
	8 36	3 19	+191	+201	+246	+266
	9 25	3 22	+199	+219	+262	+264
	10 19	3 26	+205	+220	+264	+277
	11 14	3 30	+214	+226	+261	+279
	12 07	3 34	+234	+243	+267	+280
12	8 12	4 17	+159	+180	+288	+320
	9 05	4 21	+165	+165	+273	+29 +306
	10 00	4 25	+138	+152	+271	+ 9 +305
	10 43	4 28	+120	+136	+300	− 1 +297
	11 33	4 31	+113	+126	+246	−20 +285
13	7 30	0 75	−155	−160	− 17	− 21
	8 32	0 79	−170	−167	− 52	− 30
	9 43	0 84	−164	−157	− 56	− 31
1958						
Jan. 8	7 19	0 38	− 67	− 66	+ 99	+ 89
	8 18	0 42	− 92	− 80	+ 65	+ 82
9	8 28	1 43	−208	−200	−177	−167
	9 27	1 47	−201	−205	−159	−199
Mar. 4	3 45	2 51	+ 24	+ 36		
	7 19	2 66	+ 87	+ 83		
5	2 56	3 48	+250	+250	+268	+279
	5 57	3 60	+244	+262	+286	+259
	7 18	3 66	+233	+242	+264	+279
6	5 02	0 17	+ 40	+ 38	+189	+212
	5 49	0 20	+ 29	+ 26	+201	+199
	6 31	0 23	+ 18	+ 32	+158	+166

* Plates obtained with the Cassegrain spectrograph of the 60-inch telescope of the Mount Wilson Observatory

TABLE 3

ORBITAL ELEMENTS OF 29 CANIS MAJORIS

	Harper	Pearce	Struve and Sherman	New
P (days)	4.3934	4.39351	4.39351	4.39341
e	0.156±0.017	(0.156±0.017)	0.062±0.015	0.090±0.016 (m.e.)
ω	37°.64 ±4°.95	(37°.64 ±4°.95)	51°.5 ±10°	42°.2 ±9°.9
K_1 (km/sec)	218.44 ±3.14	217.1 ±4.9	216.4 ±3.1	222.5 ±3.2
γ (km/sec)	−12.12±2.28	−10.6 ±3.6	+9.3 ±4.7	+13.5 ±2.5
T (days)	JD 2417240.248±0.061	(JD 2417240.248±0.061)	Phase 4.338±0.122	Phase 4.071±0.122
T_0 (days)	. . .	. . .	. . .	Phase 3.556±0.012
$a \sin i$ (km)	13035000	. . .	13046000	13380000

In the photographic region the absorption lines of the weaker component of the system are exceedingly faint. However, on many plates the lines of this component can be seen in the line He I 4472 when its radial velocity is negative (phases near 3.4 days). The average radial velocity obtained from direct measurements of this component at phase 3.25 days is approximately −125 km/sec. This line can also be clearly seen on spectrophotometric tracings, but the radial velocities obtained from the tracings are approximately −75 km/sec (Fig. 1). The difference between the direct measurements and those made on tracings may be due in part to observational scatter, especially in the reconstructed profiles of the tracings, and may also be influenced by the tendency of the direct measurer to make his setting at a point that corresponds to the maximum photographic gradient on the plate rather than at the deepest point of the true profile of the weaker line.

