Light-curves and elements of five variable stars in the region around α Centauri (prepared for publication and partly discussed by P. Th. Oosterhoff)
Gent, H. van

TABLE 3 *(continued)*

J. D. — 2420000	var. 133	var. 159	J. D. — 2420000	var. 133	var. 159	J. D. — 2420000	var. 133	var. 159
d	m P	m P	d	m P	m P	d	m P	m P
7968·2674	14·19 s ·886	14·43 ·316	7970·2623	13·78 ·177	14·47 ·130	7971·2594	13·93 ·321	14·52 r ·036
·2747	14·39 ·909	14·43 ·337	·2696	13·74 ·200	14·40 ·151	·2667	14·07 p ·344	14·48 ·058
·2807	14·51 ·928	14·44 ·355	·2755	13·72 ·219	14·38 ·169	·2725	14·15 p ·363	14·42 ·074
70·2260	13·91 ·063	14·56 r ·024	71·2231	13·76 ·207	14·78 r ·930	8683·3068	14·01 s ·848	
·2332	13·81 ·085	14·49 r ·045	·2303	13·72 ·230	14·75 r ·951	99·2690	13·79: ·187	
·2405	13·81 ·108	14·52 ·067	·2376	13·78 ·253		8709·2486	13·78 ·659	
·2478	13·79 ·131	14·48 ·088	·2449	13·83 ·276	14·65 r ·994			
·2550	13·72 ·154	14·44 ·109	·2522	13·84 ·299	14·56 r ·015			

Light-curves and elements of five variable stars in the region around β Centauri,

by *H. van Gent* †.

(Prepared for publication and partly discussed by P. Th. Oosterhoff).

Five variables in the region around β Centauri are discussed, which were estimated on Franklin-Adams plates. The elements of three known Cepheids have been confirmed. The other two variables are new, one probably belonging to the class of RV Tau variables and the other being a W UMa-type star.

After his return from Johannesburg to Leiden the late Dr VAN GENT planned to investigate the variables in a field around β Centauri of which he had taken with the Franklin-Adams camera well over three hundred plates. With the blink-comparator of the Union Observatory he had investigated 32 pairs of plates and discovered 253 stars which probably are variable. He made estimates of the brightness of ten variables in the usual manner before his work was suddenly brought to a close by his unexpected death. Five of these variables, for which he had determined a provisional period from his own material, are discussed in the present note.

The plates, 345 in number, are centred on C.P.D. — 58° 5038. The main data about the five variables have been collected in Tables 1 and 2. The numbers in the first column were assigned to the variables by Dr VAN GENT. Only two are new variables, the other three are already known Cepheids. The mean error of the periods in the fifth column is expressed in units which correspond with the last decimal place given for the period. The magnitude of the variables at maximum and at minimum has been derived from the magnitudes of the comparison stars, for which the C.P.D., some grating plates and star counts have been used. The brightness of the comparison stars in steps and in magnitudes is given in Table 3. The following remarks refer to the individual variables.

TABLE 1

var.	name	α (1875)	δ (1875)	type	period	m.e.	reciprocal period	epoch *) — 2420000
		h m s	° ′		d		d^{-1}	d
1		13 00 49	— 58 42·8	RV Tau?				
2	MY Cen	13 03 12	— 60 57·6	δ Cep	3·71870	± 8	·268911	7458·12
11		13 09 10	— 61 57·8	W UMa	·7553542	± 28	1·323882	7621·2693
3	XX Cen	13 32 08	— 56 58·6	δ Cep	10·9571	± 8	·091265	7538·026
10	V 381 Cen	13 42 24	— 56 57·5	δ Cep	5·07883	± 9	·196896	7598·38

*) Epoch of maximum for Cepheids and epoch of primary minimum for eclipsing variable.

