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COMMUNICATIONS FROM THE OBSERVATORY AT LEIDEN

Twenty new variable stars in or near the constellation Scutum, by *P. Th. Oosterhoff*.

During the summer of 1935 the writer took a number of plates of the Scutum cloud and its surroundings with the 10-inch Cook refractor of the Mount Wilson Observatory for the study of variable stars in this region. Eastman 40 plates, 8 × 10 square inches in size, were used with an exposure time of 30 minutes. The plates were centred at the star B.D. −8°4726, the equatorial co-ordinates of which are: α (1855) = $18^h42^m27^s \cdot 8$ and δ (1855) = −8°4′·1. One millimetre on these plates equals about three minutes of arc.

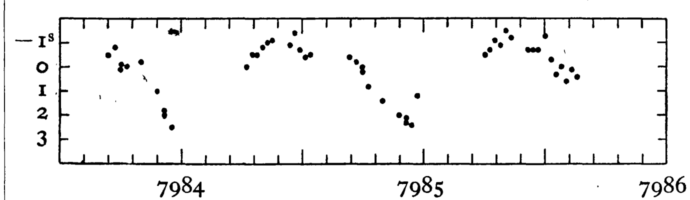
In order to facilitate the discovery of bright variables with small range, a number of plates has been taken with the 5-inch Ross camera, which was attached to the mounting of the Cook refractor. These plates were taken out of focus and show images of very homogeneous blackening. The brand of the plates, their size and exposure time, were the same as above. The scale of these plates is approximately 1 mm = 4′·0.

Observations made at widely different longitudes are of great value for the determination of periods. Therefore plates of this field have been taken by Dr H. VAN GENT with the Franklin-Adams camera of the Union Observatory at Johannesburg during the same opposition. I am much indebted to Dr VAN GENT for his kind cooperation, which has been extremely helpful. This is clearly shown by the following table, which gives the time intervals covered by observations during three consecutive days.

J. D.	number of plates	observatory
2427983·69 – ·97	8	Mount Wilson
84·26 – ·54	11	Union
·68 – ·99	9	Mount Wilson
85·24 – ·65	16	Union

As a further illustration the observations of variable 14 during these days are shown in Figure 1. For variables with periods shorter than two days the period can be read off immediately.

FIGURE 1.



The observations with the Franklin-Adams camera have been continued in recent years. The scale of these plates is practically the same as that of the Cook refractor and the quality of the photographic images is very similar for these instruments.

The central part of the field has been observed at Johannesburg with the Rockefeller twin astrograph of the Leiden Observatory. The scale of this instrument is 90 seconds on a millimetre. All the plates taken at Johannesburg have a size of 20 × 20 square centimetres. In all, the following numbers of plates are available at the Leiden Observatory:

Mount Wilson	5-inch Ross	:	33
,, ,,	10-inch Cook	:	90
Johannesburg	Franklin-Adams	:	153
,,	Rockefeller astrograph	:	52
	total number	:	328 [1])

The twenty variables discussed in the present note have all been discovered by the writer in the blink comparators of the Mount Wilson and Leiden observatories. They were estimated on the plates in the usual way with the aid of an eye-piece, enlarging ten times. Charts on which the variables and their comparison stars have been marked are given in Figure 2. No chart is given when the variable can be identified by its B.D. number. The mean brightness of the comparison stars, expressed in step values, is given in Table 1.

[1]) The J.D.'s of these plates are given in Table 4.

FIGURE 2.

The size of the diagrams in minutes of arc is indicated in the corner.

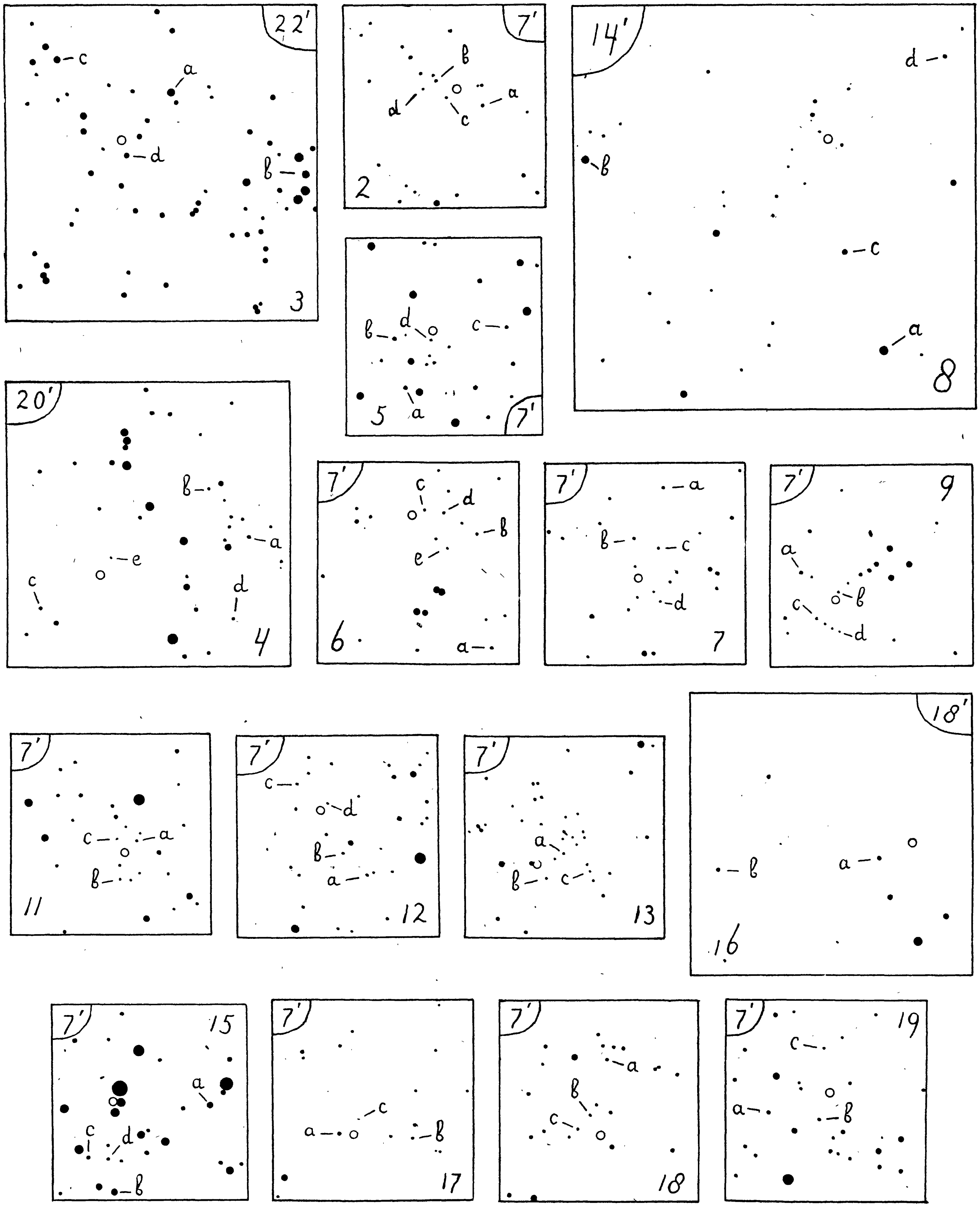


TABLE 1.

Variable	a	b	c	d	e
	s	s	s	s	s
1	·0	3·2	6·2	8·2	10·9
2	·0	3·5	6·8	8·2	
3	·0	2·7	5·0	6·6	
4	·0	·6	2·4	3·9	5·8
5	·0	1·1	3·9	5·8	
6	·0	3·5	5·6	7·1	8·4
7	·0	1·8	4·3	6·7	
8	·0	1·7	5·0	7·3	
9	·0	3·7	6·3	8·4	
10 Oo	·0	3·9	6·2	9·1	
10 v.d.B.v.E.	·0	3·6	5·3	7·8	
11	·0	2·9	4·8		
12	·0	2·5	4·6		
13	·0	2·9	5·1		
15	·0	2·0	3·5	5·5	
16	·0	3·7			
17	−2·8	·0	5·4		
18	·0	·8	3·3		
19	·0	2·5	4·3		
20	·0	3·4	6·6		

The main data of the variables are contained in Table 2. The reciprocal period in the seventh column does not always correspond exactly with the period of the fifth column, but the value given has been used for the computation of the phases in the formula:

$$\text{phase} = P^{-1}\,(\text{J.D.} - 2420000).$$

J.D. in this article stands for J.D. hel. M.A.T. Gr. The epochs in the following column are epochs of maximum for the RR Lyr- and δ Cep-type variables, otherwise it are epochs of minimum. For some variables more accurate epochs have been derived, which correspond with a special phase. These are given in the remarks on the individual stars. The mean error of a single observation has been computed from the differences in brightness between observations following each other in phase. The photographic magnitudes at maximum and at minimum in the last two columns are rather uncertain. The fainter stars have been compared with stars in the cluster M 11 for which SHAPLEY has determined photographic magnitudes [6]), but the difference in quality between the images is sometimes considerable. The mean light curves of the RR Lyr- and δ Cep-type variables are shown in Figure 3, those of the eclipsing variables in the Figures 4 and 5. As a rule normal points of less than 9 observations have been indicated by an open circle. The number of observations, the mean phase and the mean brightness of each normal point are given in the first three columns of Table 6. Entries in the fourth column are explained for each variable separately. Some data of the least squares solution of the period are given in Table 7 at the end of the paper. The J.D. −2420000 and the brightness of each observation have been listed in the first and second column. The third column gives the weight or for some stars the coefficients +1 and −1, which indicate

