BULLETIN OF THE ASTRONOMICAL INSTITUTES
OF THE NETHERLANDS

1941 August 1 Volume IX No. 341

COMMUNICATIONS FROM THE OBSERVATORY AT LEIDEN

On the period and photographic lightcurve of CY Aquarii, by *A. J. Wesselink*.

The present series of observations of this variable star with the shortest period known was started a month after the announcement of its discovery by Hoffmeister [1]).

The most recent observations contained in the present paper were made in the autumn of 1940 so that the homogeneous material consisting of 604 exposures covers an interval of six years or over 36000 periods. Special attention has been paid to an accurate determination of the period. The observations were made with the 33 cm refractor of the Leiden Observatory. Guilleminot La Superguil plates, 9 cm × 12 cm, were used throughout. The exposure times were $1^{3}/_{4}$ or 2 minutes. They are sufficiently short so as not to distort the lightcurve.

If circumstances permitted the star was observed during a complete cycle on the same plate. Care was taken not to discontinue the observations during the interval occupied by the rising branch, the most valuable part of the lightcurve for the determination of the period. The maximum number of exposures made on a single plate was forty.

One photovisual plate of the brand Eastman Spectroscopic IG was taken in combination with a yellow filter. By means of this plate four comparison stars of nearly the same colour were selected.

The variable and the comparison stars used are:

var.	B.D. + 0° 4900	
a	+ 0° 4902	
b	+ 0° 4899	

	$\Delta\alpha \cos\delta$	$\Delta\delta$	
	′	′	
c	+ 9·9	+ 4·7	relative to the variable
d	− 11·5	+ 8·8	

The plates have been measured in the Schilt photometer partly by Mr. C. J. Kooreman and partly by the writer. The reduction of these measurements has been performed in the following manner. The galvanometer readings were converted into provisional magnitudes by means of the mean relation between provisional magnitude and galvanometer reading as given in *B.A.N.* No. 318. For each exposure the difference:
m_{prov} (variable) — $^1/_4$ Σ m_{prov} (comp. stars) was formed. These provisional magnitude differences have only to be divided by the gradation to obtain magnitudes on the ordinary scale of magnitudes. For a more detailed exposition of this procedure we refer to *B.A.N.* No. 318 where a full account is given of its validity. The gradation can be found from the provisional magnitudes of the comparison stars, when the magnitudes of these stars are known on the ordinary scale.

Table 1.

comp. star	m (prov.)	m	m (Wachmann)
	m	m	m
a	− ·79	− ·55	10·47
b	− ·03	− ·02	—
c	+ ·11	+ ·08	11·11
d	+ ·71	+ ·49	—

From 471 exposures accurate provisional magnitudes were obtained by taking the mean value of the provisional magnitude for each comparison star. They are given in the second column of Table 1; their mean value has been taken zero.

The factor needed to reduce them to the normal scale of magnitudes was found from two plates taken with a grating in front of the objective. The definitively adopted magnitudes with their mean value as zero point are given in the third column of Table 1. The provisional scale is seen to be 1·4 times wider than the definitive one, which shows the gradation of the Guilleminot La Superguil plates to be 1·4 times the average of the plates from which the table in *B.A.N.* No. 318 has been derived.

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[1]) *B.Z.* No. 25 (1934).

In a study of CY Aquarii A.A. WACHMANN ¹) determined the photographic magnitudes of two of the comparison stars used in the present investigation, viz. a and c, by means of magnitudes of stars in Selected Area 115.

WACHMANN's results are given in the fourth column of Table 1. The difference $m(\mathrm{c}) - m(\mathrm{a})$ is according to WACHMANN ${}^{\mathrm{m}}\!\cdot64$, in excellent agreement with the value ${}^{\mathrm{m}}\!\cdot63$ found for this difference by the present writer.