TABLE 2

var.	number of observations	m.e. of one estimate	brightness at max.		brightness at min.	
		s	s	m	s	m
1	331		1	11·6	13	12·8
2	214	± ·90	1·2	12·5	10·3	13·3
11	335	± ·77	2·3	11·0	8·5	11·8
3	341	± 1·05	3·5	7·7	13·8	9·9
10	341	± 1·09	— 1·1	8·0	9·8	9·4

TABLE 3

star	C. P. D.	brightness	star	C. P. D.	brightness
Var. I	°	s m		°	s m
a	− 58 4712	·0 11·5	c	− 61 3562	8·4 11·8
b		4·1 11·9	d		14·4 12·4
c		9·3 12·4			
d		15·4 13·0	XX Cen	− 56 5865	
e		18·7 13·4	a	− 56 5856	·0 6·5
			b	− 56 5860	6·5 8·7
MY Cen			c	− 56 5857	9·2 9·2
b		·0 12·4	d	− 56 5874	11·8 9·6
c		4·2 12·8	e	− 56 5880	16·5 10·4
d		9·2 13·2			
e		14·3 13·7	V381 Cen	− 56 5960	
			a	− 56 5963	·0 8·1
Var. II	− 61 3558		b	− 56 5973	2·9 8·5
a	− 62 3135	·0 10·6	c	− 56 5970	5·8 8·6
b	− 61 3549	4·8 11·5	d	− 57 6341	12·1 9·8

Variable 1.

A chart of the variable and its comparison stars is shown in Figure 1. No variation in brightness could be detected in a single night and consequently night means have been formed, which are given in Table 4 and some of which are shown in Figure 2. The light variation is not strictly periodic and the brightness at maximum and at minimum shows distinct variations. There are some indications that the rising branch sometimes is steeper than the descending branch. Tentatively the star is classified as a variable of the RV Tauri-type with an apparent mean cycle of about 40 days, although it may also be related with variables like SX Centauri.