TABLE 2.

current number	α (1855)	δ (1855)	type	period	m.e. in last decimal place	reciprocal period	J.D. of epoch −2420000	number of observations	m.e. of one observation	brightness at maximum		brightness at minimum	
	h m s	° ′		d		d^{-1}	d		s	s	m	s	m
1 1)	18 33 13·6	− 6 14·5	δ Cep	7·4156	± 6	·134849	8671·54 *	318	±·76	2·3	11·2	7·3	12·0
2	18 33 22·3	− 7 12·2	Algol	1·638566	13	·6102912	8753·391	262	·58	3·9	14·0	6·6	14·7
3	18 34 43·7	− 5 28·5	δ Cep	3·91725	14	·255281	8671·74 *	238	·66	·2	11·4	5·7	12·5
4	18 34 50·4	− 4 28·0	δ Cep	9·9923	5	·100086	8670·16 *	218	·61	·5	13·0	4·3	13·8
5	18 35 23·6	−19 52·8	δ Cep	17·1336	23	·058362	8776·6 *	154	·92	1·4	13·4	8·0	15·0
6	18 36 18·1	− 8 22·7	Algol	1·79524	4	·557028	9015·525	253	·69	3·1	14·5	7·5	15·1
7	18 41 44·5	− 9 58·5	Algol	2·550086	7	·3921436	8671·491	263	·71	2·8	14·5	>7·7	>15·3
8 2)	18 41 49·7	− 9 39·7	Algol	4·192325	17	·238531	8069·626 I 8067·639 II	318	·50	1·3	11·6	5·0	12·1
9	18 44 5·9	− 5 54·8	Algol	16·5347	5	·060479	8777·83	253	·78	3·3	14·6	>9·1	>15·6
10 3)	18 46 35·8	− 6 11·1	Algol	4·95360	6	·2018734	8727·374	320	·70	1·1	10·9	8·3	11·9
11	18 47 12·1	−10 10·8	RR Lyr	·4944679	13	2·022383	8774·294 *	144	·82	1·8	14·5	6·3	15·5
12	18 47 34·4	− 8 44·7	Algol	5·25581	9	·190266	8780·50	255	·66	·6	14·9	>6·6	>15·7
13	18 47 54·4	− 8 3·4	RR Lyr	·4497060	29	2·223675	8755·344 *	173	·75	·8	14·7	5·6	15·7
14 4)	18 47 56·2	− 6 8·9	β Lyr	1·786183	19	·559853	7978·655	302			9·8		10·2
15	18 48 9·8	− 5 42·6	Algol	2·866296	25	·348877	8727·42	220	·74	1·9	14·0	>5·7	>15·4
16	18 49 56·5	− 0 53·2						33		− ·5	10·8	4·5	11·5
17	18 51 ·5	− 6 8·7	δ Cep	15·354	4	·06513	8778·19 *	220	·80	− ·4	14·5	4·4	15·3
18	18 51 33·2	− 7 42·6	Algol	2·544614	14	·392985	8004·755	237	·60	− ·2	14·4	5·4	15·2
19	18 51 37·1	− 9 27·0	Algol	1·008914	9	·991165	9081·293	236	·66	2·0	14·5	4·4	15·0
20 5)	19 00 30·8	− 7 39·5	δ Cep	6·8069	11	·146914	8719·90 *	153	·57	1·1	8·4	4·1	9·3

*) The epochs marked with an asterisk are epochs of maximum, while the others are epochs of minimum.

1) B.D. −6°4830.

2) This Algol variable has an orbital eccentricity >·04.

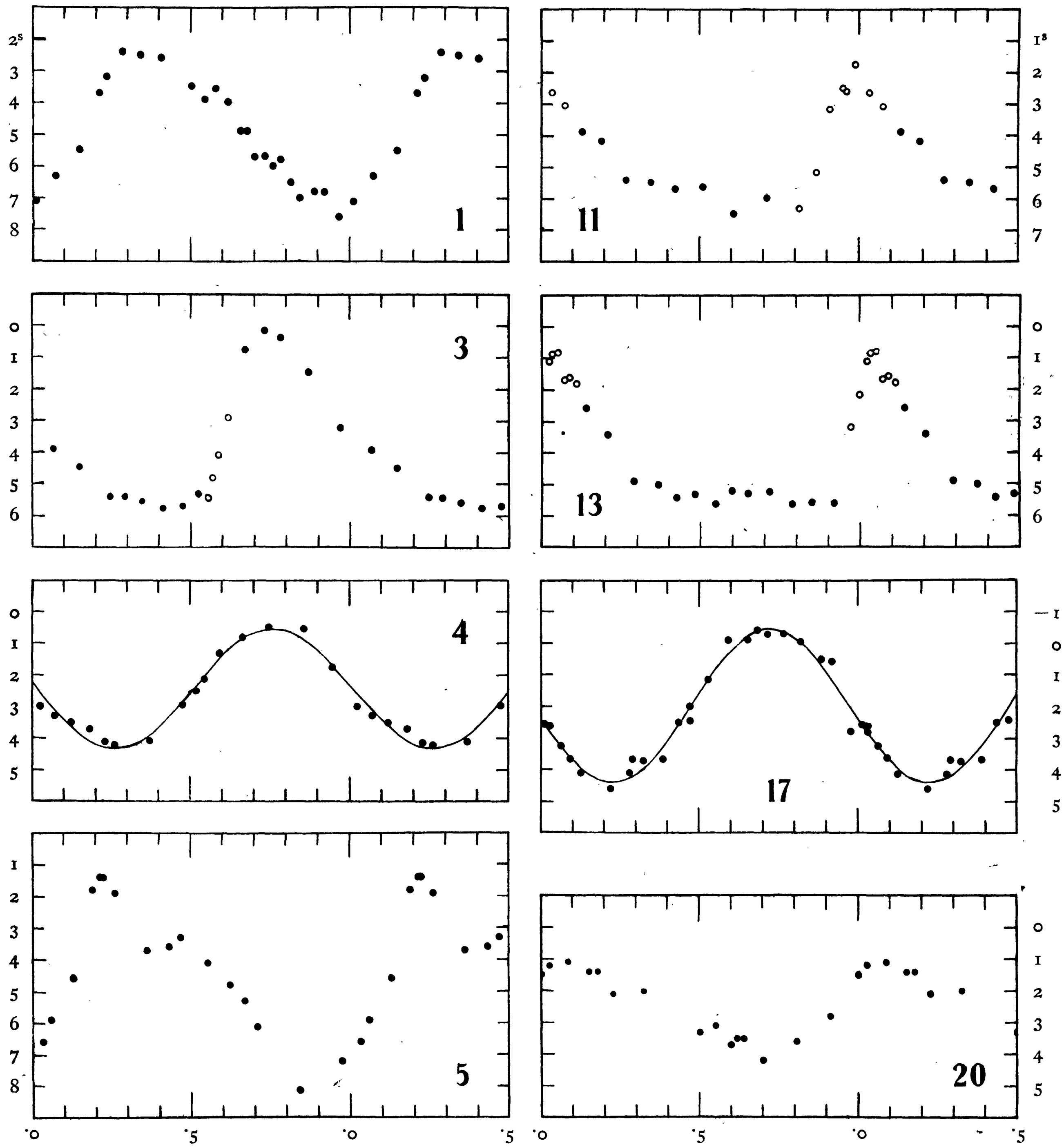
3) B.D. −6°4951.

4) B.D. −6°4965 = H.D. 175447, B9.

5) B.D. −7°4861 = H.D. 178287, G5.

6) *Mt. Wilson Contr.* No. 126.

FIGURE 3.



the rising and descending branch of the light curve respectively. The last two columns show the number of periods elapsed since the first epoch and the residuals (O—C). The variables give rise to the following remarks.

