Parallax and Orbital Motion of the Triple System 26 Draconis from Photographs taken with the Sproul 24-inch Refractor

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Measurement and reduction of photographic plates taken with the Sproul refractor over the interval 1913–1961 yield $+0\farcs0774\pm0\farcs0058$ (p.e.) for the relative parallax and $+0\farcs4720\pm0\farcs0182$ for the semi-axis major of the photocentric orbit of 26 Draconis AB. The fractional mass of the companion is $B=0.389$. The adopted value for the absolute parallax, $+0\farcs066\pm0\farcs003$, leads to masses of $1.30\odot$ and $0.83\odot$ for the primary and secondary components, respectively. The projected relative yearly motion of 26 Draconis C, separated from AB by $738\farcs31$, is 0.191 ± 0.036 a.u., a value which indicates a hyperbolic orbit. However, this value is not accurately determined, due to the large error caused by the cosmic scatter of the background stars, and a periodic orbit must be considered as a likely possibility.

1. INTRODUCTION

THE star 26 Draconis is a known triple system. The visual binary 26 Dra AB = BD $+61°1678$ = ADS 10660, $17^h34^m\!.0$, $+61°57'$ (1900), has a period of 74.16 yr and a semi-axis major of $1\farcs50$ (Hall 1949). The combined visual magnitude is 5.23 and the spectral type of 26 Dra A is G1V (Johnson and Morgan 1953). According to Eggen (1956b) $\Delta m=2.74$. A distant companion which is $4\farcm1$ east and $11\farcm6$ south of 26 Dra AB was found by van Maanen and Gingrich (1921) and confirmed by Kovalenko (1928) to have a common proper motion and therefore to be physically related to the brighter pair. This proper-motion companion 26 Dra C, $17^h34^m\!.5$, $+61°45'$ (1900) has a magnitude of 9.9 and a spectral type of M1V (Eggen 1956b).

Since the investigation by van de Kamp and Hoffleit at the Sproul Observatory (1946) and that of Hall at the Yerkes Observatory (1949), a large amount of photographic material has been obtained at the Sproul Observatory. The very adequate coverage of one orbital period of 26 Dra AB warrants a new determination of the parallax and mass ratio. The material used here is about three times as extensive as that used in van de Kamp's and Hoffleit's investigation and includes all of their material.

2. MATERIAL AND MEASURES

The procedure described in previous Sproul papers has been followed (van de Kamp and Lippincott 1949). This star has been photographed with the 24-inch Sproul refractor since 1913. The material consists of 154 plates with 484 exposures taken on 56 nights, resulting in a total weight of 122, and is summarized in Table I. The exposure time for a single photographic image averaged about 10 min before 1938, about 2 min for the interval 1938–48 and 1 min after 1948.

The dependences and their yearly changes are listed in Table II along with the standard frame and the positions of 26 Dra AB, and C for 1950.0. Two sets of dependences were used; the 1920 set applies to the early plates through 1928, and the 1950 set to the later material. The spectra of the reference stars were kindly furnished by Dr. A. N. Vyssotsky. The magnitude of 26 Dra AB was reduced to 10.0 by the use of a rotating sector of 1.2% opening in order to eliminate errors due to large differences in image size. The magnitudes given for the four reference stars are based on their measured mean diameters and are intended only for purposes of identification. All plates were measured on the St. Clair–Kasten measuring machine by the author.

3. PARALLAX, PROPER MOTION, AND ORBITAL MOTION

The maximum separation of the components of 26 Dra AB is about $1\farcs7$ or 0.1 mm. At no time does the composite image appear elongated on the photographic plate. It has been assumed here that the measured position of the blended image represents the photocenter, or center of intensity of light, of the pair.

The night means are represented by the following equations of condition:

$$X=c_x+\mu_x t+\pi P_\alpha+\alpha Q_\alpha,$$
$$Y=c_y+\mu_y t+\pi P_\delta+\alpha Q_\delta,$$

where the symbols have the usual meaning; t is counted from 1950.000. The positions in x for 26 Dra C given in Table I for the interval 1938.439 through 1941.644 have been corrected for a color equation γ_x; the correction amounts to -0.0010 mm (Lippincott 1957).

