	Plate No.	Date	J. D. 2410000+	V ₁	Red.	V ₂	(O-C) V ₁	(O-C) V ₂
26	1145C	1899 Jan.	27 4682.898	-21.55		+85.6	-0.06	+1.9
27	1151D		29 4684.840	+ 9.96		+46.3	-2.47	+2.1
28	1154D		30 4685.945	+28.37		.....	-9.68	.....
29	1159D	Feb.	6 4692.857	+28.12		.....	+4.21	.....
30	1173C		13 4699.790	+26.80	W	.....	+4.07	.....
31	1176B		14 4700.918	+50.08		- 1.4	+1.44	-3.3
32	1182D		15 4701.922	+67.06		-22.4	-0.45	-2.3
33	1187C		21 4707.831	+12.90	W	.....	-0.03	.....
34	1205A	April	3 4748.677	+71.09	W	-21.9	+2.26	-0.2
35	1219C		10 4755.772	-17.25	W	+80.2	-0.36	+1.8
36	1603D	1900 Jan.	10 5030.915	-22.24		+80.5	-1.44	-2.4
37	1665D	Feb.	27 5078.881	+69.58	W	-18.7	+1.89	+1.6
38	1700B	April	4 5114.721	- 6.56	W	+64.9	+0.14	-1.6
39	5156B	1908 March	8 8009.761	+82.66		-31.1	+3.49	+2.6
40	5162C		9 8010.827	+62.82		-25.4	-4.48	-5.5
41	5169C		11 8012.817	+26.43		.....	+0.60	.....

TABLE II.

	Plate No.	Date	J. D. 2410000+	V ₁	V ₂	(O-C)V ₁	(O-C)V ₂
(1)	386	1905 April	14 6950.399	+80.84	-34.58	+0.48	+0.52
(2)	390		19 6955.397	+ 3.87	+58.59	-0.77	+5.35
(3)	643	1906 April	4 7305.385	-26.91	+84.34	-1.75	-3.67
(4)	648		6 7307.378	-18.33	+85.57	-0.88	+6.56
(5)	653		7 7308.366	- 3.20	+56.94	-2.50	-2.53
(6)	655		8 7309.360	+25.25	.....	+4.05	.....
(7)	659		9 7310.355	+44.55	+11.45	+0.36	+4.35
(8)	661		10 7311.316	+65.47	-15.13	+2.00	+0.27
(9)	665		11 7312.362	+77.04	-26.25	-0.26	+5.28
(10)	668		12 7313.368	+82.09	-38.23	+1.06	-2.35
(11)	673		15 7316.350	+39.07	+ 6.61	+0.15	-6.63
(12)	677		20 7321.335	-24.22	+86.53	-0.87	+0.64

LICK OBSERVATORY,
1908 April.

H. C. PLUMMER.

THE ORBIT OF β HERCULIS.

The variability of the radial velocity of β *Herculis* was discovered by Dr. Campbell in 1899 July and announced in the *Astrophysical Journal*, **11**, 140, 1899. The spectrum of this star is indicated by K in the Draper Catalogue and by XVa in Miss Maury's classification; that is to say, it resembles *Arcturus* in type.

A number of photographs of the spectrum sufficient for a determination of the orbit were made, chiefly in 1900 to 1902. A discussion of these was undertaken by Dr. H. M. Reese, who, however, left the Lick Observatory in 1903 June before the results of his work had been put in shape for publication. It is on this work that the elements published in the "First Catalogue of Spectroscopic Binaries" (L. O. B., No. 79) are based. The date of periastron passage is there omitted, and it should be remarked that the position of the node and the projected mean distance as given are in error. The other elements are approximately correct.

It was at first intended to make a fresh discussion

of the measured velocities and some preliminary work was done with this object. But a further inspection of the manuscript left by Dr. Reese made it evident that his work was so far advanced that to proceed further with a new investigation of the old material would involve a needless repetition of his computations. Indeed, a few corrections in the final stage and a certain amount of verification were all that was necessary to deduce a set of elements which well represent the orbit at the epoch of the observations.

After some trials the following elements were adopted by Dr. Reese to serve as a preliminary orbit:

ELEMENTS I.

Period, $U = 412$ days; $\mu = 2\pi U^{-1} = 0.01525$
 $T = 1897$ June 1 (Gr. m. noon) + 189^d.
 $e = 0.54$

$\omega = 29^{\circ}168$

Velocity, $V = V_0 + K \cos u$

$= -19.45 + 13.05 \cos u$

Velocity of system, $\gamma = V_0 - Ke \cos \omega = -25.60$ km.