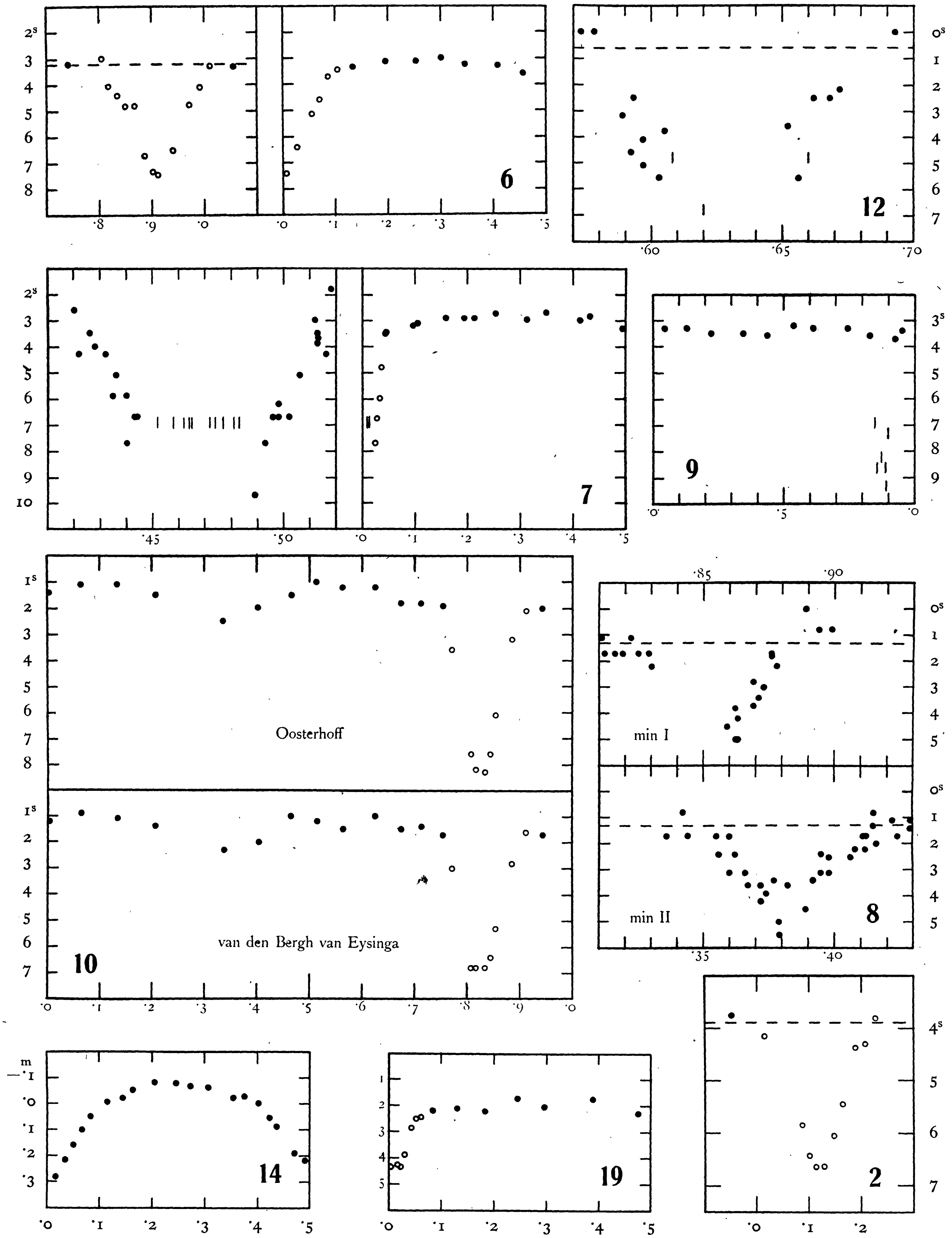
Var. 1: The star does not occur in the H.D. catalogue, but its spectrum was found to be G by SCHALÉN [1]). Five comparison stars have been used; their positions relative to the variable are:

		$\Delta\alpha \cos\delta$	$\Delta\delta$
a	B.D. $-6°4832$	$+103''$	$-347''$
b		$+289$	$+148$
c	B.D. $-6°4828$	$-\ 99$	$+\ 13$
d		$+417$	$-\ 23$
e		$+709$	$+114$

The period has been derived from 43 observations on the rising branch. Observations during the same

[1]) *Medd. Upsala* No. 61.

Figure 4.


6
12
7
9
Oosterhoff
van den Bergh van Eysinga
10
min I
min II
8
14
19
2

night were combined to one normal epoch and weights were assigned proportional to the number of observations. These epochs were then reduced to brightness $4^{s}{\cdot}5$ by means of the adopted slope ${}^{s}{\cdot}1 \mathrel{\hat{=}} {}^{d}{\cdot}036$. The elements for this point on the rising branch, computed by least squares, are:

$$\text{J.D.} + {\cdot}36\,(s - 4{\cdot}5) = 2428069^{d}{\cdot}65 + 7^{d}{\cdot}4156\,(E - 19)$$
$$\pm 4 \qquad \pm 6 \qquad \text{(m.e.)}$$

The variable seems to be faint on the Franklin-Adams Charts 87 and 111. A solution of the period from all the minima yields: $7^{d}{\cdot}4162 \pm {}^{d}{\cdot}0004$ (m.e.), which is in satisfactory accordance with the period given above. There is an indication of a hump on the descending branch of the mean light curve, which is to be expected for a variable with this period.

Var. 2: A provisional period was derived from the observations near minimum. An improved value has been obtained from 16 observations on the rising branch. The observations on the descending branch are few in number and have not been used. The slope of the branch was assumed to be: ${}^{s}{\cdot}1 \mathrel{\hat{=}} {}^{d}{\cdot}0018$. A least squares solution has been made for a point of brightness $5^{s}{\cdot}5$. The resulting elements are:

$$\text{J.D.} + {\cdot}018\,(s - 5{\cdot}5) = 2428671^{d}{\cdot}536 + 1^{d}{\cdot}638566\,(E - 438)$$
$$\pm 5 \qquad \pm 13 \qquad \text{(m.e.)}$$

It seems likely that this period must be doubled, as the fraction of the period occupied by the minimum is ·22. There is no difference in depth between even and odd minima.

Var. 3: The period of this δ Cep-type variable has been derived from 41 observations on the rising branch. Observations of a single night were combined into mean values and these were reduced to brightness $3^{s}{\cdot}0$, the adopted slope being: ${}^{s}{\cdot}1 \mathrel{\hat{=}} {}^{d}{\cdot}0105$. A solution by least squares yields the elements:

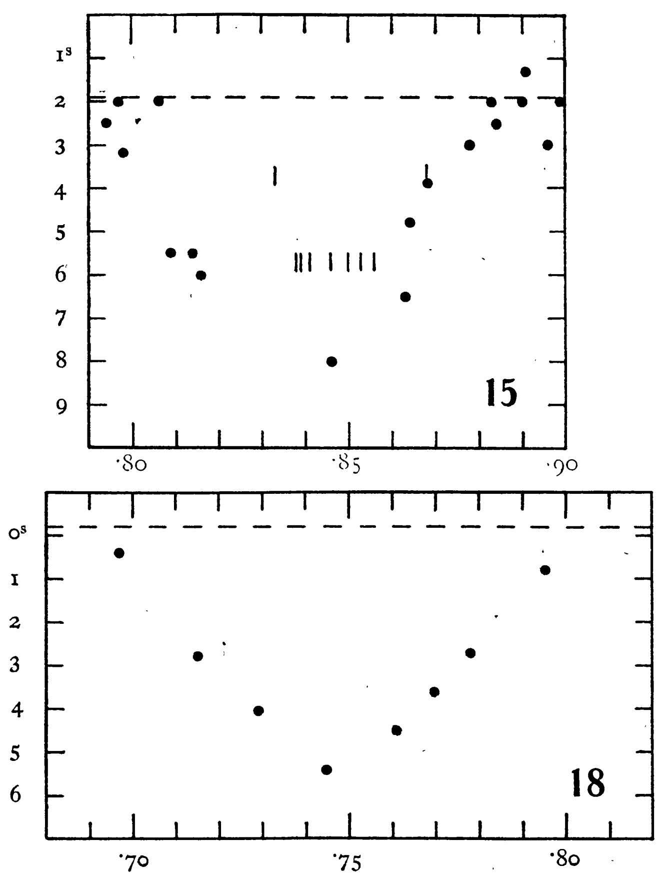
$$\text{J.D.} + {\cdot}105\,(s - 3{\cdot}0) = 2428671^{d}{\cdot}31 + 3^{d}{\cdot}91725\,(E - 190)$$
$$\pm 2 \qquad \pm 14 \qquad \text{(m.e.)}$$

The mean light curve is smooth and shows no special features. The variable is found to be bright on Franklin-Adams Chart 111. A solution of the period from the observed maxima gives: $3^{d}{\cdot}91685 \pm {}^{d}{\cdot}00007$ (m.e.). The epochs used and their residuals are:

J.D.	E	O−C
d		d
2418887·4	0	−·0
2427962·9	2317	+·2
78·5	2321	+·1
8013·8	2330	+·1
8671·5	2498	−·2
8777·3	2525	−·2
8996·5	2581	−·3
9020·5	2587	+·2
9106·5	2609	+·0
9439·5	2694	+·1

The difference between the two periods derived above is: ${}^{d}{\cdot}00040 \pm {}^{d}{\cdot}00016$ (m.e.).

FIGURE 5.



Var. 4: The position of this variable is 5′·7 following and 2′·4 north of TY Sct. The period finally adopted has been computed from 50 observations on the rising branch of the light curve. Observations of the same night were combined into means and weights were assigned proportional to the number of observations. The observations were then reduced to brightness $2^{s}{\cdot}5$ with the adopted slope: ${}^{s}{\cdot}1 \mathrel{\hat{=}} {}^{d}{\cdot}055$. The elements derived by least squares are:

$$\text{J.D.} + {\cdot}55\,(s - 2{\cdot}5) = 2428068^{d}{\cdot}18 + 9^{d}{\cdot}9923\,(E - 14)$$
$$\pm 3 \qquad \pm 5 \qquad \text{(m.e.)}$$

The mean light curve can be well represented by a sine curve, which has been derived by least squares. The resulting formula is:

$$\text{brightness} = 2^{s}{\cdot}42 + 1^{s}{\cdot}89 \sin 2\pi P - {}^{s}{\cdot}15 \cos 2\pi P$$
$$\pm 6 \qquad \pm 9 \qquad \pm 8 \qquad \text{(m.e.)}$$

The residuals (O−C) of the normal points from this sine curve are shown in the fourth column of Table 6. They seem to be slightly systematic, but the epoch of maximum has nevertheless been computed from this formula.