The orbital factors have been calculated from the orbit determination by Hall (1949):

$$P=74.16\text{ yr},\quad i=\pm105\fdg6,$$
$$T=1949.73,\quad \omega=322\fdg7,$$
$$e=0.19,\quad \Omega=153\fdg3,$$
$$a=1\farcs50.$$

Separate solutions for the pair 26 Dra AB and for the

Table I. Observing data, measured positions, and residuals.

Epoch	Date	H.A. min.	No. of pl.	No. of exp.	Obs.[a]	P_α	P_δ	Q_α	Q_δ	X_{AB} (unit .0001 mm)	X_C (unit .0001 mm)	Y_{AB} (unit .0001 mm)	Y_C (unit .0001 mm)	v_x AB (unit .0001 mm)	v_x C (unit .0001 mm)	v_y AB (unit .0001 mm)	v_y C (unit .0001 mm)	p
1913.171	Mar. 3		1	3	B	+.97	− .17	+.27	− .95	+ 366	+13 0773	+19 9376	−16 9370	− 33	+38	−22	+16	1
.193	11	−48	1	2	B	+.99	− .03	+.27	− .95	+ 390	0756	9426	9362	− 13	+17	+28	+24	1
14.217	20	− 9	1	1	M	+.99	+ .12	+.30	− .98	+ 548	0847	9130	9591	+ 7	−34	+15	+63	1
.296	Apr. 18	+ 6	1	1	M	+.82	+ .58	+.30	− .98	+ 531	0900	9177	9683	− 14	+15	+65	−27	1
.329	30	− 3	1	3	P	+.69	+ .73	+.30	− .98	+ 541	0967	9128	9616	− 2	+84	+18	+43	1
15.284	Apr. 14	+ 2	1	2	Ma	+.86	+ .52	+.33	−1.00	+ 721	+13 1056	+19 8883	−16 9900	+ 40	+33	+50	+23	1
.287	15	−13	1	2	P	+.85	+ .53	+.33	−1.00	+ 698	1036	8915	9924	+ 17	+13	+81	− 1	1
.353	May 9	−21	1	3	P	+.57	+ .83	+.34	−1.00	+ 673	1031	8860	9887	− 8	+10	+33	+41	1
.538	Jul. 16	+ 2	1	3	M	−.51	+ .88	+.34	−1.01	+ 686	1041	8735	9965	+ 27	+39	−41	+11	1
.544	18	−14	1	3	M	−.54	+ .86	+.34	−1.01	+ 661	1021	8805	−16 9997	+ 3	+19	+32	−19	1
.558	23	− 6	1	3	M	−.61	+ .81	+.34	−1.01	+ 680	+13 1011	+19 8741	−17 0009	+ 23	+11	−27	−25	1
.560	24	−53	1	3	Ma	−.63	+ .80	+.34	−1.01	+ 652	1019	8748	−16 9989	− 4	+19	−19	− 4	1
16.330	Apr. 30	−25	1	3	P	+.68	+ .74	+.36	−1.02	+ 826	1165	8496	−17 0258	+ 12	+ 4	−54	−65	1
28.502	Jul. 2	+10	1	2	K	−.31	+ .97	+.54	− .86	+2432	2828	5242	3447	+ 55	+21	−17	−12	1
.519	8	+ 8	1	2	P	−.40	+ .93	+.54	− .86	+2478	2820	5258	3460	+102	+14	+ 5	−18	1
38.439	Jun. 10	− 4	2	4	K	+.08	+1.01	+.36	− .21	+3642	+13 4220	+19 2679	−17 6101	+ 21	+10	−16	−12	2
39.610	Aug. 11	− 8	2	6	P	−.83	+ .58	+.32	− .11	+3706	4282	2404	6403	− 19	−64	+22	+16	2
40.503	Jul. 2	−15	4	11	D	−.31	+ .97	+.28	− .03	+3842	4444	2161	6698	− 8	−36	−12	−57	3
41.393	May 24	−22	2	6	D	+.36	+ .94	+.24	+ .04	+4009	4634	1921	6908	+ 26	+ 2	−24	−28	2
.401	27	− 2	4	11	S	+.31	+ .96	+.24	+ .04	+4009	4638	1907	6883	+ 27	+ 7	−36	− 1	3
.412	31	−18	2	8	Hf	+.25	+ .98	+.24	+ .04	+3965	+13 4618	+19 1905	−17 6903	− 15	−11	−36	−19	2
.620	Aug. 14	+11	4	13	S	−.86	+ .53	+.23	+ .06	+3972	4610	1869	6950	+ 12	− 3	− 2	+ 7	3
.644	23	+16	2	7	P	−.93	+ .40	+.23	+ .06	+3953	4618	1839	6985	− 7	+ 5	−20	−15	2
42.308	Apr. 23	−16	4	12	S	+.78	+ .63	+.20	+ .12	+4097	4737	1701	7133	− 9	−28	0	+ 4	3
.559	Jul. 23	− 8	4	14	D	−.61	+ .81	+.19	+ .14	+4024	4705	1667	7181	− 55	−39	+23	+16	3