Owing to changes in the seeing the gradation was found to vary from one exposure to another on the same plate. Therefore, instead of using a mean value for all exposures on the same plate, gradations were computed from the provisional magnitudes of each exposure. The factor actually used for the reduction of provisional magnitude difference to ordinary magnitude difference for each exposure was the average value of the factors found from the exposure itself and the two exposures which are nearest to it in time. The resulting definitive magnitudes of the variable are given in the third column of Table 4 for each exposure.

The Julian Day Heliocentric Mean Astronomical Time Greenwich has been computed for each exposure in two independent ways for control.

The formula used for the reduction to the sun is:

$$\text{reduction to the sun} = -{}^{\mathrm{d}}\!\cdot005367\ \mathrm{X} + {}^{\mathrm{d}}\!\cdot002045\ \mathrm{Y}.$$

In this formula X and Y are the rectangular co-ordinates of the sun in the equatorial system. X and Y were taken from the *Nautical Almanac.*

Phases were at first computed by means of the reciprocal period $16^{\mathrm{d}^{-1}}\!\cdot3831331$, which corresponds to the period given in *Katalog und Ephemeriden veränderlicher Sterne für* 1940, according to A. JENSCH ²).

The individual magnitudes were plotted against the phase and showed this reciprocal period to be too large. A correction was determined from the observations on the rising branch.

In the second approximation phases were computed with the improved reciprocal period according to the formula: phase =

$$16^{\mathrm{d}^{-1}}\!\cdot3831107\ (\text{J. D. Hel. M.A.T. Grw.} - 2420000).$$

The mean lightcurve then formed served for the final improvement of the period.

The mean lightcurve was shifted both in phase and in magnitude relative to an observed part of the lightcurve derived from a single plate in such a way that the best fit between the curves was obtained.

The shift x in phase of the mean lightcurve and the shift y in magnitude were determined by least squares.

The value of disp.² y = (mean plate error)² + (mean night error)², and the mean value of y over all plates, $\bar{y} = 0$, were taken into account.

This is of particular importance when only a linear part of the lightcurve has been observed. The actual calculation of the shifts and their weights was carried out as follows:

The equations of condition are:

$$\begin{aligned} m(\varphi) &= \overline{m}(\varphi - x) + y, && n \text{ equations of unit weight.} \\ y &= 0 && \text{, one equation of weight } p. \end{aligned}$$

Here φ is the phase, m the magnitude, $\overline{m}$ the magnitude on the mean lightcurve, n the number of exposures on the plate. If unit weight corresponds to the internal mean error of a single exposure the weight corresponding to disp. y is p, which has been found to be 5 for these observations,

Since x is small we may write the equations of condition in the form:

$$\begin{aligned} -m'x + y &= m - \overline{m}, && \text{weight } 1,\ n \text{ equations} \\ y &= 0 && \text{, weight } p, \text{ one equation,} \end{aligned}$$

where $m' = \dfrac{dm}{d\varphi}$; the normal equations are:

$$\begin{aligned} \Sigma m'^2\,x - \Sigma m'\,y &= -\,\Sigma m'\,(m - \overline{m}) \\ -\,\Sigma m'\,x + (n + p)\,y &= \Sigma\,(m - \overline{m}). \end{aligned}$$

The phase shifts x, and their weights, as determined from each plate according to the procedure just mentioned, were now used for a least squares solution in which x was assumed to be a linear function of the time.

The result of this computation is:

$$\begin{aligned} x = {}^{\mathrm{P}}\!\cdot0000 &+ 17 \times 10^{-8}\,(t - 16800) && (1) \\ \pm\,\cdot0010 &\pm 10 && (\text{m.e.}) \end{aligned}$$

Here t is the number of periods elapsed since the epoch of plate 3023. The constant 16800 between the parentheses is the weighted mean epoch.

In Table 2 details of the least squares solution are given. The alternation of the signs of the residuals is satisfactory, so that a variable period is not yet indicated.