Var. 5: This variable is faint and on many plates estimates were impossible. The period has been computed from 10 observations on the steepest part of the rising branch. These were first reduced to brightness $3^s.5$, the adopted slope being: $^s.1 \mathrel{\hat{=}} {}^d.028$. The elements given by least squares are:

$$\text{J.D.} + .28\,(s - 3.5) = 2429015^d.30 + 17^d.1336(E-65)$$
$$\pm\ 8 \quad \pm\ 23 \ \text{(m.e.)}$$

The mean light curve has only little weight because of the small number of observations and the faintness of the variable. The maximum seems to be very sharp and is followed by a broad shoulder. These features are probably characteristic for variables with periods near 17 days. Variables with similar light curves are: W Vir ($17^d.3$) [1]), V 377 Sgr ($16^d.2$) [2]) and V 383 Sgr ($16^d.4$) [3]).

Var. 6: The period of this Algol variable has been derived from 12 observations near the deepest part of the minimum. The elements determined by least squares are:

$$\text{J.D.} = 2429015^d.530 + 1^d.79524\ (E - 574)$$
$$\pm\ 13 \quad \pm\ 4 \quad \text{(m.e.)}$$

The mean light curve indicates the effect of ellipticity. In order to show this more clearly a reflected light curve has been computed. The phase of primary minimum was found to be .910 and consequently all phases were counted from this value without regard to sign. Although the effect is rather small, it seems to be well established by the new light curve. The fraction of the period covered by the minimum is .2.

Var. 7: This Algol variable becomes invisible during the central part of the eclipse. The period has been determined from 18 observations on the steep descending and rising branches. First these were reduced to brightness $6^s.0$ by means of the adopted slope: $^s.1 \mathrel{\hat{=}} {}^d.00106$. Then a least squares solution has been made, which includes as third unknown the half width of the minimum at brightness $6^s.0$. The resulting elements are:

$$\text{J.D.} + .0106\,(s - 6.0)\,X = 2428671^d.4909 + 2^d.550086\ (E - 292) + {}^d.0808\ X$$
$$\pm\ 15 \quad \pm\ 7 \quad \pm\ 16\ \text{(m.e.)}$$

where X is -1 for the descending and $+1$ for the rising branch. The observations near minimum are shown in the left hand part of the figure. A short line indicates that the variable is invisible, but certainly fainter than $6^s.7$. The phase of minimum is .4696. As the maximum seems to be slightly curved by ellipticity, a reflected light curve has been plotted in the right hand part of the figure. In the present case this light curve has been obtained from the same normal points as before, but with their phase counted from the phase of minimum. These phases are given in the fourth column of Table 6.

Var. 8: This Algol variable is of special importance, as it shows orbital eccentricity. The period derived from 9 minima in a preliminary solution is: $2^d.09616 \pm {}^d.00006$ (m.e.). The epochs used and their residuals (O—C) are:

J.D.	E	O—C
d		d
2427901.95	0	—.04
62.82	29	+.04
83.78	39	+.04
8006.77	50	—.03
69.64	80	—.04
8719.48	390	—.01
80.36	419	+.08
9438.50	733	+.03
57.28	742	—.06

The residuals for the even epochs are all negative, those for the odd epochs being positive. The mean light curve, computed with the double period, shows two minima of nearly equal depth and a constant brightness outside the eclipses. The Julian Day, the phase computed by the formula: phase = $^{d^{-1}}.238531$ (J.D. — 2420000), and the brightness of the individual observations near both minima are given in Table 3.

TABLE 3.
Min. I

J.D.Hel.M.A.T.Gr. —2420000	phase	brightness
d	p	s
7901.9645	.863	4.2
.9645	.863	5.0
.9964	.871	3.4
26.9007	.812	1.7
.9334	.819	1.7
.9334	.819	1.7
.9743	.829	1.7
85.5896	.811	1.1
.6111	.816	1.7
.6360	.822	1.1
8006.7672	.862	3.8
.7672	.862	5.0
69.6407	.859	4.5
8719.5087	.873	3.0
.5305	.878	2.2
9021.4233	.889	.0
50.4995	.825	1.7
.5213	.830	2.2
9109.4807	.894	.8
.5026	.899	.8
9457.3406	.869	3.7
.3406	.869	2.8
.3701	.876	1.7
.3701	.876	1.8

[1]) *H. A.* **80**, 225.
[2]) *B. A. N.* No. 235.
[3]) *B. A. N.* No. 227.

TABLE 3 (*continued*).

Min. II

J.D.Hel.M.A.T.Gr. −2420000	phase	brightness	J.D.Hel.M.A.T.Gr. −2420000	phase	brightness
d	P	s	d	P	s
7962·8162	·379	5·0	8755·3547	·424	1·7
·8995	·398	2·5	80·3648	·389	4·5
·8995	·398	3·1	84·3341	·336	1·7
·9572	·412	1·7	9107·4586	·411	1·7
83·7000	·360	3·1	·4804	·416	2·0
·7244	·366	3·1	11·4151	·355	1·7
·7514	·372	3·6	·4368	·360	1·7
·7514	·372	4·2	9434·3922	·395	2·4
·7778	·379	5·5	·3922	·395	3·1
·8327	·392	3·4	·4393	·406	2·5
·9014	·408	2·2	·4622	·412	2·2
·9292	·415	1·3	38·3603	·342	·8
·9292	·415	·8	·3707	·344	1·7
·9605	·422	1·1	·4229	·356	2·4
8004·7207	·374	3·9	·4458	·362	2·4
42·6820	·429	1·4	·4683	·367	3·6
·6820	·429	1·1	·5099	·377	3·4
67·6812	·392	3·4	·5306	·382	3·6

These observations have been plotted in Figure 4. Only the rising branch has been observed for minimum I and the phase of minimum is therefore somewhat uncertain. The phase of minimum may be taken to be ·856 for minimum I and ·382 for minimum II. Consequently $e \cos \varpi$ equals ·041 and $e >$ ·041. The period has been redetermined for both minima separately. For minimum I 12 observations on the rising branch have been reduced to brightness $3^{s}\cdot0$ with the aid of the adopted slope: $^{s}\cdot1 \mathrel{\hat{=}} {}^{d}\cdot0022$. A least squares solution yields the elements:

$$\text{Min. I:}\quad \text{J.D.} + \cdot022\,(s - 3\cdot0) = 2428719^{d}\cdot497 + 4^{d}\cdot192331\,(E - 195)$$
$$\pm\ 4 \qquad \pm\ 23 \qquad \text{(m.e.)}$$

For minimum II the period has been computed from 18 observations on the descending and rising branches. These observations were also reduced to brightness $3^{s}\cdot0$, the adopted slope being: $^{s}\cdot1 \mathrel{\hat{=}} {}^{d}\cdot0028$. The elements including the half width of the minimum, derived by least squares, are:

$$\text{Min. II:}\quad \text{J.D.} + \cdot028\,(s - 3\cdot0)\ X = 2428780^{d}\cdot330 + 4^{d}\cdot192319\,(E - 195) + {}^{d}\cdot068\ X$$
$$\pm\ 4 \qquad \pm\ 24 \qquad \pm\ 4 \ \text{(m.e.)}$$

The two periods are practically equal and the movement of the line of apsides is too slow to be noticed during the four years covered by the observations. The mean value of the two has been given in Table 2. There is an indication that minimum II is broader than minimum I; their duration is estimated to be $^{P}\cdot071$ and $^{P}\cdot064$ respectively, but more accurate photometric data will be required to confirm this difference.

Var. 9: This star is a faint Algol variable, which is well below the limit of the plate during the central part of the eclipse. The period has been determined from 11 observations on the descending and rising branches of the light curve. They have been reduced to brightness $7^{s}\cdot0$ by means of the adopted slope: $^{s}\cdot1 \mathrel{\hat{=}} {}^{d}\cdot0052$. The elements, including the half width of the minimum at this brightness, were computed by least squares. They are:

$$\text{J.D.} + \cdot052\,(s - 7\cdot0)\ X = 2428777^{d}\cdot83 + 16^{d}\cdot5347\,(E - 53) + {}^{d}\cdot453\ X$$
$$\pm\ 3 \qquad \pm\ 5 \qquad \pm\ 32 \quad \text{(m.e.)}$$

The shape of the minimum is very uncertain, its duration is about $^{P}\cdot08$.