43.307	Apr. 23	− 9	4	10	D	+.78	+ .63	+.15	+ .20	+4198	+13 4883	+19 1447	−17 7389	− 25	−21	0	+15	
.544	Jul. 18	−17	4	10	D	−.54	+ .86	+.14	+ .22	+4228	4863	1397	7424	+ 31	−20	+ 1	+34	3
44.265	Apr. 7	−48	2	4	D	+.91	+ .40	+.10	+ .28	+4286	5002	1163	7666	− 52	−40	−31	+ 4	1
.328	30	−14	4	8	D	+.69	+ .72	+.10	+ .28	+4304	5006	1183	7666	− 33	−36	− 8	+ 7	2
.594	Aug. 4	−15	4	12	D	−.76	+ .66	+.09	+ .31	+4308	5002	1110	7742	− 2	−17	−13	+ 5	3
.607	Aug. 9	+ 8	4	10	D	−.82	+ .60	+.09	+ .31	+4276	+13 5008	+19 1097	−17 7760	− 32	−10	−21	− 7	3
45.609	10	−18	4	8	D	−.82	+ .59	+.04	+ .38	+4428	5132	0833	8017	+ 5	−25	−25	+ 5	3
.617	13	− 6	4	8	D	−.85	+ .55	+.04	+ .38	+4382	5130	0847	8018	− 41	−28	− 8	+ 7	3
46.398	May 26	0	4	13	D	+.33	+ .95	.00	+ .44	+4561	5296	0652	8250	− 1	−18	−20	−33	3
.515	Jul. 7	−16	4	13	D	−.38	+ .94	−.01	+ .45	+4473	5308	0633	8256	− 72	+ 7	−10	− 7	2
47.411	May 31	+ 6	4	9	D	+.25	+ .98	−.06	+ .51	+4663	+13 5424	+19 0401	−17 8482	− 11	−27	−12	+ 5	3
48.670	Sep. 1	+28	2	6	De	−.98	+ .25	−.12	+ .58	+4757	5572	0039	8851	− 13	− 4	−15	+ 2	2
49.366	May 14	−12	4	16	Dt	+.51	+ .87	−.15	+ .62	+4901	5740	+18 9930	8997	− 11	+ 7	+30	+16	3
.423	Jun. 4	−22	4	16	Dt	+.18	+ .99	−.16	+ .62	+4969	5751	9886	9077	+ 66	+24	− 2	−54	3
50.425	Jun. 5	0	4	16	Rb	+.17	+1.00	−.20	+ .66	+5025	5871	9623	9294	+ 3	+ 6	− 1	− 3	3
52.306	Apr. 22	−13	4	15	Li	+.79	+ .62	−.28	+ .72	+5260	+13 6158	+18 9127	−17 9809	− 8	+ 7	+21	+ 1	3
.337	May 3	− 7	4	16	Fr	+.66	+ .76	−.29	+ .72	+5276	6170	9099	9820	+ 12	+19	− 4	− 8	3
.648	Aug. 24	+19	4	15	Co	−.94	+ .38	−.30	+ .73	+5256	6148	9031	9914	+ 21	+20	+24	− 4	3
54.392	May 24	+ 1	4	15	fl	+.36	+ .94	−.36	+ .75	+5489	6454	8591	−18 0321	− 9	+30	+35	+32	3
.464	Jun. 18	−26	1	2	Wy	−.07	+1.01	−.36	+ .75	+5474	6388	8541	0375	− 15	−27	+ 3	− 5	1
.469	20	−44	4	15	Wy	−.10	+1.01	−.36	+ .75	+5467	+13 6451	+18 8551	−18 0370	− 22	+36	+15	+ 1	3
.518	Jul. 8	−48	4	14	Wy	−.39	+ .94	−.36	+ .75	+5473	6419	8509	0388	− 10	+ 9	−12	− 2	3
55.504	Jul. 3	−16	4	12	Wy	−.31	+ .97	−.39	+ .75	+5589	6552	8270	0641	− 15	+ 2	+18	+ 8	3
56 263	Apr. 6	−11	2	7	bi	+.92	+ .38	−.41	+ .74	+5730	6710	8101	0835	− 18	+ 4	+85	+40	2
.271	9	−16	4	16	Br	+.90	+ .43	−.41	+ .74	+5752	6712	8002	0850	+ 4	+ 6	−14	+25	3
.432	Jun. 7	−12	4	16	Wy	+.13	+1.00	−.41	+ .73	+5756	+13 6717	+18 7983	−18 0904	+ 19	+21	−10	− 9	3
59.610	Aug. 11	−14	4	16	Wd	−.83	+ .58	−.46	+ .64	+6092	7108	7064	1769	− 1	+10	−17	− 7	3
.613	12	+ 1	2	8	Jo	−.84	+ .57	−.46	+ .64	+6088	7094	7089	1763	− 5	− 4	+10	+ 1	2
60.539	Jul. 15	+10	4	15	Wa	−.51	+ .88	−.46	+ .60	+6258	7274	6821	2017	+ 33	+34	− 7	−19	3
61.385	May 20	+19	2	8	H	+.41	+ .92	−.46	+ .56	+6380	7398	6608	2205	+ 9	+ 3	+20	+17	2
.443	Jun. 11	+30	2	7	H	+.06	+1.01	−.46	+ .56	+6455	+13 7410	+18 6575	−18 2230	+ 91	+22	+ 1	+ 4	2