An attempt has also been made to reconstruct the profile of the weaker component

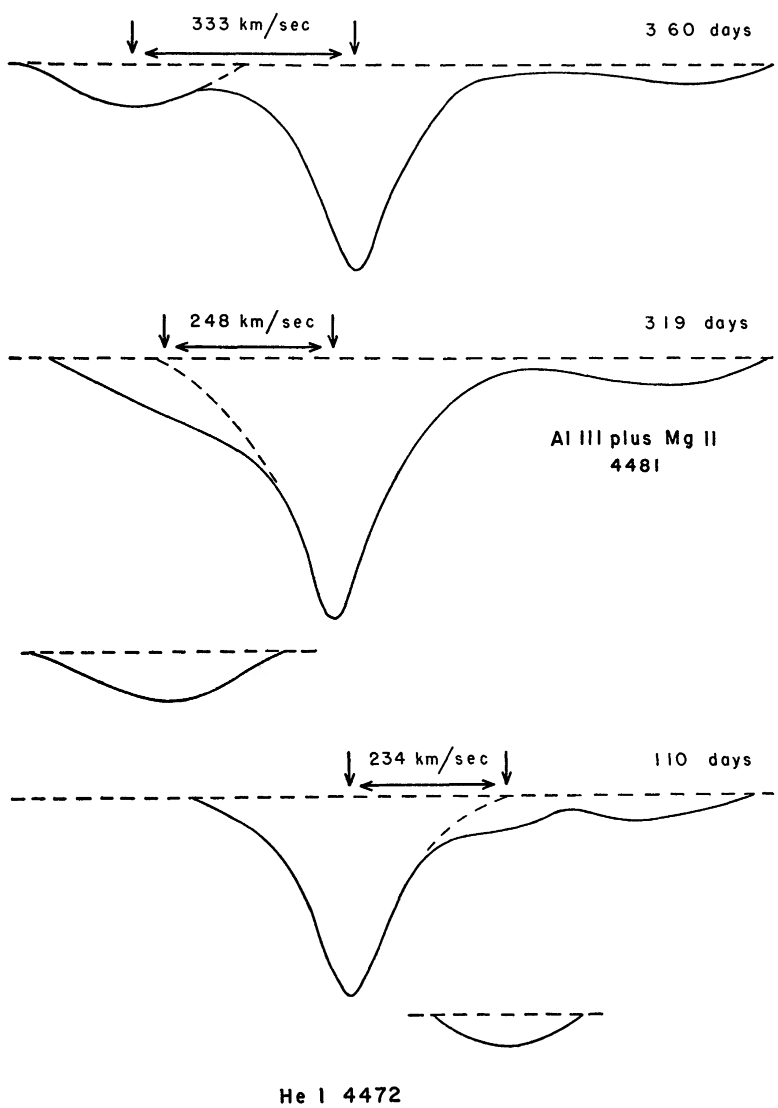

FIG. 1.—Density tracings of the two components of the line He I 4472 at three different phases The fainter component is clearly shown at phases near 3.4 days but may be spurious at phase 1 1 day.

TABLE 4

RADIAL VELOCITIES OF 29 CANIS MAJORIS FROM He I 5876

PHASE (days)	RADIAL VELOCITY (km/sec)		PHASE (days)	RADIAL VELOCITY (km/sec)	
	Primary	Secondary		Primary	Secondary
1 26	−210		4 17	+230	
2 25	− 66	..	4 21	+161	...
3 44	+239	−194	4 25	+146	.
3 52	+230	−189	4 28	+148	
0 04	+107		4 31	+140	...
0 07	+ 83		0 75	−189	+192
0 99	−176	.	0 79	−195	+168
1 06	−148	+167	0 38	−105	
1 10	−164	+177	0 42	− 96	
3 13	+143	−128	1 43	−189	
3 16	+148	−142	1 47	−201	..
3 22	+143	−189	3 60	+253	−124
3 26	+160	−140	3 66	+238	− 95
3 30	+180	−143	0 17	+ 38	
3 34	+204	−142	0 20	+ 28	