Var. 10: The comparison stars and their positions relative to the variable are:

		$\Delta\alpha \cos\delta$	$\Delta\delta$
a:	B.D. −6°4956	+5′·2	−4′·6
b:		−9·9	−6·9
c:	B.D. −6°4948	−4·4	−4·2
d:		−4·0	+3·0

The variable has been estimated first by Miss H. VAN DEN BERGH VAN EYSINGA, who also derived the period. Later the star has been treated independently by the writer. The final period has been determined from 31 observations on the descending and rising branches of the primary minimum. These were reduced to brightness $6^{s}\cdot0$ with the adopted slope: $^{s}\cdot1 \mathrel{\hat{=}} {}^{d}\cdot0043$. A least squares solution, including the half width of the minimum as a third unknown, yields the elements:

$$\text{J.D.} + \cdot043\,(s - 6\cdot0)\ X = 2428043^{d}\cdot778 + 4^{d}\cdot95360\,(E - 23) + {}^{d}\cdot147\ X$$
$$\pm\ 5 \qquad \pm\ 6 \qquad \pm\ 5 \ \text{(m.e.)}$$

The mean light curves, computed with the estimates by Miss VAN DEN BERGH VAN EYSINGA and by the writer, are given in Table 6 and Figure 4. The number of observations and the mean phase of the normal points are the same for both series of estimates, with the exception of the normal points 4, 6, 7 and 8. For these the number of estimates by Miss VAN DEN BERGH VAN EYSINGA is slightly smaller. The correct values have not been added in Table 6, as the differences are unimportant. The secondary minimum, which is well established by the mean light curves, seems to be mainly due to the ellipticity of the components. Some data about the light variation are:

	Oo.	v. d. B. v. E.
	s	s
maximum	1·1	1·0
minimum I	8·3	6·9
minimum II	2·5	2·3
amplitude I	7·2	5·9
amplitude II	1·4	1·3
mean error of single estimate	± ·70	± ·60

Var. 11: The variable is very faint. Estimates on the Mount Wilson 10-inch plates were only possible when the variable is near maximum. These estimates have been used for the determination of the period only. The period has been derived from 30 observations on the rising branch. These were first reduced to brightness 4^{s}·0, the adopted slope being: ^{s}·1 $\widehat{=}$ ^{d}·00144. The resulting elements are:

$$\text{J.D.} + \cdot 0144\ (s - 4\cdot 0) = 2429017^{d}\cdot 530 + {}^{d}\cdot 4944679\ (E - 2254)$$
$$\pm\ 2 \quad \pm\ 13 \quad \text{(m.e.)}$$

Although the light curve is of low weight, it is evident that the variable belongs to BAILEY's subclass *a*.

Var. 12: This variable is very faint and is invisible on the plates during the central part of the eclipse. The period has been derived from 12 observations on the descending and rising branches of the light curve. They were reduced to brightness 3^{s}·7 with the aid of the adopted slope: ^{s}·1 $\widehat{=}$ ^{d}·0027. The elements, including the width of the minimum, are:

$$\text{J.D.} + \cdot 027\ (s - 3\cdot 7)\ X = 2428780^{d}\cdot 499 + 5^{d}\cdot 25581\ (E - 167) + {}^{d}\cdot 181\ X$$
$$\pm\ 10 \quad \pm\ 9 \quad \pm\ 10$$

The number of observations near minimum is so small, that the individual observations have been given in Table 6. The minimum occupies about one tenth of the period. On Franklin-Adams Chart 87 comparison star *a* is visible, but no trace of the variable can be seen. Therefore it seems likely that this chart has been taken during minimum. Its Julian Day is 2418915^{d}·293, and the phase, calculated with the reciprocal period from Table 2, is ·617, which is within the deepest part of the minimum. Hence no correction is needed to the period derived above.

Var. 13: This RR Lyr-type variable is very faint and during minimum estimates could be made on a small number of plates only. The period has been derived from 15 epochs of maximum, the elements being:

$$\text{J.D.} = 2428755^{d}\cdot 350 + {}^{d}\cdot 4497060\ (E - 1712)$$
$$\pm\ 4 \quad \pm\ 29 \quad \text{(m.e.)}$$

The light curve belongs to BAILEY's subclass *a*.

Var. 14: This bright variable is B.D. −6°4965 and H.D. 175447, spectrum B9. As the range of the light variation is small, only one comparison star has been used, namely: B.D. −6°4959 = H.D. 175357, spectrum A0. From the estimates no satisfactory period could be found. Therefore the variable and the comparison star have been measured on all the plates in the Schilt microphotometer. The galvanometer readings have been turned into differences of provisional magnitudes by means of WESSELINK's table in *B.A.N.* No. 318. Differences in gradation could not be taken into account, but this did not seem serious, as the difference between variable and comparison star is never larger than ^{m}·3. The individual measures are given in Table 4.

TABLE 4.

J.D.hel. −2420000	m_{pg}	J.D.hel. −2420000	m_{pg}	J.D.hel. −2420000	m_{pg}	J.D.hel. −2420000	m_{pg}	J.D.hel. −2420000	m_{pg}	J.D.hel. −2420000	m_{pg}
M.W. Ross 5″											
d	m	d	m	d	m	d	m	d	m	d	m
7901·9645	·18	7962·8995	−·06	7991·7757	−·06	8043·6715	·00	7926·9007	·32	7928·9127	−·06
02·9764	−·06	63·8780	−·07	8006·7672	−·04	44·7991	·26	·9334	·20	·9440	−·11
26·9334	·30	75·7256	−·04	12·7302	·08	64·6815	−·01	·9743	·09	29·8142	−·06
27·9543	·02	77·7452	·29	13·7166	·00			27·8675	·07	·8982	−·09
28·9440	−·06	78·7452	·22	·7412	−·02	M.W. Cook 10″		·9015	·02	·9239	−·06
29·9538	−·06	83·7514	·00	14·8530	−·09			·9265	−·04	·9538	·03
32·8714	·04	·9292	·28	15·7418	−·06	7901·9645	·13	·9543	−·03	·9795	−·08
53·9151	−·03	84·7473	·04	38·7434	−·01	·9964	—	·9800	−·02	32·8714	−·03
57·8903	−·02	·9257	·30	41·7175	−·06	02·9479	−·01	28·8579	−·01	·9005	−·03
60·9210	·14	89·7285	−·03	42·6820	·00	·9764	−·03	·8863	−·11	53·8047	·06

TABLE 4 (*continued*).

J.D.hel. −2420000	m_{pg}	J.D.hel. −2420000	m_{pg}	J.D.hel. −2420000	m_{pg}	J.D.hel. −2420000	m_{pg}	J.D.hel. −2420000	m_{pg}	J.D.hel. −2420000	m_{pg}
d	m	d	m	d	m	d	m	d	m	d	m
7953·8311	·00	8013·7912	−·06	7985·5245	−·10	8776·3479	−·16	9084·5166	−·04	9409·4677	·22
·9151	−·02	·8384	−·10	·5460	−·04	77·3219	−·16	97·2591	−·08	·4677	·13
·9408	−·04	·8801	−·14	·5681	−·07	·3437	−·10	·2809	−·14	10·4426	·04
57·7535	−·10	14·8530	−·08	·5896	−·01	78·4233	—	9100·3027	·10	·4426	−·01
·7792	−·10	15·6981	−·14	·6111	−·06	·4455	—	04·4136	−·14	·4671	·03
·8903	−·04	·7418	−·06	·6360	−·03	79·3346	−·12	·4354	−·12	·4671	·04
·9577	·02	·7856	−·12	88·2691	−·03	80·3648	−·19	06·4939	·04	27·4454	−·01
60·9210	·08	·8251	−·12	·2905	−·08	84·3341	·04	·5154	·08	·4454	·10
62·8162	−·01	38·7434	·02	·3120	−·08	88·3293	—	07·4586	·30	·4700	−·03
·8995	−·04	41·7175	−·06	·3335	−·06	·3518	—	·4804	·17	·4700	·00
·9572	−·09	42·6820	·00	·3549	·02	8815·3434	−·05	08·4624	·21	29·4604	−·05
63·8211	−·07	·7639	−·06	·3764	·02	17·3180	—	·4842	—	·4604	−·06
·8780	−·10	43·6715	·01	·3979	·11	19·3225	—	09·4807	−·07	·4850	−·06
·9551	−·10	·7256	·04	·4193	·14	33·2903	—	·5026	−·01	·4850	−·02
75·7256	−·02	44·7991	·16	·4408	·18	36·2829	—	11·4151	—	30·4345	−·04
77·7452	·18	64·6815	−·08	·4630	·08	8996·5118	·01	·4368	—	·4345	−·06
78·7139	·24	67·6812	−·04	·4844	·12	·5312	−·10	36·3624	−·13	31·4342	−·02
·7452	·14	69·6407	·11	·5059	·08	9015·5070	·20	·3840	−·16	·4342	−·04
83·7000	−·05	75·7186	−·03	·5274	·13	·5288	·24	41·3134	−·01	·5277	·00
·7244	−·08	81·6770	·00	·5488	·06	17·5575	−·06	·3413	·06	·5277	·02
·7514	·01	Franklin-Adams		·5703	−·04	·5796	−·10	63·3357	—	33·3740	−·02
·7778	·00			·5918	−·05	20·4983	−·14	·3579	—	·3740	·04
·8327	−·02	7978·2915	−·16	·6153	−·06	·5205	−·22	9397·5402	−·06	34·3922	·28
·9014	·10	79·3123	−·12	·6337	·05	21·4233	—	9407·4499	−·02	·3922	·34
·9292	·18	·3338	−·11	8668·5546	−·14	43·4860	−·16	·4738	·01	35·4144	·04
·9605	·25	84·2703	−·08	·5774	−·16	·5092	−·08	10·4969	−·04	·4144	·07
84·6966	−·04	·2918	−·13	71·5390	−·02	45·4599	−·15	·5215	−·09	37·4175	·00
·7209	−·02	·3132	−·12	·5639	·00	·4893	−·08	31·4758	−·02	·4175	−·02
·7473	·00	·3347	−·15	8719·5087	−·15	49·4125	·11	·4982	−·01	38·3603	−·08
·7737	·08	·3562	−·17	·5305	−·15	·4343	·12	34·4393	·18	·3707	−·12
·8299	·14	·3776	−·18	27·4653	−·26	50·4995	·00	·4622	·10	·5099	−·06
·8994	·20	·4476	−·16	·4868	−·21	·5213	−·10	38·4229	−·14	·5306	−·02
·9257	·23	·4690	−·21	29·4931	−·16	72·4257	−·12	·4458	−·14	39·3939	−·06
·9507	·24	·4905	−·14	·5153	−·14	·4478	—	·4683	−·12	·4043	−·06
·9744	·12	·5120	−·11	45·4316	−·18	74·3365	·12	39·4514	−·10	·5255	−·02
89·7285	−·08	·5335	−·12	·4534	−·24	·3591	·10	·4742	−·10	·5463	−·02
91·7758	·00	85·2530	−·12	50·3475	·14	·5238	·12	·4971	−·10	57·3406	·01
·9091	·08	·2745	−·14	53·3415	−·15	·5491	·06	Rockefeller		·3406	·00
8004·7207	−·08	·2960	−·18	·3633	−·13	77·2919	·06	double astrograph		·3701	—
06·7672	−·08	·3174	−·16	55·3547	−·13	·3134	−·10			·3701	—
12·7031	·12	·3389	−·22	60·4113	—	78·4457	−·10	9399·5463	·32	·3957	·00
·7302	·10	·3604	−·19	·4332	—	·4880	−·17	·5463	—	·3957	·01
·8309	·02	·4310	−·14	72·4391	−·12	81·3115	−·04	9407·4156	·00	·4244	—
13·6919	−·11	·4525	−·14	·4616	—	82·4691	·12	·4156	−·04	·4244	—
·7166	−·04	·4739	−·14	74·3275	·06	·4909	·20	09·4435	·28	·4508	—
·7412	−·01	·5023	−·20	·3494	·14	84·4948	−·14	·4435	·22	·4508	—