[a] B = Samuel J. Barton, bi = Edwin W. Bishop, Br = Sheila V. Brown, Co = A. Wayne Conger, D = Roy W. Delaplaine, De = Edwin W. Dennison, Dt = Daniel F. Detwiler, fl = Edith Flather, Fr = Laurence W. Fredrick, Hf = Dorrit Hoffleit, H = Frank Holden, Jo = F. Jerrold Josties, K = Michael S. Kovalenko, Li = Sarah Lee Lippincott, Ma = Walter H. Matos, M = John A. Miller, P = John H. Pitman, Rb = Hendrik Rubingh, S = Morton L. Slater (1941), S = K. Aa. Strand (1942), Wa = H. Martin Walter, Wd = H. John Wood, Wy = Arne A. Wyller.

TABLE II. Reference stars.

No.	Name	m_{pv}	Sp.	Diameter	x_s	y_s	Dep. 1920 AB	Dep. 1920 C	Dep. 1950 AB	Dep. 1950 C	ΔD/yr
				mm	mm	mm					
1	BD +62°1556	9.3	K0	0.203	−58.66	+32.25	.377	.041	.369	.033	−.00028
2	61 1673	10.3	G	.141	−22.39	−43.50	.032	.384	.039	.391	+.00025
3		11.2	G0	.088	+36.14	+30.23	.411	.187	.407	.183	−.00015
4	61 1682	10.1	K0	.151	+44.91	−18.98	.180	.388	.185	.393	+.00018
	26 Dra AB	(10.0)	G1V	.160	+ 0.50	+18.98					
	26 Dra C	9.9	M1V	.155	+13.58	−17.92					