The definitive value of the reciprocal period is

$$\begin{aligned} \mathrm{P}^{-1} = 16^{\mathrm{d}^{-1}}\!\cdot3831107\,(1 - {} &17 \times 10^{-8}) = 16^{\mathrm{d}^{-1}}\!\cdot3831079 \\ (\text{m.e.}) \pm {} &10 \qquad\quad \pm \quad \cdot0000016 \end{aligned}$$

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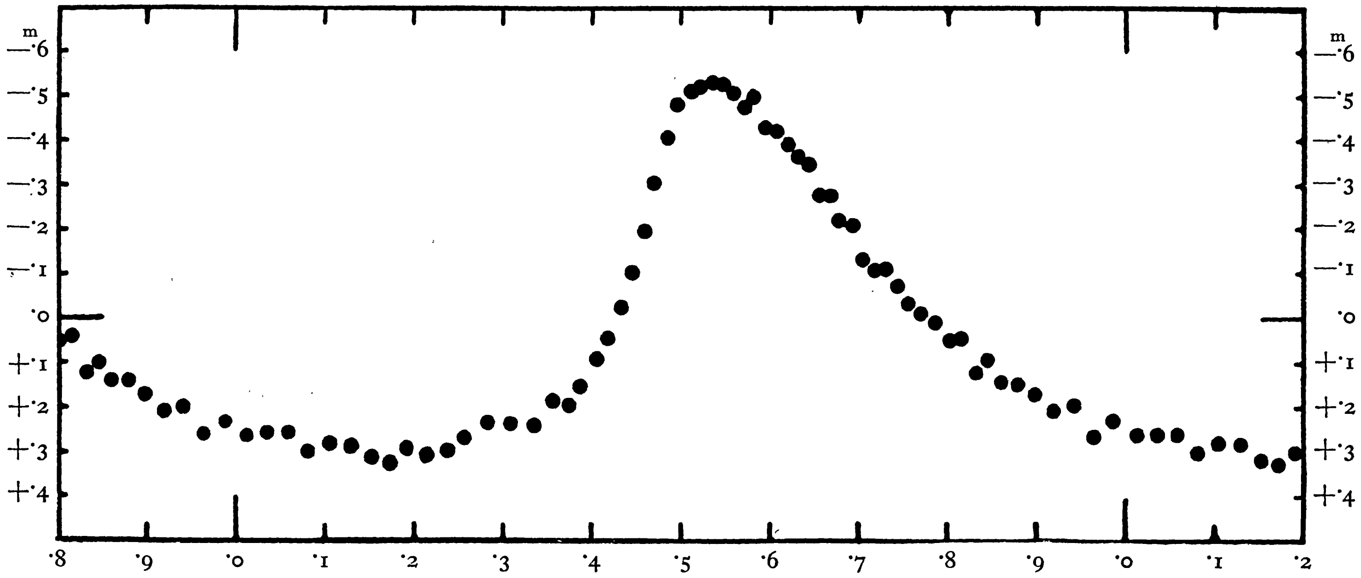
¹) *A. N.* No. 6103, **255**, 112 (1934).

²) *A. N.* No. 6330, **264**, 307 (1937).

FIGURE 1.



The corresponding value of the period is

$$P = {}^{d}{\cdot}0610384798$$
$$\pm\ {\cdot}0000000061\ \text{(m.e.)}$$

The mean error of the period is 10^{-7} of the period itself and amounts to ± ·00052 seconds of time. A change in the radial velocity of the star of only 30 metres per second would change the period by an amount equal to its mean error.

The phases of column 2 of Table 4 were calculated with the definitive formula: phase =

$$16^{d^{-1}}{\cdot}383108\ (\text{J. D. Hel. M.A.T. Grw.} - 2420000).$$

The 604 observations were arranged according to phase and means were formed, comprising 10 or 11 exposures each. The definitive normal values are given in Table 3. The mean lightcurve is shown in Figure 1. The external mean error of a single observation was found from differences in magnitude between exposures following each other in phase to be $\pm\,{}^{m}{\cdot}052$.