The Ross 5-inch plates, which were taken simultaneously with the Cook 10-inch plates, show a considerably larger gradation than the latter. They have been reduced to the Cook 10-inch plates by means of the formula:

$$m_{10}'' = -{}^{m}\cdot014 + \cdot75\, m_5''.$$

From the measures the period could be derived easily and phases were computed with the provisional formula: phase $= {}^{d-1}\cdot559884$ (J.D.−2420000). From a shift between the light curves, thus obtained for the Cook plates and for the Rockefeller plates, an improved value of the period has been derived, which is given in Table 2. Its mean error has been estimated. The measures on the Ross 5-inch, the Cook 10-inch and the Rockefeller astrograph plates were then combined into a mean reflected light curve, which has been tabulated in Table 6. From the differences in brightness between observations following each other in phase, the mean error of a single measure was found to be $\pm\,{}^{m}\cdot035$. The same has been done for the measures on the Franklin-Adams plates. This reflected light curve is given in the same table and the mean error of a single measure is $\pm\,{}^{m}\cdot053$. The two light curves are very similar, but the variable is systematically ${}^{m}\cdot07$ brighter at all phases on the Franklin-Adams plates. The cause of this effect is not clear. A final mean light curve has been computed from all measures, after a reduction of $+\,{}^{m}\cdot07$ was applied to the measures on the Franklin-Adams plates. To these the relative weight 1 has been assigned as against weight 2 to the other measures. The weight of each normal point is given in the last column of Table 6. The light curve, which belongs to the β Lyrae-type, is shown in Figure 4.

brightness at maximum : $-^{m}.08$
,, ,, primary minimum : $+.30$
,, ,, secondary minimum: $+.22$

Var. 15: The variable is the faintest star of a group of four. The most northern of these is B.D. $-5°4810$. The position of the variable relative to this star is: $\Delta\alpha \cos\delta = +15''$, $\Delta\delta = -27''$. The variable is difficult to estimate and during the central part of the eclipse it is invisible on the plates. The period has been derived from 8 observations on the descending and rising branches of the light curve. These were first reduced to brightness $5^{s}.0$ by means of the adopted slope: $^{s}.1 \triangleq {}^{d}.00126$. The following elements, including the half width of the minimum, have been derived by least squares:

$$\text{J.D.} + .0126\,(s - 5.0)\,X = 2428727^{d}.418 + 2^{d}.866296(E - 288) + {}^{d}.077\,X$$
$$\pm 5 \quad \pm 25 \quad \pm 5 \text{ (m.e.)}$$

The observations near minimum are shown in Figure 5. The phases used there have been computed according to the formula: phase $= {}^{d^{-1}}.348882$ (J.D. -2420000).

Var. 16: This variable is situated at the very edge of the Ross 5-inch plates and therefore only 33 estimates are available. They are given in Table 5. The Julian Days of these plates can be found in Table 4. The variable belongs to the δ Cep- or RR Lyr-class, but the period could not be determined.

TABLE 5.

plate	brightness	plate	brightness	plate	brightness	plate	brightness
1	^{s}4.2	10	^{s}4.2	19	^{s}4.7	28	^{s}3.7
2	−.5	11	.0	20	.0	29	4.2
3	.0	12	3.1	21	4.2	30	4.7
4	3.3	13	3.7	22	3.7	31	.5
5	3.7	14	−1.0	23	4.7	32	4.2
6	−1.0	15	3.2	24	−1.0	33	1.4
7	−.5	16	.9	25	.0		
8	−.5	17	.5	26	4.2		
9	4.2	18	3.7	27	4.7		

Var. 17: A provisional period has been derived for this variable from the maxima and the minima. As the light curve closely resembles a sine curve, both epochs are about equally good. The period given in Table 2 has been obtained in a graphical way from the observations on the rising branch. Its mean error has been estimated. The variable is faint on Franklin-Adams Chart 111, the J.D. of which is: $2418887^{d}.4$. The combination of this epoch with the minima observed by the writer yields the period: $15^{d}.3461 \pm {}^{d}.0017$ (m.e.), but the number of periods elapsed during the large time interval must be considered somewhat uncertain. The following sine curve through the normal points of the mean light curve has been computed by least squares:

$$\text{brightness} = 1^{s}.98 + 2^{s}.40 \sin 2\pi P + {}^{s}.40 \cos 2\pi P$$
$$\pm 7 \quad \pm 10 \quad \pm 10 \quad \text{(m.e.)}$$

This curve has been drawn in Figure 3 and the residuals from this formula are given in the fourth column of Table 6. The mean epoch of maximum in Table 2 has been derived from this formula.

Var. 18: This star is a faint Algol variable. The period has been determined from 28 observations on the descending and rising branches of the light curve. They were first reduced to brightness $3^{s}.0$ with the adopted slope: $^{s}.1 \triangleq {}^{d}.00212$. A least squares solution gives the following elements, which include the half width of the minimum:

$$\text{J.D.} + .0212\,(s - 3.0)\,X = 2428671^{d}.443 + 2^{d}.544614\,(E - 302) + {}^{d}.0726\,X$$
$$\pm 3 \quad \pm 14 \quad \pm 34 \text{ (m.e.)}$$

The minimum occupies about .11 of the period. There is no secondary minimum.

Var. 19: This star is also a faint Algol variable. The period, which has been derived from the observations near minimum, is very close to one day. The elements of minimum are:

$$\text{J.D.} = 2429081^{d}.293 + 1^{d}.008914\,(E - 1059)$$
$$\pm 6 \quad \pm 9 \quad \text{(m.e.)}$$

A mean light curve is given in Table 6. The phase of minimum was found to be $^{P}.06$. The normal points show a considerable dispersion and the observations seem to be of low weight. A reflected mean light curve is shown in Figure 4. Primary minimum covers about .15 of the period. The light curve does not give any positive information about a secondary minimum.

Var. 20: This is the brightest star of the present list. According to the H.D. catalogue (178287) its spectrum is G5. Estimates are very difficult, as the image is overexposed and as the neighbouring stars of similar brightness are of early spectral type. The following comparison stars have been used:

a: B.D. $-7°4865$ = H.D. 178409 A0
b: 4864 = 178408 A5
c: 4857 = 178133 G0

The photographic images are considerably distorted, due to the fact that the variable is situated near the edge of the plates. Satisfactory estimates could therefore be made on the Franklin-Adams plates only. The star proved to be a δ Cep-type variable. The period has been derived from 40 observations on the ascending branch of the light curve. Observations of the same night were combined into means, which have been reduced to brightness $2^{s}{\cdot}0$ with the adopted slope: $^{s}{\cdot}1 \mathrel{\widehat{=}} {}^{d}{\cdot}056$. Weights have been assigned proportional to the number of observations and a solution by least squares gave the elements:

$$\text{J.D.} + {\cdot}56\,(s - 2{\cdot}0) = 2428719^{d}{\cdot}21 + 6^{d}{\cdot}8069\,(\text{E} - 108)$$
$$\pm\,7 \qquad \pm\,11 \qquad (\text{m.e.})$$

The mean light curve, though of small weight, shows the usual asymmetry, $M - m$ being $^{P}{\cdot}32$ or $2^{d}{\cdot}2$. Improved photometric observations may well show a hump on the descending branch, which usually sets in for periods between 6 and 7 days. The variable is faint on Franklin-Adams Chart 87, but the number of periods elapsed between J.D. 2418915·3 and the minima of the present observations cannot be determined unambiguously.

TABLE 6.