FIGURE 1

Var. 1

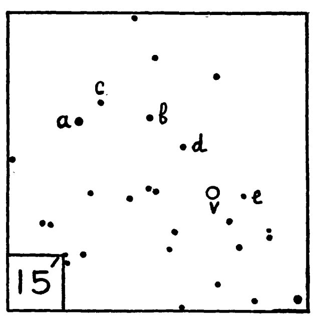


FIGURE 2

Variable 1 : night means

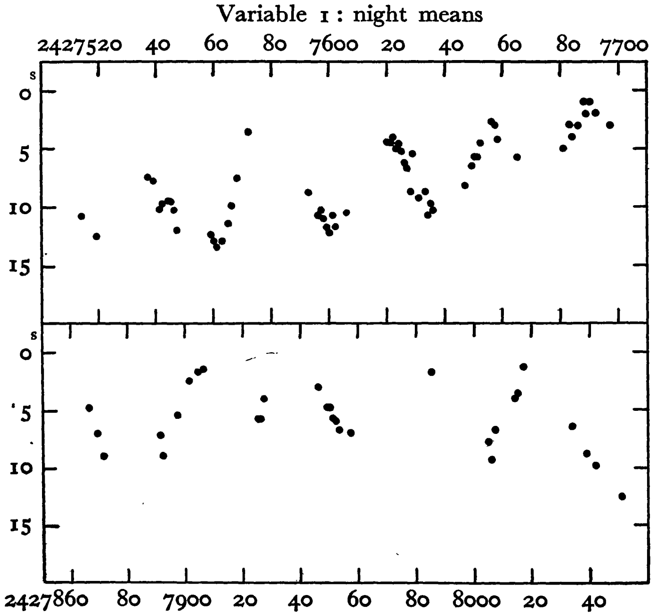


TABLE 4

Variable 1 : night means

J.D. — 2420000	bright-ness	n	J.D. — 2420000	bright-ness	n	J.D. — 2420000	bright-ness	n
d	s		d	s		d	s	
6399·5	4·6	2	7596·3	10·8	2	7869·5	7·0	2
6410·5	4·6	5	97·3	10·3	4	71·5	8·9	3
11·4	3·3	2	98·3	11·1	3	91·3	7·2	1
16·6	5·2	2	99·2	11·8	2	92·5	9·0	4
40·6	9·3	1	7600·3	12·2	2	97·5	5·4	1
53·3	12·8	4	01·3	10·8	2	7901·4	2·6	4
56·3	12·8	3	02·3	11·8	2	04·6	1·7	3
60·6	12·4	1	06·3	10·6	2	06·5	1·5	2
71·5	1·0	2	20·2	4·4	3	25·4	5·8	10
72·5	·5	2	21·3	4·5	3	26·3	5·8	3
76·4	2·4	2	22·3	4·1	3	27·5	4·1	2
77·5	2·8	2	23·2	5·1	1	46·2	3·1	3
78·4	2·0	2	24·2	4·6	2	49·4	4·8	2
79·5	2·0	2	25·3	5·2	2	50·3	4·8	2
80·4	3·5	5	26·2	6·2	1	51·3	5·8	2
82·3	3·7	2	27·2	6·7	1	52·3	5·9	2
83·3	6·0	2	28·3	8·8	3	53·4	6·7	3
85·4	5·4	1	29·2	5·4	1	57·3	7·0	3
97·3	12·4	1	31·2	9·3	4	85·2	1·8	2
6507·3	3·6	2	33·3	8·8	2	8005·2	7·7	4
09·5	2·0	2	34·2	10·8	2	06·2	9·3	3
35·3	12·0	2	35·3	9·8	2	07·2	6·7	1
39·3	9·3	2	36·2	10·3	2	14·3	4·1	2
40·3	10·3	2	47·2	8·2	2	15·2	3·6	2
7334·2	5·0	1	49·3	6·6	2	17·2	1·3	2
37·2	6·7	1	50·2	5·8	1	34·2	6·4	3
7457·5	10·3	1	51·2	5·8	2	39·3	8·8	2
79·5	17·4	3	52·2	4·6	2	42·3	9·8	2
7514·3	10·8	2	56·2	2·7	2	51·2	12·4	2
19·3	12·6	2	57·2	3·0	2	66·2	3·1	1
37·3	7·4	2	58·3	4·2	2	69·2	2·5	1
39·3	7·8	4	65·2	5·8	2	70·2	2·5	1
41·3	10·2	2	81·2	5·0	2	72·2	2·5	1
42·3	9·8	8	83·2	3·0	2	74·2	5·8	1
44·5	9·5	11	84·2	4·1	2	8228·5	3·3	2
45·3	9·6	6	86·2	3·1	2	8339·3	6·2	1
46·4	10·3	2	88·2	1·0	1	41·3	3·3	3
47·3	12·0	4	89·2	2·0	1	46·3	3·0	2
59·2	12·4	1	90·2	1·0	1	60·2	9·8	2
60·2	12·9	2	92·2	2·0	2	8402·2	5·0	2
61·2	13·4	2	97·2	3·1	2	03·2	6·2	2
63·3	12·9	2	7807·6	11·7	2	8628·4	5·1	1
65·4	11·4	4	11·6	6·7	3	42·5	7·4	2
66·3	9·9	8	19·6	2·5	2	58·5	12·4	2
68·4	7·6	7	43·6	5·8	2	60·3	12·4	1
72·3	3·6	4	44·4	6·7	1			
93·3	8·8	2	66·6	4·8	2			

Variable 2 = *MY Cen.*

This variable is identical with HV 6430, which has been discovered by SHAPLEY and SWOPE [1]). They found a variation of δ Cephei-type with a period of

[1]) *H.A.* **90**, No. 5, 178, 1934.