Consequently the total weight of the lightcurve is

$$604 \times (\pm^{m}{\cdot}052)^{-2} = 223000\ m^{-2}.$$

In Figure 2 the individual observations made in a single night and covering four successive cycles are shown. The light variation appears to be regular.

According to formula (1) the position of the mean lightcurve in phase has a mean error of $\pm\,{}^{P}{\cdot}0010$. It is easy to calculate Julian Days for a date near the mean date of all observations and corresponding to the phases of Table 3. The mean error of position of this mean lightcurve is $\pm\,{}^{d}{\cdot}000061$ or ± 5·2 seconds of time.

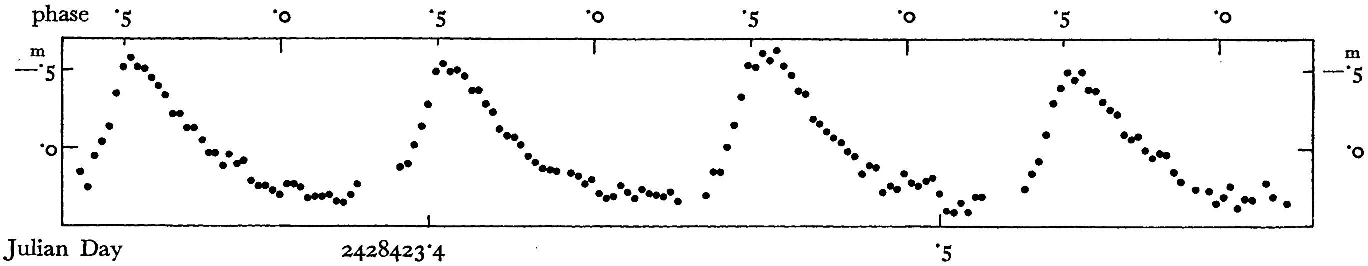
Assuming the phase of maximum brightness to be ·53 we have the following mean epoch:

J. D. Hel. M.A.T. Grw.
of maximum brightness = $2428725^{d}{\cdot}4219$.

TABLE 2.

Plate	$\frac{t}{100}$	x (O)	x (C)	O—C	weight
		P	P	P	
3023	0	+ ·0070	— ·0028	+ ·0098	13
3033	1	— ·0098	— ·0028	— ·0070	2
3035	1	— ·0014	— ·0028	+ ·0014	16
3725	119	+ ·0004	— ·0008	+ ·0012	20
3726	119	— ·0014	— ·0008	— ·0006	16
3727	119	— ·0054	— ·0008	— ·0046	16
3729	120	— ·0044	— ·0008	— ·0036	23
3730	120	— ·0016	— ·0008	— ·0008	23
3731	120	+ ·0045	— ·0008	+ ·0053	24
3732	120	— ·0015	— ·0008	— ·0007	23
3792	124	— ·0073	— ·0007	— ·0066	20
3825	132	+ ·0021	— ·0006	+ ·0027	20
3826	132	— ·0055	— ·0006	— ·0049	17
4095	178	+ ·0151	+ ·0002	+ ·0149	4
4096	178	— ·0067	+ ·0002	— ·0069	22
4596	246	+ ·0055	+ ·0014	+ ·0041	18
4606	247	+ ·0062	+ ·0014	+ ·0048	23
5117	307	+ ·0026	+ ·0024	+ ·0002	11
5127	311	— ·0005	+ ·0025	— ·0030	8
5391	358	+ ·0021	+ ·0032	— ·0011	20
5434	366	+ ·0048	+ ·0034	+ ·0014	24

FIGURE 2.



The most rapid change in brightness occurs at the brightness — ^{m}·22 on the rising branch or at the phase ·460. A date near the mean of all observations corresponding to this phase is

J. D. Hel. M.A.T. Grw. 2428725^{d}·41767.

The same brightness — ^{m}·22 on the descending branch is reached ^{P}·220 later or at phase ·680.