1

	P	s
14	·014	7·1
14	·076	6·3
14	·150	5·5
14	·213	3·7
14	·236	3·2
14	·285	2·4
13	·342	2·5
13	·406	2·6
13	·501	3·5
13	·546	3·9
14	·579	3·6
14	·617	4·0
14	·657	4·9
14	·682	4·9
14	·702	5·7
14	·735	5·7
14	·760	6·0
14	·782	5·8
14	·816	6·5
14	·841	7·0
14	·887	6·8
14	·922	6·8
14	·969	7·6

2

	P	s
6	·0137	4·15
6	·0778	5·85
6	·1008	6·43
6	·1122	6·63
6	·1293	6·63
6	·1480	6·05
6	·1643	5·45
6	·1887	4·37
6	·2070	4·30
6	·2283	3·80
25	·2844	3·88
25	·3516	3·96
25	·4247	4·05
26	·5067	3·94
26	·6165	3·73
25	·7466	3·88
25	·8316	3·87
25	·9505	3·76

3

	P	s
19	·0682	3·92
19	·1447	4·48
19	·2452	5·43
19	·2928	5·42
19	·3469	5·57
20	·4166	5·76
20	·4783	5·70
20	·5210	5·32
6	·5570	5·45
6	·5678	4·82
6	·5850	4·08
6	·6188	2·93
10	·6769	·76
10	·7330	·18
10	·7810	·39
10	·8724	1·45
19	·9699	3·22

4

	P	s	s
15	·0227	3·00	+·46
15	·0707	3·28	+·18
15	·1223	3·51	−·12
15	·1813	3·71	−·36
15	·2273	4·14	−·13
15	·2600	4·21	−·11
14	·3706	4·07	+·17
15	·4761	2·96	+·11
15	·5191	2·51	+·17
14	·5430	2·14	+·09
14	·5922	1·33	−·17
14	·6644	·80	−·07
14	·7459	·48	−·05
14	·8577	·54	−·31
14	·9445	1·77	+·13

5

	P	s
10	·034	6·6
10	·058	5·9
9	·127	4·6
10	·192	1·8
10	·214	1·4
10	·223	1·4
10	·261	1·9
10	·362	3·7
10	·432	3·6
10	·467	3·3
10	·555	4·1
9	·621	4·8
9	·666	5·3
9	·710	6·1
9	·840	8·1
9	·974	7·2

6

	P	s
4	·0108	3·32
26	·0558	3·31
26	·1607	3·09
26	·2454	3·12
25	·3554	3·35
25	·4746	3·50
25	·5580	3·28
26	·6415	3·08
26	·7418	3·20
4	·8042	3·00
4	·8178	4·05
4	·8330	4·42
4	·8495	4·82
4	·8668	4·82
4	·8860	6·72
4	·9020	7·35
4	·9122	7·45
4	·9400	6·48
4	·9715	4·75
4	·9922	4·10

reflected light curve

	P	s
8	·0061	7·41
8	·0255	6·40
8	·0522	5·14
8	·0694	4·60
8	·0881	3·71
8	·1029	3·45
29	·1313	3·38
29	·1940	3·14
30	·2512	3·13
30	·3000	2·97
29	·3474	3·23
29	·4081	3·26
29	·4570	3·57

7

	P	s	P
21	·0392	2·83	·4304
21	·1198	2·67	·3498
21	·2172	2·72	·2524
21	·2761	2·91	·1935
21	·3646	3·12	·1050
3	·4227	3·47	·0469
4	·4328	4·82	·0368
4	·4418	6·75	·0278
4	·4565	>6·7	·0131
3	·4703	>6·7	·0007
4	·4795	>6·7	·0099
4	·4940	7·70	·0244
3	·5020	6·00	·0324
4	·5128	3·52	·0432
23	·5668	3·20	·0972
23	·6281	2·93	·1585
23	·6813	2·92	·2117
23	·7821	2·97	·3125
23	·8821	2·99	·4125
10	·9768	3·28	·4928

8

	P	s
21	·0239	1·43
21	·1460	1·29
21	·2307	1·39
22	·3028	1·30
5	·3586	2·26
5	·3702	3·68
5	·3812	4·40
5	·3944	3·08
5	·4070	2·22
22	·4369	1·30
21	·4833	1·50
21	·5163	1·47
21	·5579	1·14
21	·6253	1·29
21	·6721	1·33
21	·7196	·96
22	·7875	1·32
4	·8265	1·68
4	·8615	4·58
4	·8680	3·52
4	·8758	2·18
22	·9360	1·10

9

	P	s
22	·0444	3·3
22	·1322	3·3
22	·2206	3·5
22	·3459	3·5
22	·4373	3·6
22	·5390	3·2
22	·6144	3·3
22	·7439	3·3
10	·8272	3·6
5	·8478	>6·7
5	·8576	>8·4
5	·8736	>8·0
5	·8860	>8·4
5	·8916	>9·1
5	·8982	>7·1
5	·9108	4·9
10	·9246	3·7
22	·9510	3·4

10

		Oo.	v.d.B.v.E.
	P	s	s
20	·0027	1·4	1·2
20	·0637	1·1	·9
20	·1320	1·1	1·1
20	·2072	1·5	1·4
20	·3356	2·5	2·3
20	·4014	2·0	2·0
20	·4669	1·5	1·0
20	·5123	1·0	1·2
20	·5640	1·2	1·5
20	·6251	1·2	1·0
20	·6744	1·8	1·5
20	·7120	1·8	1·4
11	·7527	1·9	1·7
6	·7707	3·6	3·0

TABLE 6 (*continued*).

	P	s	s
6	·8072	7·6	6·8
6	·8160	8·2	6·8
6	·8322	8·3	6·8
6	·8427	7·6	6·4
6	·8527	6·1	5·3
6	·8850	3·2	2·8
7	·9104	2·1	1·6
20	·9412	2·0	1·7

11

	P	s
6	·0342	2·65
6	·0762	3·07
12	·1305	3·88
12	·1913	4·18
12	·2650	5·43
12	·3461	5·48
12	·4231	5·68
12	·5117	5·63
12	·6068	6·47
12	·7128	5·97
6	·8140	6·30
6	·8665	5·17
6	·9085	3·17
6	·9507	2·50
6	·9622	2·63
6	·9885	1·78

12

	P	s
18	·0349	·74
18	·0797	·59
17	·1357	·58
18	·2143	·43
18	·2683	·56
18	·3262	·37
18	·3749	·67
18	·4469	·67
18	·5069	·87
1	·563	·0
1	·569	·5
1	·573	·0
1	·578	·0
1	·589	3·2
1	·592	4·6
1	·593	2·5
1	·597	4·1
1	·597	5·1
1	·603	5·6
1	·605	3·8
1	·608	>4·6
1	·620	>6·6
1	·620	>6·6
1	·652	3·6 :
1	·656	5·6
1	·660	>4·6
1	·662	2·5
1	·668	2·5
1	·668	2·5
1	·672	2·2
1	·693	·0
18	·7567	·79
18	·8479	·64
18	·9216	·47
18	·9812	·38

13

	P	s
5	·0212	1·12
5	·0334	·86
5	·0506	·80
5	·0714	1·66
5	·0908	1·58
5	·1118	1·80

	P	s
10	·1408	2·59
10	·2053	3·41
10	·2921	4·90
10	·3667	5·02
10	·4224	5·41
10	·4818	5·32
10	·5491	5·62
10	·5988	5·20
10	·6471	5·29
11	·7162	5·23
11	·7854	5·65
11	·8470	5·57
10	·9197	5·60
5	·9694	3·22
5	·9986	2·18

14

Ross 5″, Cook 10″ and Rockefeller Astr. reflected light curve

	P	m
3	·0093	·313
6	·0305	·222
6	·0447	·190
6	·0582	·123
6	·0705	·090
6	·1013	·017
12	·1228	−·011
12	·1516	−·029
12	·1781	−·063
12	·2238	−·075
12	·2623	−·065
12	·3009	−·072
12	·3418	−·029
12	·3681	−·023
12	·3903	−·012
6	·4065	−·013
6	·4182	·030
5	·4304	·052
3	·4650	·167
3	·4897	·233
3	·4917	·213

Franklin-Adams reflected light curve

	P	m
4	·0228	·168
4	·0375	·160
6	·0707	·028
6	·0872	−·047
10	·1203	−·070
10	·1502	−·105
10	·1738	−·142
10	·2255	−·174
10	·2568	−·153
10	·2737	−·124
10	·3004	−·151
10	·3673	−·087
10	·4042	−·045
7	·4319	·021
6	·4587	·060
6	·4733	·153
6	·4887	·140

all observations reflected light curve

	P	m	
8	·0172	·282	12
10	·0342	·216	17
9	·0494	·160	16
9	·0664	·103	16
13	·0822	·052	16

	P	m	
19	·1138	−·004	33
21	·1436	−·021	32
21	·1634	−·054	32
21	·2042	−·081	33
23	·2470	−·079	33
23	·2718	−·065	32
20	·3068	−·061	33
20	·3542	−·023	33
19	·3764	−·028	32
19	·4016	−·004	34
11	·4220	·054	16
12	·4376	·085	17
14	·4705	·193	16
10	·4911	·218	16

15

	P	s
19	·0462	1·94
18	·1205	1·72
18	·2219	1·78
11	·3032	2·10
20	·3884	1·80
21	·4851	1·81
20	·5565	1·92
21	·6431	2·08
6	·7395	1·83
3	·7577	3·57
3	·7703	4·50
5	·7974	>5·60
5	·8122	>5·70
3	·8253	>4·07
3	·8387	2·50
6	·8540	2·10
19	·8894	1·93
19	·9634	1·81