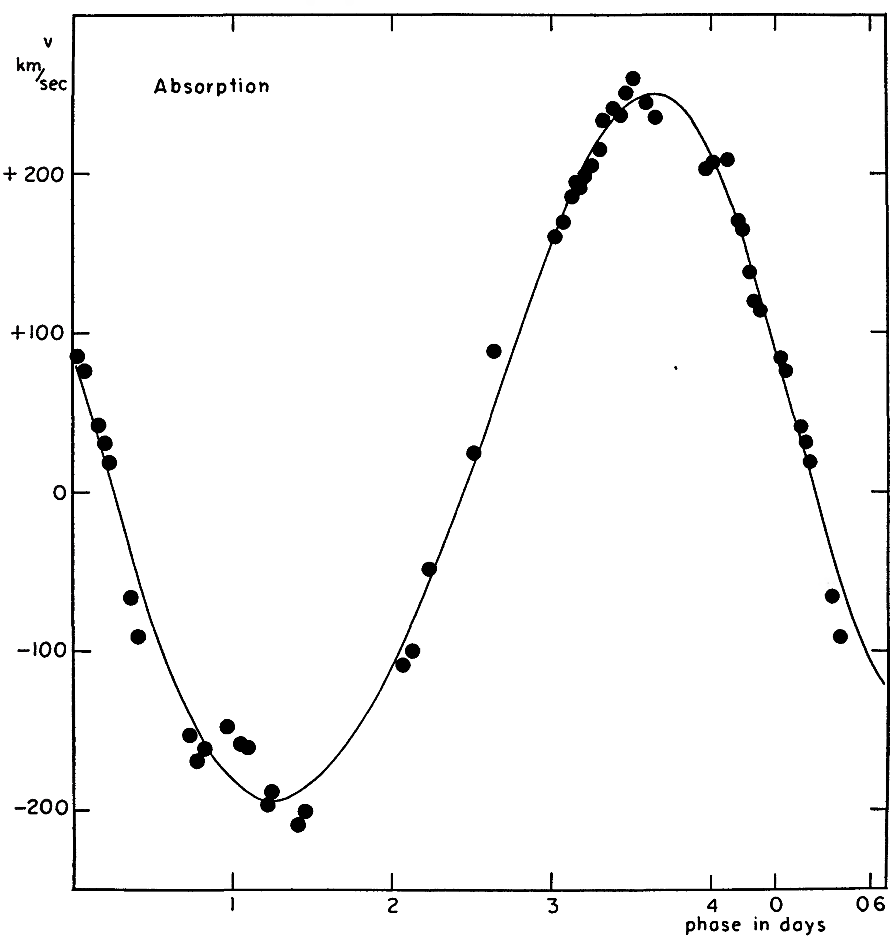

FIG. 2 —The velocity-curve of 29 Canis Majoris obtained from the radial velocities of the primary component.

at phases near 0.9 day. Visual inspection of these plates shows no indication whatsoever of the existence of the line at this phase. The average radial velocity obtained from the tracings, approximately -40 km/sec, is probably spurious.

Much more accurate measurements of the fainter absorption component have been made for the line He I 5876 (Struve, Sahade, Zebergs, and Lynds 1958, Pl. III), which was photographed on many occasions in the first order of the spectrum simultaneously with the second-order spectrum of the violet region. The intensity of this component changes drastically with the phase. When the fainter star is approaching, its line at λ 5876 is very conspicuous. When the fainter star is receding, its line is near the limit of

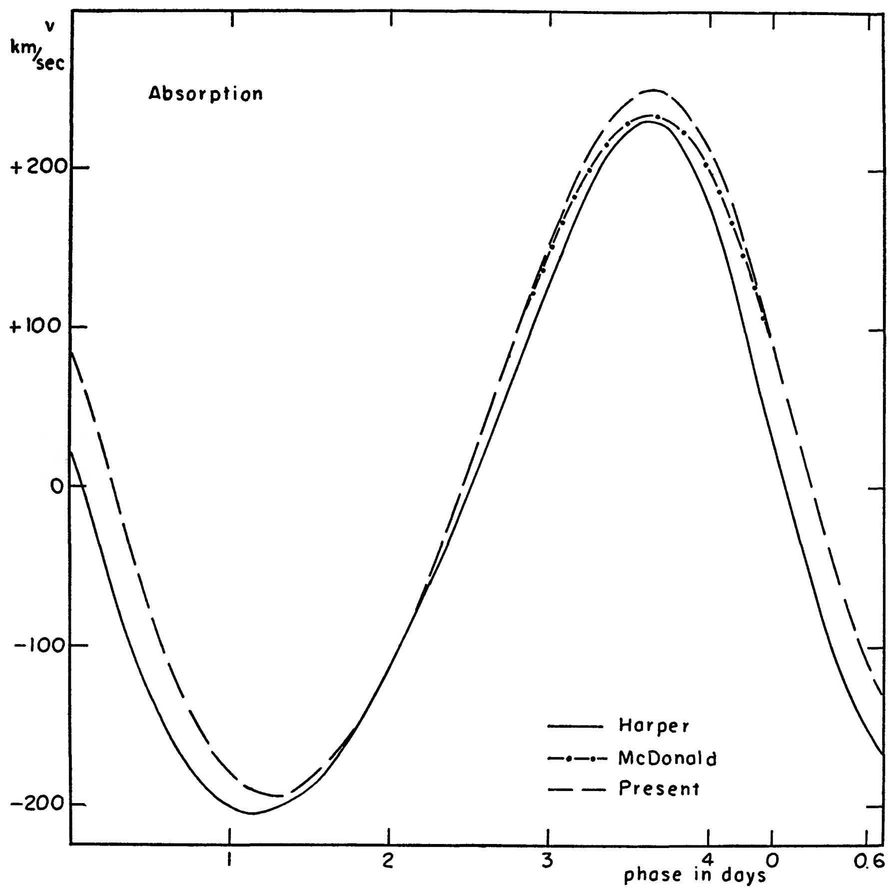

FIG 3.—The velocity-curves obtained at Ottawa in 1915–1917, at the McDonald Observatory in 1940, and at the Mount Wilson Observatory in 1957–1958.

visibility. At this phase the profile of the fainter absorption component is complicated by a faint, broad emission line which lies on the longward side of the stronger absorption component of He I 5876. Table 4 lists the radial velocities of He I 5876 separately for the two components. Despite the relatively large scatter of the velocities of the secondary component, we infer from the direct measurements of He I 5876 that, approximately, $K_2 = 185$ km/sec and $\gamma_2 = +20$ km/sec. It would seem, therefore, that 29 Canis Majoris—a system whose brighter component is of spectral type Of, while that of the fainter component may be O or B—shares with HD 47129 and several other systems of early spectral type the strange property $K_2 < K_1$, despite the fact that the intensities of the lines of the secondary are smaller at all phases than those of the primary. The difference $\gamma_1 - \gamma_2$ may not be significant.