TABLE 3.
Normal values.

phase	magnitude	n	phase	magnitude	n
P	m		P	m	
·0111	+ ·26	10	·2144	+ ·31	10
·0353	+ ·26	10	·2355	+ ·30	10
·0591	+ ·26	10	·2565	+ ·27	10
·0801	+ ·30	10	·2825	+ ·24	10
·1027	+ ·28	10	·3079	+ ·23	10
·1287	+ ·28	10	·3343	+ ·24	10
·1503	+ ·32	10	·3560	+ ·18	10
·1701	+ ·33	10	·3744	+ ·20	10
·1911	+ ·30	10	·3874	+ ·16	10

TABLE 3 (*continued*).

phase	magnitude	n	phase	magnitude	n
P	m		P	m	
·4034	+ ·09	10	·6664	— ·28	10
·4166	+ ·04	10	·6769	— ·22	10
·4304	— ·01	10	·6920	— ·21	10
·4435	— ·10	10	·7026	— ·13	10
·4582	— ·20	10	·7162	— ·11	10
·4694	— ·31	10	·7278	— ·11	10
·4840	— ·40	10	·7428	— ·07	10
·4945	— ·48	10	·7564	— ·04	10
·5100	— ·51	10	·7698	— ·01	10
·5200	— ·52	10	·7839	+ ·01	10
·5346	— ·54	10	·8001	+ ·05	10
·5459	— ·53	10	·8137	+ ·04	10
·5586	— ·51	10	·8304	+ ·12	10
·5703	— ·48	10	·8455	+ ·10	10
·5826	— ·50	10	·8602	+ ·14	10
·5949	— ·43	10	·8783	+ ·14	10
·6068	— ·42	10	·8972	+ ·17	10
·6191	— ·40	10	·9189	+ ·21	11
·6300	— ·37	10	·9396	+ ·20	11
·6427	— ·35	10	·9630	+ ·26	11
·6528	— ·28	10	·9870	+ ·23	11

TABLE 4.

J. D. Hel. M.A.T. Grw. — 2420000	phase	magnitude	J. D. Hel. M.A.T. Grw. — 2420000	phase	magnitude	J. D. Hel. M.A.T. Grw. — 2420000	phase	magnitude	J. D. Hel. M.A.T. Grw. — 2420000	phase	magnitude
plate 3023			plate 3033			plate 3035					
d	P	m	d	P	m	d	P	m	d	P	m
7693·37377	·3734	+ ·24	7697·35480	·5950	— ·45	7697·44483	·0700	+ ·28	7697·46734	·4386	— ·09
·37550	·4017	+ ·13	·35653	·6223	— ·37	·44656	·0983	+ ·24	·46907	·4671	— ·35
·37723	·4300	+ ·02	·35826	·6517	— ·29	·44829	·1267	+ ·26	·47080	·4954	— ·56
·37896	·4584	— ·14	·35999	·6800	— ·21	·45002	·1550	+ ·31	·47253	·5238	— ·62
·38060	·4853	— ·38	·36172	·7084	— ·11	·45175	·1833	+ ·26	·47426	·5521	— ·57
·38243	·5152	— ·50	·36345	·7367	— ·06	·45349	·2119	+ ·31	·47599	·5805	— ·52
·38381	·5378	— ·50	·36519	·7652	— ·06	·45522	·2402	+ ·29	·47772	·6088	— ·45
·38520	·5606	— ·49	·36865	·8219	+ ·08	·45695	·2685	+ ·32	·47946	·6373	— ·44
·38693	·5890	— ·47	·37038	·8503	+ ·13	·45868	·2969	+ ·29	·48119	·6657	— ·30
·38866	·6173	— ·43	·37211	·8786	+ ·14	·46041	·3252	+ ·29	·48292	·6940	— ·17
·39039	·6456	— ·36	·37384	·9069	+ ·19	·46214	·3536	+ ·20	·48465	·7223	— ·16
·39212	·6740	— ·28				·46387	·3819	+ ·16	·48638	·7507	— ·07
·39385	·7023	— ·20				·46560	·4103	+ ·09	·48811	·7790	— ·01

TABLE 4 *(continued)*.