distant companion C in both right ascension and declination yield the following results:

	mm		p.e.	Weight
c_x AB	= + 0.500934			
C	+13.580021			
c_y AB	+18.953959			
C	−17.919225			
μ_x AB	+ .012800	= +0″.2415	±0″.0008	5045
C	+ .013865	= + .2616	.0004	18195
μ_y AB	− .027495	= − .5188	.0013	1361
C	− .026700	= − .5038	.0003	17486
π_x AB	+ .004163	= + .0786	.0085	44.31
C	+ .004712	= + .0889	.0069	47.69
π_y AB	+ .002574	= + .0486	.0182	6.64
C	+ .000712	= + .0134	.0163	6.76
α_x	+ .024316	= + .4588	.0336	2.84
α_y	+ .026378	= + .4978	.0292	2.59
p.e.1_x AB	± .00301	= ± .0568		
C	± .00254	= ± .0479		
p.e.1_y AB	± .00249	= ± .0470		
C	± .00225	= ± .0425		

A combined solution in right ascension and declination for π and α yields the following values:

	mm		p.e.	Weight
c_x AB	= + 0.501025			
C	+13.579974			
c_y AB	+18.953471			
C	−17.921842			
μ_x AB	+ .012814	= +0″.2418	±0″.0006	7705
C	+ .013861	= + .2616	.0003	18248
μ_y AB	− .027446	= − .5179	.0010	2657
C	− .026716	= − .5041	.0003	18476
π AB	+ .003987	= + .0752	.0072	51.93
C	+ .004215	= + .0795	.0061	54.45
α	+ .024935	= + .4705	.0222	5.44
p.e.1 AB	± .00274	= ± .0517		
C	± .00239	= ± .0451		

For a solution combining the values for 26 Dra AB and C, π and α become

mm

$$\pi = +.004104 = +''.0774 \pm 0''.0058$$
$$\alpha = +.025012 = +.4720 \pm 0.0182$$
$$\text{p.e.}1 = \pm .00225 \;= \pm .0425$$

These values, together with those of c and μ from the combined solution, have been used to calculate the residuals in Table I, and are adopted for further discussion.

4. PARALLAX, MASS RATIO, AND MASS OF 26 DRA AB

Table III lists the mean epoch for the normal places of the residuals in x and in y, together with their weights and number of nights. It is apparent, as it is from Table I, that a trend exists for 26 Dra C in the x coordinate. However, since the trend is not reflected in the y coordinate, it is premature at this time to conclude that a significant deviation from a random distribution exists.

The relative parallax of +0″.0774±0″.0058 is in very close agreement with Hall's (1949) value of +0″.078 ±0″.006; it is rather smaller than van de Kamp's and Hoffleit's (1946) value of +0″.102±0″.007 and supersedes this earlier Sproul determination. The mean apparent magnitude 10.2 and spectral type G5, of the reference stars, yield a mean parallax of +″.004 for these stars according to Vyssotsky and Williams (1948) and Binnendijk (1943). The Sproul value for the absolute parallax thus becomes +0″.081 for the triple system 26 Dra.

Other trigonometric parallaxes adjusted for the Yale precepts (Jenkins 1952) are

Allegheny	+0″.048	±0″.007	(p.e.)
Greenwich	+ .053	.015	
McCormick	+ .071	.013	
Yerkes	+ .078	.012	

for 26 Dra AB, and

McCormick	+0″.043	±0″.012
Mt. Wilson	+ .065	.015

for 26 Dra C.

The weighted mean value combined with the current Sproul value adjusted for Yale precepts for the probable error only is

$$\pi_{\text{abs}} = +0''.066 \pm 0''.003.$$

The value of α from the combined solution leads to

$$\alpha/a = \text{B} - \beta = +.315 \pm .012 \text{ (p.e.)}$$

assuming no error in Hall's value for a. Eggen's value

TABLE III. Normal places of residuals.