3·7186 days. These results are fully confirmed here. The period has been computed from 41 observations on the rising branch, which were reduced to brightness $6^s·8$ by means of the adopted slope of 1 step in ·0725 days. Details of a least-squares solution are given in Table 5, the resulting elements being:

$$\text{Epoch } (6^s·8 \text{ on rising branch}) = 2427457^d·635 + 3^d·71870\,E$$
$$\pm 12 \quad \pm 8 \text{ m.e.}$$

The maximum comes ·48 days later. The mean light-curve is shown in Figure 3. Data about the normal points are given in Table 6. It may be remarked that the period given here differs slightly from that derived by VAN GENT, viz. 3·70651, which yields one period more within the interval covered by the Johannesburg observations.

TABLE 5

s = 6·8 on rising branch	n	E	O—C
d			d
2426416·35	2	— 280	— ·05
72·19	1	— 265	+ ·01
79·62	2	— 263	·00
83·38	2	— 262	+ ·04
6509·31	2	— 255	— ·06
35·46	2	— 248	+ ·06
39·11	2	— 247	— ·01
7457·55	1	0	— ·08
7539·42	4	+ 22	— ·03
65·49	4	+ 29	+ ·01
98·92	2	+ 38	— ·03
7606·48	2	+ 40	+ ·10
21·33	3	+ 44	+ ·07
36·13	2	+ 48	·00
47·24	2	+ 51	— ·05
51·00	2	+ 52	— ·01
58·47	2	+ 54	+ ·03
84·40	2	+ 61	— ·08
88·24	1	+ 62	+ ·05
91·85	1	+ 63	— ·06

FIGURE 3

MY Cen

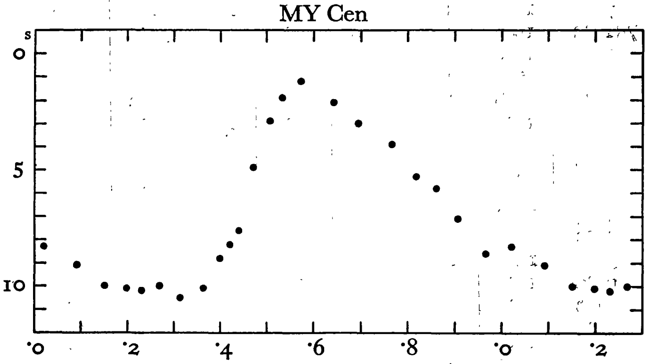


TABLE 6

n	mean phase	mean brightness
	P	s
11	·0214	8·3
11	·0919	9·1
11	·1511	10·0
11	·1988	10·1
11	·2307	10·2
11	·2685	10·0
11	·3132	10·5
11	·3627	10·1
7	·3989	8·8
7	·4209	8·2
7	·4401	7·6
7	·4709	4·9
7	·5070	2·9
7	·5337	1·9
7	·5730	1·2
11	·6437	2·1
11	·6955	3·0
11	·7674	3·9
11	·8194	5·3
11	·8611	5·8
11	·9066	7·1
11	·9674	8·5

Variable 11.

This new variable belongs to the W UMa-type. A provisional value of the apparent period has been derived from 19 epochs of minimum, which are given together with the residuals $(O—C)$ in Table 7. Even and odd minima seem to be of equal range. The resulting elements are:

$$\text{Min.} = 2427652^d·213 + {}^d·3776813\,E$$
$$\pm 2 \quad \pm 29 \text{ m.e.}$$

An improved value of the period has been computed from 64 observations on the rising and descending branches in the manner described by J. DE KORT in *B.A.N.* No. 345, 250, 1941. The observations were reduced to brightness $6^s·0$ with the adopted slope of 1 step in ·0159 days. The results of the least-squares solution are:

$6^s·0$ on descending branch,	primary	min.:	$2427621^d·2326$		
			± 32 m.e.		
„ „ rising „	„	„ :	2427547 ·2813		
			± 36		
„ „ descending „	secondary	„ :	2427598 ·1915		
			± 31		
„ „ rising „	„	„ :	2427626 ·2210		
			± 27		
	period	„ :	·7553542		
			± 28		