17

	P	s	s
10	·0106	2·56	+·02
10	·0282	2·61	−·19
10	·0615	3·24	−·02
10	·0908	3·64	+·04
10	·1248	4·13	+·17
10	·2189	4·60	+·20
10	·2793	4·12	−·13
10	·2888	3·67	−·53
10	·3223	3·74	−·22
10	·3855	3·66	+·40
10	·4360	2·49	−·06
10	·4732	2·43	+·44
10	·5266	1·16	−·02
10	·5924	− ·11	−·44
10	·6528	− ·10	+·11
10	·6839	− ·42	−·04
10	·7157	− ·27	+·18
10	·7643	− ·29	+·09
10	·8183	− ·05	−·01
10	·8842	·48	−·21
10	·9172	·56	−·56
10	·9760	2·78	+·77

18

	P	s
14	·0724	− ·26
14	·1279	− ·27
14	·1689	·02
14	·2131	− ·36
15	·2851	− ·31
14	·3251	− ·06
14	·3619	− ·21
14	·4379	− ·16
14	·5324	− ·01
14	·5761	− ·31

	P	s
14	·6410	− ·41
5	·6972	·40
5	·7154	2·80
5	·7288	4·04
5	·7448	5·40
5	·7608	4·50
5	·7696	3·60
5	·7780	2·74
5	·7954	·82
14	·8628	− ·01
14	·9301	·02
14	·9757	− ·26

19

	P	s
4	·0058	2·2
4	·0162	2·7
4	·0295	3·8
4	·0378	4·2
4	·0395	4·6
4	·0542	4·5
4	·0675	4·0
4	·0842	4·1
4	·1055	2·9
4	·1200	2·6
16	·1541	2·0
16	·2029	2·1
16	·2834	2·0
16	·3521	2·0
16	·4415	1·6
16	·5679	2·3
16	·6886	1·9
16	·7793	2·2
16	·8223	1·4
16	·8815	2·4
16	·9231	2·2
16	·9754	2·3
4	·9980	2·6

reflected light curve

	P	s
6	·0043	4·35
6	·0182	4·25
6	·0220	4·35
6	·0303	3·87
6	·0435	2·85
6	·0518	2·52
6	·0603	2·45
30	·0846	2·22
30	·1302	2·12
30	·1834	2·23
30	·2441	1·73
30	·2962	2·04
30	·3885	1·75
14	·4761	2·31

20

	P	s
10	·001	1·5
10	·026	1·2
11	·086	1·1
11	·156	1·4
11	·180	1·4
10	·224	2·1
10	·327	2·0
10	·502	3·3
10	·553	3·1
10	·599	3·7
10	·620	3·5
10	·638	3·5
10	·700	4·2
10	·804	3·6
10	·916	2·8

TABLE 7.

1

rising branch 4^{s}·5

d	s			d
7928·91	4·1	5	0	+·02
57·91	5·5	3	4	—·15
88·45	3·5	18	8	+·01
8069·64	4·0	1	19	—·19
8729·50	5·6	2	108	+·26
74·34	3·8	2	114	—·05
88·34	6·1	2	116	—·05
8833·29	6·6	1	122	+·59
8996·52	4·9	2	144	+·06
9077·30	6·3	2	155	—·23
9100·30	5·2	1	158	+·13
07·47	5·2	2	159	—·12
9433·37	6·4	2	203	—·08

2

rising branch 5^{s}·5

d	s		d
7953·805	7·5	0	—·003
·831	6·0	0	—·004
84·951	6·0	19	—·017
88·269	4·9	21	+·004
·290	5·9	21	+·043
8012·831	4·9	36	—·035
8671·539	6·3	438	+·017
·564	3·5	438	—·010
9020·520	6·8	651	—·008
43·486	5·7	665	—·001
·509	4·9	665	+·007
84·495	4·9	690	+·029
9410·522	6·0	889	+·002
38·360	6·4	906	—·009
·371	5·2	906	—·019
·423	3·5	906	+·002

3

rising branch 3^{s}·0

d	s			d
7926·936	2·7	3	0	—·13
77·745	3·8	1	13	—·12
78·292	·0	1	13	+·03
85·601	5·4	4	15	+·06
89·728	2·2	1	16	—·07
8013·704	·0	2	22	+·18
44·799	·8	1	30	+·02
75·719	5·0	1	38	+·04
8671·552	·6	2	190	—·01
8745·442	5·6	2	209	—·02
53·352	5·0	2	211	—·01
77·333	·7	2	217	+·02
8996·522	·7	2	273	—·16
9043·498	2·9	2	285	+·04
74·536	5·0	2	293	—·04
78·467	4·2	2	294	—·11
82·480	4·6	2	295	+·03
9106·504	1·0	2	301	+·17
9141·327	3·4	2	310	—·01
9407·462	5·4	2	378	—·04
31·487	1·4	2	384	+·06
39·451	·0	1	386	+·05

4

rising branch 2^{s}·5

d	s			d
7927·93	2·7	5	0	—·25
28·90	1·4	4	0	+·01
57·84	3·0	4	3	—·14
77·75	3·2	1	5	—·12
7978·58	2·0	3	5	+·05
88·43	2·3	16	6	+·08
8038·74	2·0	1	11	+·26
67·68	3·9	1	14	+·27
8727·48	2·6	2	80	—·13
77·33	3·4	2	85	+·20
9017·57	2·2	2	109	—·04
77·30	2·5	2	115	—·10
97·27	3·2	2	117	+·26
9107·47	2·1	2	118	—·13
9397·54	·6	1	147	—·66
9407·46	2·4	2	148	+·25

5

rising branch 3^{s}·5

d	s		d
7901·96	2·0	0	—·08
02·00	2·2	0	+·02
8004·72	2·0	6	—·12
38·74	3·9	8	+·16
9015·51	3·3	65	+·15
·53	2·8	65	+·03
49·41	4·5	67	+·12
84·49	·4	69	—·44
·52	2·3	69	+·34
9100·30	5·2	70	—·19

6

minima >7^{s}·0

d		d
7984·97	0	—·09
8013·79	16	·00
·88	16	+·09
8780·36	443	+·01
9015·51	574	—·02
·53	574	·00
9410·44	794	—·04
·47	794	—·01
·50	794	+·02
·52	794	+·04
37·42	809	+·01
·42	809	+·01

7

descending and rising branch 6^{s}·0

d	s			d
7926·9334	6·7	+1	0	—·0058
·9743	3·0	+1	0	—·0041
85·4310	5·1	—1	23	+·0035
·4525	6·7	—1	23	+·0081
·5896	6·2	+1	23	—·0069
·6111	5·1	+1	23	+·0030
8064·6815	3·5	+1	54	+·0038
8671·5390	9·7	+1	292	+·0065
·5639	6·7	+1	292	—·0014
8727·4868	4·0	—1	314	—·0041
9074·3365	6·7	—1	450	+·0053
84·4948	3·5	—1	454	—·0028
·5166	5·9	—1	454	—·0064
97·2809	5·9	—1	459	+·0074
9107·4586	4·3	—1	463	+·0017
·4804	7·7	—1	463	—·0125
9431·4758	7·7	+1	590	—·0036
·4982	6·7	+1	590	+·0082

8

minimum I

rising branch 3^{s}·0

d	s		d
7901·964	4·2	0	—·003
7901·964	5·0	0	+·015
·996	3·4	0	+·012
8006·767	3·8	25	—·016
·767	3·9	25	—·014
69·641	4·5	40	—·012
8719·509	3·0	195	+·012
·530	2·2	195	+·015
9457·341	3·7	371	+·009
·341	2·8	371	—·010
·370	1·7	371	—·006
·370	1·8	371	—·003

minimum II

descending and rising branch 3^{s}·0

d	s			d
7962·900	2·5	+1	0	—·010
·900	3·1	+1	0	+·007
83·700	3·1	—1	5	—·024
·724	3·1	—1	5	·000
·751	3·6	—1	5	+·013
·751	4·2	—1	5	—·004
·833	3·4	+1	5	—·013
·901	2·2	+1	5	+·022
8004·721	3·9	—1	10	+·013
67·681	3·4	+1	25	—·012
8780·365	4·5	+1	195	+·009
9111·437	1·7	—1	274	+·018
9434·392	2·4	+1	351	—·025
·392	3·1	+1	351	—·005
·439	2·5	+1	351	+·025
38·423	2·4	—1	352	—·016
·446	2·4	—1	352	+·007
·468	3·6	—1	352	—·005

9

descending and rising branch 7^{s}·0

d	s			d
7901·965	4·2	+1	0	—·128
·996	6·3	+1	0	+·013
84·448	10·4	+1	5	+·005
·469	9·4	+1	5	—·026
·721	6·3	+1	5	+·065
·747	5·4	+1	5	+·044
·774	5·0	+1	5	+·050
8777·344	6·3	—1	53	+·001
78·423	3·7	+1	53	—·034
9439·526	9·1	+1	93	—·037
·546	10·4	+1	93	+·051

10

descending and rising branch 6^{s}·0

d	s			d
7929·814	8·1	—1	0	+·026
·898	9·1	+1	0	+·040
·924	7·9	+1	0	+·015
·954	6·2	+1	0	—·028
·954	7·4	+1	0	+·023
·980	6·8	+1	0	+·023
79·312	7·4	—1	10	+·018
·334	7·6	—1	10	+·031
84·270	7·9	—1	11	+·001
·292	8·1	—1	11	+·015
·448	6·6	+1	11	—·007
·469	5·6	+1	11	—·029
·490	5·4	+1	11	—·017
·512	4·8	+1	11	—·021
·534	4·4	+1	11	—·016
8013·838	4·4	—1	17	—·002
·880	5·4	—1	17	—·003
38·743	6·7	—1	22	+·036
·743	8·4	—1	22	—·037