Epoch	Σp	Σn	v_x AB	v_x C	v_y AB	v_y C
			unit .0001 mm			
1914.90	13	13	+4	+21	+12	+6
28.51	2	2	+78	+18	−3	−8
40.82	19	8	+6	−11	−16	−14
43.60	21	8	−19	−25	−4	+10
46.59	16	6	−20	−18	−15	−4
51.09	18	6	+14	+14	+11	−9
55.32	21	8	−8	+14	+18	+12
60.44	12	5	+24	+13	+1	+1

of 2.74 for Δm leads to $\beta=0.074$ and B=0.389. If the above values of P, a, and π_{abs} are adopted, we find

$$a=22.7\pm1.0 \text{ a.u.}$$

and

$$M_A+M_B=2.13\pm0.28\odot,$$

where the p.e. of the masses arises only from the error in the semi-axis major. The individual masses are

$$M_A=1.30\odot,\quad M_B=0.83\odot.$$

The value of 0.389 for B in this investigation is considerably less than Hall's (1949) value for B of 0.473. The difference between these values is much larger than the p.e. of either. Hall's larger value may be caused by a less complete blending of the photographic images of the two stars due to the longer focal length of the Yerkes refractor, thus reducing the need for the full correction β.

With the adopted value for the parallax, values of 4.41 and 7.15 are derived for the absolute visual magnitudes of the two stars, and 9.00 for 26 Dra C. The absolute bolometric magnitudes of the three stars are 4.4, 6.6, and 7.7, respectively, using the bolometric corrections of Eggen (1956a) for the G star and of Limber (1960) for the two fainter stars. A spectral class of M0 has been assumed for 26 Dra B for the purpose of determining the bolometric correction. The values for the masses and luminosities found in the present investigation when plotted on the mass–luminosity diagram by van de Kamp (1961), show that both stars of the close pair lie very close to the $L\sim M^4$ sequence, the main-sequence mass–luminosity relation. The B−V color is +0.61 for the G component (Johnson and Morgan 1953) and is +1.4 and +1.5 for 26 Dra B and C, respectively, assuming color indices for the spectral types M0V and M1V based on the measures by Johnson (1955). The positions of the three stars on the color–luminosity diagram by Johnson and Morgan (1953) show that the stars A and C lie very close to the standard main sequence while B appears to lie some distance above it. The high position of B can best be attributed to an inaccuracy in the assumed spectral classification of M0. Both the mass and the luminosity of 26 Dra B are improbably high for a dwarf of spectral class M0. It appears likely that this star has an earlier spectral class. There appears to be little evidence, other than the very dubious position of B on the color–luminosity diagram, that any of these three stars are spectroscopic binaries from the data of this investigation.

TABLE IV. Proper motions of background stars.

No.	Name	Position X	Position Y	m_{pv}	μ_x	μ_y
		mm	mm			
1	BD +62°1556	−55.6	+13.7	9.3	+0″.024	0″.000
2	61°1673	−19.4	−61.9	10.3	− .002	− .045
3		+39.2	+11.7	11.2	+ .008	+ .001
4	1682	+48.0	−37.5	10.1	+ .014	.000
5		−49.2	+26.0	12.2	− .008	− .011
6		−46.0	+54.0	12.3	− .041	+ .111
7	1672	−41.5	−18.8	10.6	+ .003	+ .012
8		−38.7	+29.4	12.5	− .001	+ .005
9	1674	−19.0	−64.3	9.3	+ .014	− .042
10	1675	−19.3	−31.1	8.9	− .020	+ .008
11		−16.8	−41.2	12.3	.000	− .016
12		−8.8	−42.1	12.4	+ .012	− .027
13		+18.9	−5.2	12.4	− .007	+ .005
14		+26.0	+0.1	12.1	− .019	−. 005
15	1681	+43.9	−36.7	10.5	+ .024	+ .122
16	1684	+53.4	−33.4	8.6	+ .003	+ .011
17		+42.8	+26.0	12.4	− .006	+ .010
18		+48.8	−3.8	12.6	− .006	− .032
19		+50.0	+3.7	12.5	+ .005	− .008
20		+54.5	−10.1	12.4	+ .003	− .010

5. APPARENT ORBITAL MOTION OF C AND AB

Table IV gives the proper motions of 20 field stars surrounding 26 Dra. The first four stars are the reference stars as given in Table II. The measured positions from the approximate center of the plate are also given for the purpose of identification. The magnitudes of the first four stars are taken from Table II; the others are from the investigation of Hoffleit (unpublished). The proper motions were derived from measures on two pairs of plates separated by an interval of 46.7 yr. Star No. 12 is a double; only the brighter component was measurable.