The elements of primary minimum are therefore:

$$\text{J.D. } 2427621^{d}\cdot 2693 + {}^{d}\cdot 7553542\, E$$
$$\pm \quad 24 \quad \pm \quad 28$$

The choice of the primary minimum is somewhat arbitrary as the minima differ only a few hundredths of a magnitude in range. Phases were computed by the formula: phase = 1·323882 (J.D. − 2420000). The phase of primary minimum was found to be ·662.

A reflected mean light-curve is shown in Figure 5. Data about the normal points are given in Table 8. The transition in the light-curve from the effect of eclipse to that of ellipticity seems more pronounced than for most variables of this type.

A chart of the variable and its surroundings is given in Figure 4.

FIGURE 4
Var. 11

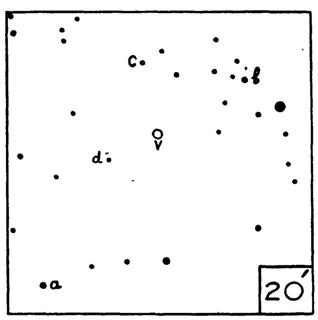


FIGURE 5
Var. 11

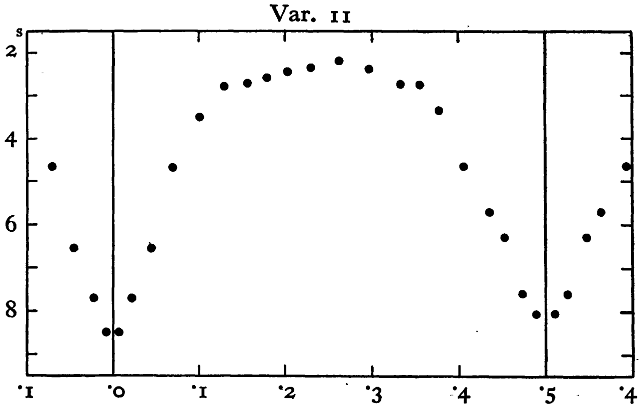


TABLE 7

Epoch of minimum	*E*	*O−C*	Epoch of minimum	*E*	*O−C*
d		d	d		d
2426497·290	− 3058	+ ·002	2427652·225	0	− ·012
7542·326	− 291	− ·006	83·210	+ 82	+ ·003
61·228	− 241	+ ·012	86·230	+ 90	+ ·001
68·387	− 222	− ·005	7891·304	+ 633	− ·006
·408	− 222	+ ·016	7904·524	+ 668	− ·005
93·308	− 156	− ·011	25·314	+ 723	+ ·013
98·217	− 143	− ·012	51·349	+ 792	− ·012
7601·243	− 135	− ·007	8015·269	+ 961	+ ·020
·265	− 135	+ ·015	72·214	+ 1112	− ·005
29·199	− 61	·000			

TABLE 8

n	mean phase	mean brightness
	P	s
10	·0074	8·49
10	·0222	7·72
15	·0451	6·56
15	·0707	4·67
15	·1013	3·52
20	·1304	2·78
20	·1570	2·72
20	·1793	2·58
20	·2028	2·46
20	·2307	2·35
20	·2623	2·20
20	·2970	2·38
20	·3332	2·74
20	·3558	2·75
20	·3776	3·36
20	·4060	4·65
15	·4358	5·71
15	·4526	6·28
10	·4740	7·59
10	·4891	8·06