The residuals computed from this set of elements are given under $(O - C)_1$ in the table at the end of this paper. With these and the system of weights given in the preceding column 32 equations of condi-

$$\begin{array}{rrrrrrrr}
 +15.120u & - 3.084u & - 9.330w & - 13.618x & + 15.560y & + 4.060z & + 5.336 & = 0 \\
 - 3.084 & +22.529 & + 6.725 & + 44.088 & - 58.487 & - 9.671 & + 9.175 & \\
 - 9.330 & + 6.725 & +48.359 & + 15.900 & - 24.937 & - 0.345 & - 3.730 & \\
 -13.618 & +44.088 & +15.900 & +120.912 & -146.939 & -18.156 & + 5.707 & \\
 +15.560 & -58.487 & -24.937 & -146.939 & +194.977 & +22.276 & -14.924 & \\
 + 4.060 & - 9.671 & - 0.345 & - 18.156 & + 22.276 & +29.250 & - 5.097 &
 \end{array}$$

where $u = \delta K$, $v = 10 \delta \omega$, $w = 10 \delta e$, $x = 10,000 \delta \mu$, $10 y = \delta T$, and $z = \delta V$. The solution by Dr. Reese gives the following set of corrections:

$$\begin{array}{l}
 \delta \mu = + 0.0000534 \\
 \delta T = + 2.^{\text{m}}649 \\
 \delta e = + 0.0098 \\
 \delta \omega = - 0.^{\text{m}}079643 \text{ cosec } 1'' = - 4.^{\text{m}}563 \\
 \delta K = - 0.268 \text{ km.} \\
 \delta \gamma = + 0.080 \text{ km.}
 \end{array}$$

the application of which to the previous set of elements gives the improved system:

ELEMENTS II.

$$\begin{array}{l}
 \mu = 0.0153034; U = 410.575 \text{ days} \\
 T = \text{J. D. } 241\,5500.374 = 1901 \text{ April } 25:9^{\text{h}} \text{ G. M. T.} \\
 e = 0.5498; \phi = 33^{\circ} 21' \\
 \omega = 24^{\circ} 36'.3 \\
 K = 12.782 \text{ km.; } V = -19.13 + 12.782 \cos u \\
 \gamma = -25.52 \text{ km.}
 \end{array}$$

Hence may be deduced

$$\begin{array}{l}
 a \sin i = [4.13833] KU \cos \phi \\
 \quad = 60,280,000 \text{ km.} \\
 \text{and } (m + m') \sin^3 i = \mu^2 (a \sin i)^3 (1 + m/m')^3 \div [20.99508] \\
 \quad = 0.0519 (1 + m/m')^3
 \end{array}$$

where m is the mass of the star whose spectrum has been observed and m' the mass of the other star, the Sun's mass being unity.

The residuals obtained by comparing the observed velocities with the values directly computed by means of Elements II are given in the column $(O - C)_2$ in the table. The result of the least square solution is to reduce the sum $[pv^2]$ from 27.83 to 17.27, and the latter number shows that the probable error of a single measure of unit weight is ± 0.52 km.

Numbers corresponding to $(O - C)_2$ have also been calculated by substituting the differential corrections found for the elements in the equations of condition. The excess of the numbers $(O - C)_2$ calculated directly over those obtained by substitution are given

tion were formed in the usual way according to the differential formulae of Lehmann-Filhés. The normal equations resulting are as follows:

in the last column of the table under the heading Δ . The differences are due not only to possible accumulation of small errors in the course of the calculation but also to the linear form of the equations of condition, and their magnitude is fair evidence that no serious mistakes have been overlooked in the course of the computations and that the neglect of higher powers of the differential corrections has had no important effect on the final elements.

Two more recent plates have been measured and compared with the final set of elements. The results are given at the end of the table. With regard to the residuals derived from these plates it is to be remarked that a small systematic difference from the previous series is very possible since in the interval the Mills spectrograph has been reconstructed. The range of spectrum measured is therefore different, the center being shifted from $H\gamma$ to $\lambda 4500$, and this fact may well have a systematic effect in the case of a star which is not solar in type.

The first column of the following table gives a consecutive number to the plates and the second the number recorded by the observer. The date is given in the third column and the corresponding Julian Day in the fourth; the fraction is reckoned from Greenwich mean noon. The fifth column, headed "Red.," indicates by whom the plates have been measured and reduced: C stands for Dr. Campbell, W for Mr. Wright, Cs for Dr. H. D. Curtis, and R for Dr. Reese. The measured velocities are given under the heading "Vel.," and in the next column the weight assigned to each plate according to its quality in combining the equations of condition; where a plate has been measured by two persons, the mean of the two results has been adopted. Under $(O - C)_1$ stand the residuals calculated from Elements I and under $(O - C)_2$ those calculated directly from Elements II. Finally the last column under Δ gives the excess of the quantities in the previous column over the corresponding quantities calculated by the substitution of the results of the least squares solution in the equations of condition.