Figure 2 shows the velocity-curve for the primary component. Figure 3 shows the comparison of the velocity-curves obtained by Harper, at McDonald, and in the present investigation. Figure 4 shows the results of the measurements of the emission lines. No attempt has been made to derive orbital elements from these measurements. The two curves represent the earlier McDonald data and those obtained in the present investigation. During the phase interval 3.98–4.31 days the emission line of He II is double. The trend of the velocities of the fainter components is approximately the same as that of the stronger components; hence both components must be associated with the brighter member of the system.

The McDonald observations were originally reduced with a value $P = 4.39351$ days. Combining the McDonald data with those obtained in the present investigation, the period is found to be 4.39341 days. This same value of the period adequately represents the maximum radial velocity of Harper's velocity-curve; hence it seems possible to compute all phases with the same formula:

$$\text{Zero phase} = \text{JD } 2436185.064 + 4.39341E \text{ days}.$$

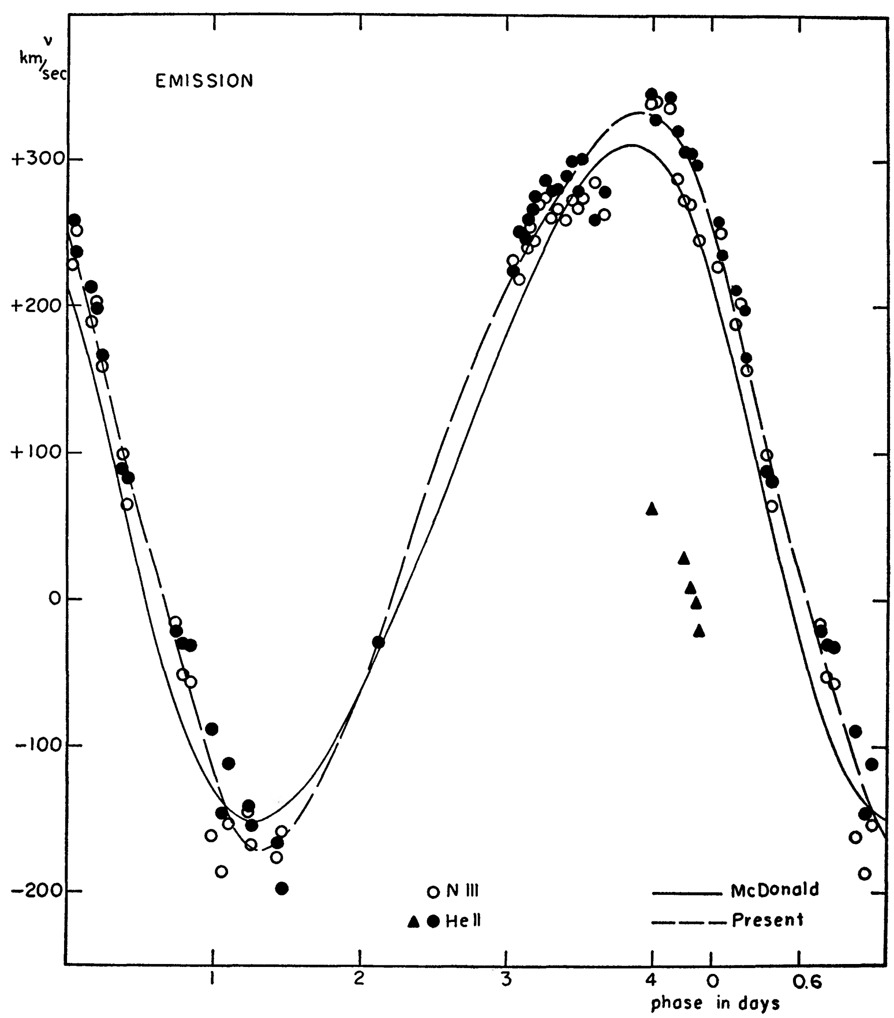

FIG. 4.—The velocity-curve of 29 Canis Majoris obtained from the emission lines of N III 4634 and 4641 and He II 4686.

The interstellar absorption lines give the following radial velocities:

	No Plates	Radial Velocity (km/sec) (m e)
Ca II	38	+31 0±0 2
Na I	30	+29 7±0 5

The spectroscopic behavior of the emission and absorption lines of Hα, He 5876 and 6678, and He II 6527 and 6683 has already been described elsewhere (Struve *et al.* 1958).

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