J. D. Hel. M.A.T. Grw. — 2420000	phase	magnitude
plate 3035		
d	P	m
7697·48984	·8074	— ·02
·49158	·8359	+ ·10
·49331	·8642	+ ·11
·49504	·8926	+ ·20
·49677	·9209	+ ·20
·49850	·9493	+ ·23
·50023	·9776	+ ·27
·50196	·0059	+ ·36
·50543	·0628	+ ·13
·50716	·0911	+ ·39
plate 3724		
8422·39045	·9324	+ ·08
·39218	·9607	+ ·27
·39391	·9890	+ ·25
·39564	·0174	+ ·27
·39738	·0459	+ ·26
·39911	·0742	+ ·31
·40084	·1026	+ ·26
·40259	·1309	+ ·26
·40430	·1593	+ ·33
·40603	·1876	+ ·26
plate 3725		
8422·41296	·3011	+ ·26
·41469	·3294	+ ·23
·41642	·3578	+ ·17
·41815	·3861	+ ·14
·41988	·4145	— ·01
·42161	·4428	— ·12
·42335	·4713	— ·35
·42508	·4997	— ·54
·42681	·5280	— ·54
·42854	·5564	— ·51
·43027	·5847	— ·52
·43200	·6130	— ·43
·43373	·6414	— ·38
·43546	·6697	— ·33
·43720	·6982	— ·19
·43893	·7266	— ·18
·44066	·7549	— ·06
·44239	·7833	— ·05
·44412	·8116	+ ·04
·44585	·8400	+ ·07
·44758	·8683	+ ·13
·44932	·8968	+ ·11
·45105	·9251	+ ·18
·45278	·9535	+ ·25
·45451	·9818	+ ·21
·45624	·0102	+ ·25
·45797	·0385	+ ·23
·45970	·0669	+ ·27
·46144	·0954	+ ·28
·46317	·1237	+ ·27
plate 3726		
8422·47009	·2371	+ ·28
·47182	·2655	+ ·23
·47355	·2938	+ ·30
·47529	·3223	+ ·25
·47702	·3506	+ ·23
·47875	·3790	+ ·16
·48048	·4073	+ ·09
·48221	·4357	— ·04
·48394	·4640	— ·31
·48567	·4924	— ·49
d	P	m
8422·48741	·5209	— ·55
·48914	·5492	— ·52
·49087	·5776	— ·50
·49260	·6059	— ·43
·49433	·6342	— ·36
·49606	·6626	— ·29
·49779	·6909	— ·23
·49953	·7194	— ·14
·50126	·7478	— ·08
·50299	·7761	— ·01
·50472	·8045	+ ·12
·50645	·8328	+ ·09
·50818	·8611	+ ·14
·50991	·8895	+ ·18
·51164	·9178	+ ·14
·51338	·9463	+ ·18
·51511	·9747	+ ·19
·51684	·0030	+ ·14
·51857	·0314	+ ·18
·52030	·0597	+ ·21
plate 3727		
8422·52550	·1449	+ ·25
·52723	·1734	+ ·35
·53069	·2299	+ ·29
·53242	·2583	+ ·21
·53415	·2866	+ ·22
·53588	·3150	+ ·21
·53762	·3435	+ ·22
·53935	·3718	+ ·11
·54108	·4001	+ ·12
·54281	·4285	+ ·05
·54454	·4568	— ·22
·54627	·4852	— ·40
·54800	·5135	— ·51
·54974	·5420	— ·52
·55147	·5704	— ·43
·55320	·5987	— ·39
·55493	·6271	— ·36
·55666	·6554	— ·24
·55839	·6837	— ·15
·56012	·7121	— ·15
·56185	·7404	— ·02