The resulting corrections for differences in dependence background to be applied to the motion of C relative to the center of mass of A and B are

$$[(D_C-D_{AB})\mu_x]=-''.0075\pm''.0005,$$

$$[(D_C-D_{AB})\mu_y]=-''.0162\pm''.0008.$$

A summary of the relative proper motion results is given below:

	x	y
C observed	+″.2616±″.0003	−″.5041±″.0003
AB observed	+.2418±.0006	−.5179±.0010
(C−AB) observed	+.0198±.0007	+.0137±.0010

Correction for background	$-.0075\pm.0005$	$-.0162\pm.0005$
(C−AB) corrected	$+.0123\pm.0008$	$-.0025\pm.0012$

corresponding to a total orbital motion w of $0''.0126 \pm .0008$.

The probable errors given here are those of the measures alone. In addition to these, however, is the "cosmic error" inherent in the fact that the background stars provide the only reference system. This additional error amounts to $\pm 0''.0022$ in the x direction and $\pm 0''.0029$ in the y direction (van de Kamp 1941). Measurement and cosmic errors combined thus yield a total probable error of $\pm 0''.0023$ for the total apparent orbital motion w.

The condition for a parabolic orbit may be stated as follows (van de Kamp 1961):

$$V^2 r = 8\pi^2(M_{A,B}+M_C),$$

where V is the linear velocity in a.u./yr and r the radius vector in a.u.

For 26 Dra C and AB, the projected separations Δx and Δy are $+246''.80$ and $-695''.84$, respectively, giving a separation ρ of $738''.31$, which corresponds to 11200 a.u. The linear value of the apparent orbital motion w, i.e., the projected value of V, is 0.191 ± 0.036 a.u.

The observed values of w and ρ yield a projected value of 409 for $V^2 r$. If a mass of $0.5\odot$ is assumed for M_C, the quantity $M_{AB}+M_C$ is $2.63\odot$ and the parabolic criterion becomes $V^2 r = 208$. Hence the observed projected value of $V^2 r$ is about twice the critical parabolic limit, thus indicating a hyperbolic orbit of C relative to AB. However the appreciable value of the probable error in V makes an elliptical orbit a distinct possibility.

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REFERENCES

Binnendijk, L. 1943, *Bull. Astron. Inst. Neth.* **10**, 9.
Eggen, O. J. 1956a, *Astron. J.* **61**, 361.
——. 1956b, *ibid*, **61**, 405.
Hall, R. G. 1949, *ibid.* **54**, 106.
Jenkins, L. F. 1952, *General Catalogue of Trigonometric Stellar Parallaxes* (Yale University Observatory, New Haven, Connecticut).
Johnson, H. L. 1955, *Ann. d'Astrophys.* **18**, 309.
Johnson, H. L., and Morgan, W. W. 1953, *Astrophys. J.* **117**, 313.
Kovalenko, M. 1928, *Publs. Astron. Soc. Pacific* **40**, 392.
Limber, D. N. 1960, *Astrophys. J.* **131**, 177.
Lippincott, S. L. 1957, *Astron. J.* **62**, 55.
van de Kamp, P. 1941, *Ann. N. Y. Acad. Sci.* **XLII**, 151.
——. 1961, *Publs. Astron. Soc. Pacific* **73**, 402.
van de Kamp, P., and Hoffleit, D. 1946, *Publs. Am. Astron. Soc.* **10**, 175.
van de Kamp, P., and Lippincott, S. L. 1949, *Astron. J.* **55**, 16.
van Maanen, A., and Gingrich, C. H. 1921, *Publs. Astron. Soc. Pacific* **33**, 319.
Vyssotsky, A. N., and Williams, E. T. R. 1948, *Publ. McCormick Obs.* **10**, 33.