	Plate No.	Date		J. D. 2410000+	Red.	Vel.	Wt.	(O-C) ₁	(O-C) ₂	Δ
1	765A	1898 June	13	4454.768	W R	-31.90 -32.60	1	-0.86	-1.02	-0.04
2	775A		19	4460.779	W	-29.76	1	+1.45	+1.34	-0.04
3	1200B	1899 Feb.	27	4713.053	C	-23.28	1	+2.31	+0.93	0.00
4	1359A	July	31	4867.767	W	-30.91	1	+0.45	+0.27	-0.04
5	1405A	Aug.	21	4888.685	C	-30.84	1	-0.16	-0.21	-0.03
6	1606C	1900 Jan.	11	5031.080	C	-20.95	1	-2.27	-1.27	0.00
7	1642A	Feb.	8	5059.033	R	-12.71	1	-1.07	-0.11	+0.05
8	1667B		28	5079.045	R	-6.67	1	-0.17	-0.03	+0.07
9	1678A	March	12	5091.975	R	-9.17	1	-0.27	-0.83	+0.03
10	1693A		26	5105.945	R	-16.24	1	+0.86	+0.06	+0.02
11	1744C	May	22	5162.852	R	-30.00	1	+1.33	+0.45	0.00
12	1779A	June	19	5190.724	R	-31.51	1	+0.84	+0.11	-0.01
13	1849A	Aug.	8	5240.702	R	-32.46	1	-0.23	-0.60	+0.05
14	2074C	1901 April	9	5484.008	R	-7.68	1	+0.10	+0.23	+0.02
15	2128E	May	8	5513.840	R	-15.40	1	-0.82	-0.70	-0.01
16	2147E		19	5524.808	R	-20.81	1	+0.02	-0.18	-0.02
17	2170C	June	17	5553.743	R	-30.03	½	-0.83	-1.57	0.00
18	2215C	Aug.	6	5603.697	Cs R	-32.94 -32.53	1	-0.37	-1.06	0.00
19	2245E		23	5620.705	R	-30.90	1	+1.60	+0.98	0.00
20	2261C	Sept.	3	5631.705	R	-32.75	1	-0.28	-0.84	-0.01
21	2271C		17	5645.693	R	-32.30	1	+0.04	-0.45	-0.01
22	2328F	Dec.	31	5750.111	R	-29.64	1	-0.57	-0.50	+0.07
23	2340E	1902 Feb.	13	5794.091	R	-25.72	1	+0.55	+0.85	-0.01
24	2353D	March	11	5820.972	R	-23.43	1	+0.30	+0.72	-0.01
25	2365F	April	9	5849.915	R	-19.42	½	+0.28	+0.74	+0.01
26	2368C		13	5853.897	R	-19.25	½	-0.28	+0.16	0.00
27	2404B	June	8	5909.744	R	-6.72	1	+0.10	+0.42	+0.09
28	2427C		17	5918.912	R	-10.22	1	+0.18	+1.14	+0.03
29	2463A	July	20	5951.755	R	-27.35	½	-0.99	-1.23	-0.05
30	2482A	Aug.	3	5965.753	R	-26.27	¼	+2.93	+2.39	-0.02
31	2508B		19	5981.756	R	-29.68	1	+1.28	+0.61	0.00
32	2539B	Sept.	14	6007.696	R	-31.28	1	+0.93	+0.24	0.00
33	4084A	1905 Oct.	24	7143.613		-6.42		.....	+1.42	.....
34	5148F	1908 Feb.	25	7997.074		-22.83		.....	+1.20	.....

H. C. PLUMMER.

LICK OBSERVATORY,
1908 April.NOTE ON MR. NÖRLUND'S ORBIT OF ξ URSAE MAJORIS.

In his investigation of the orbit of the visual binary, ξ *Ursae Majoris*, Mr. N. E. Nörlund has detected the existence of a perturbation in that system, having a period of 1.80 years.¹ The principal component of this pair was found by me to be a spectroscopic binary,² and it is of interest to note that a plat of all

the observations of radial velocity so far secured at this observatory (to the number of seventeen) indicates a period very close to 1.8 years. The spectroscopic orbit will be more fully investigated here in the future.

W. H. WRIGHT.

¹ *Astr. Nach.*, 170, 123, 1905.² *Astrophysical Journal*, 12, 254, 1900.LICK OBSERVATORY,
1908 June.