Variable 3 = *XX Cen.*

This δ Cephei-type variable has been discovered by Miss LEAVITT [1]) and has been further investigated by ROBINSON [2]), who gave a mean light-curve and the following elements of maximum:

$$\text{max.} = 2419846^{d}\cdot 821 + 10^{d}\cdot 956130\, E.$$

An independent determination of the period was made from the estimates of this paper. As the light-curve is practically symmetrical with regard to the maximum, 60 observations on the steepest parts of rising and descending branches shortly before and after maximum have been used. They were reduced to brightness $7^{s}\cdot 0$ with the adopted slope of + or − 1 step in ·265 days. The data of the least-squares solution are given in Table 9 and the resulting elements are:

$$\text{J.D. } 2427538^{d}\cdot 026 + 10^{d}\cdot 9571\, E + 1^{d}\cdot 17\, X$$
$$\pm \quad 5 \quad \pm \quad 8 \quad \pm \quad 5 \text{ m.e.}$$

where *X* equals − 1 for the rising and + 1 for the descending branch. The first term of these elements is the epoch of maximum. The mean light-curve, shown in Figure 6, is characteristic for δ Cephei-type variables with such a period and it resembles closely the light-curve of ROBINSON, although the maximum is less sharp. This may be caused by the fact that the variable is heavily overexposed on the Johannesburg plates, expecially near maximum. Data about the normal points are given in Table 10.

1) *H.C.* No. 122, 1906; *A.N.* **173**, 382, 1906.
2) *H.B.* No. 869, 10, 1929; *H.A.* **90**, No. 2, 48, 1933.

TABLE 9

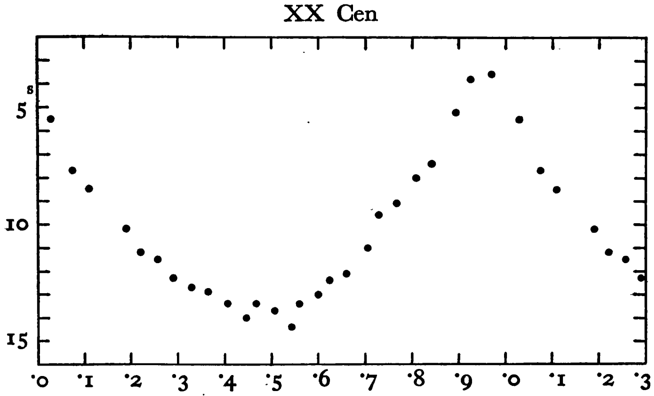
J.D. — 2420000	n	bright-ness	X	E	O—C
d		s			d
5706·618	1	7·8	— 1	— 167	— ·18
07·351	2	6·5	— 1	— 167	+ ·21
6399·519	2	6·8	+ 1	— 104	— ·09
6410·527	5	6·3	+ 1	— 103	+ ·09
76·433	2	7·6	+ 1	— 97	— ·09
85·369	1	6·5	— 1	— 96	+ ·27
6507·315	2	5·4	— 1	— 94	+ ·01
09·465	2	7·6	+ 1	— 94	+ ·08
39·300	2	8·0	— 1	— 91	— ·19
40·302	2	4·4	— 1	— 91	— ·14
7537·285	2	5·4	— 1	0	+ ·01
39·325	4	8·2	+ 1	0	— ·19
47·358	2	9·0	— 1	+ 1	+ ·08
59·214	1	5·4	— 1	+ 2	+ ·02
61·239	2	8·5	+ 1	+ 2	— ·28
72·293	4	7·8	+ 1	+ 3	+ ·01
7602·252	2	9·0	— 1	+ 6	+ ·18
24·212	2	6·5	— 1	+ 8	— ·43
26·200	1	4·6	+ 1	+ 8	— ·02
27·199	1	6·5	+ 1	+ 8	+ ·47
35·300	2	7·2	— 1	+ 9	— ·12
57·213	2	6·0	— 1	+ 11	— ·43
81·225	2	5·0	+ 1	+ 13	+ ·12
90·243	1	7·8	— 1	+ 14	+ ·21
92·228	2	5·6	+ 1	+ 14	·00
7843·557	2	7·8	— 1	+ 28	+ ·12
7953·359	3	9·0	— 1	+ 38	+ ·67
8074·217	1	5·2	— 1	+ 49	— ·01
8339·275	1	6·5	+ 1	+ 73	+ ·34
8402·231	2	6·2	— 1	+ 79	— ·45

TABLE 10

n	mean phase	mean brightness	n	mean phase	mean brightness
	P	s		P	s
13	·0295	5·5	13	·5432	14·4
13	·0754	7·7	13	·5604	13·4
13	·1106	8·5	13	·6009	13·0
13	·1905	10·2	13	·6235	12·4
13	·2212	11·2	13	·6605	12·1
13	·2578	11·5	13	·7053	11·0
13	·2915	12·3	13	·7284	9·6
13	·3296	12·7	13	·7665	9·1
13	·3644	12·9	13	·8086	8·0
13	·4062	13·4	13	·8424	7·4
14	·4463	14·0	13	·8949	5·2
14	·4679	13·4	13	·9255	3·8
14	·5064	13·7	13	·9698	3·6

FIGURE 6

XX Cen



Variable 10 = *V* 381 *Cen.*

This variable was first discovered and has been investigated by O'CONNELL [1]). His results are fully confirmed here. The period of this δ Cephei-type variable has been determined from 43 observations on the rising branch. They were reduced to brightness $5^s·0$ with the adopted slope of 1 step in ·0717 days. Data about the least-squares solution are given in Table 11. The resulting elements are:

$$5^s·0 \text{ on rising branch} = 2427597^d·653 + 5^d·07883\,E$$
$$\pm\ 11 \quad \pm \quad 9 \text{ m.e.}$$

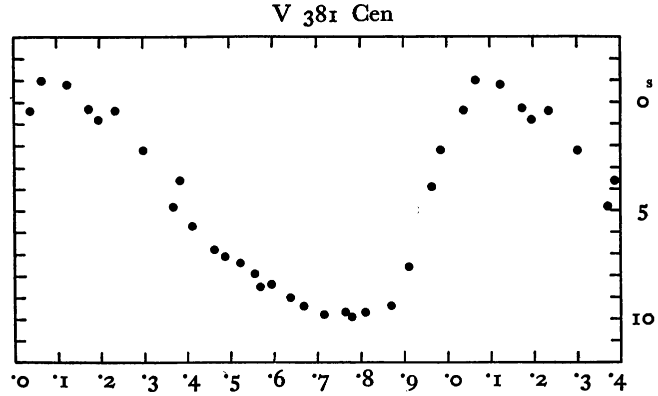
The phase of maximum in the mean light-curve, given in Figure 7, is ·09, which corresponds with the mean epoch of maximum 2427598·38. The normal points have been tabulated in Table 12.

TABLE 11

s = 5·0 on rising branch	n	E	O—C
d			d
2425713·43	1	— 371	+ ·02
6480·33	5	— 220	+ ·02
85·33	1	— 219	— ·06
7572·20	4	— 5	— ·06
97·60	2	0	— ·05
7622·98	1	+ 5	— ·07
28·11	3	+ 6	— ·02
33·31	2	+ 7	+ ·11
58·59	1	+ 12	— ·01
83·95	2	+ 17	— ·04
88·98	1	+ 18	— ·09
7866·85	2	+ 53	+ ·02
92·22	2	+ 58	— ·01
97·25	1	+ 59	— ·05
7927·81	2	+ 65	+ ·03
53·24	3	+ 70	+ ·07
8014·19	2	+ 82	+ ·07
34·42	3	+ 86	— ·01
39·55	2	+ 87	+ ·04
70·00	1	+ 93	+ ·02
8339·12	1	+ 146	— ·04
8628·62	1	+ 203	— ·04

FIGURE 7

V 381 Cen



[1]) *Riverview College Obs. Publ.* No. 1, 7, 1935.