·56359	·7689	— ·04
·56532	·7973	+ ·03
·56705	·8256	+ ·18
·56878	·8540	+ ·11
plate 3729		
8423·33212	·3598	+ ·15
·33351	·3826	+ ·25
·33489	·4052	+ ·05
·33628	·4280	— ·04
·33766	·4506	— ·14
·33905	·4734	— ·35
·34043	·4960	— ·52
·34182	·5188	— ·58
·34320	·5414	— ·52
·34459	·5641	— ·51
·34598	·5869	— ·45
·34736	·6095	— ·40
·34875	·6323	— ·34
·35013	·6549	— ·22
·35152	·6777	— ·22
·35290	·7003	— ·13
·35429	·7231	— ·13
d	P	m
8423·35567	·7457	— ·05
·35706	·7684	+ ·03
·35844	·7910	+ ·03
·35983	·8138	+ ·11
·36121	·8364	+ ·04
·36260	·8592	+ ·10
·36398	·8818	+ ·08
·36537	·9046	+ ·21
·36675	·9272	+ ·24
·36814	·9496	+ ·24
·36952	·9726	+ ·27
·37091	·9953	+ ·30
·37229	·0180	+ ·23
·37368	·0407	+ ·23
·37506	·0633	+ ·25
·37645	·0861	+ ·32
·37783	·1087	+ ·31
·37922	·1315	+ ·31
·38060	·1541	+ ·30
·38199	·1769	+ ·34
·38337	·1995	+ ·35
·38476	·2222	+ ·30
·38614	·2449	+ ·23
plate 3730		
8423·39445	·3810	+ ·12
·39584	·4038	+ ·10
·39722	·4264	— ·02
·39861	·4492	— ·14
·39999	·4718	— ·28
·40138	·4945	— ·49
·40276	·5171	— ·54
·40415	·5399	— ·49
·40553	·5625	— ·50
·40692	·5853	— ·46
·40830	·6079	— ·37
·40969	·6307	— ·37
·41107	·6533	— ·28
·41246	·6761	— ·23
·41384	·6987	— ·12
·41522	·7213	— ·08
·41661	·7441	— ·07
·41800	·7668	— ·02
·41938	·7894	+ ·05
·42077	·8122	+ ·09
·42216	·8350	+ ·13
·42354	·8576	+ ·14
·42493	·8804	+ ·15
·42770	·9257	+ ·16
·42908	·9483	+ ·18
·43047	·9711	+ ·23
·43185	·9937	+ ·20
·43324	·0165	+ ·29
·43462	·0391	+ ·32
·43601	·0619	+ ·31
·43739	·0845	+ ·24
·43878	·1073	+ ·28
·44016	·1299	+ ·32
·44155	·1526	+ ·26
·44293	·1753	+ ·29
·44432	·1980	+ ·30
·44570	·2206	+ ·31
·44709	·2434	+ ·28
·44847	·2660	+ ·34
plate 3731		
d	P	m
8423·45401	·3568	+ ·30
·45540	·3796	+ ·15
·45678	·4022	+ ·15
·45817	·4249	— ·01
·45955	·4475	— ·15
·46094	·4703	— ·33
·46232	·4929	— ·53
·46371	·5157	— ·52
·46509	·5383	— ·61
·46648	·5611	— ·56
·46786	·5837	— ·63
·46925	·6065	— ·53
·47063	·6291	— ·47
·47202	·6518	— ·37
·47340	·6744	— ·35
·47479	·6972	— ·19
·47617	·7198	— ·16
·47756	·7426	— ·11
·47894	·7652	— ·07
·48033	·7880	— ·04
·48171	·8106	+ ·02
·48310	·8334	+ ·05
·48448	·8560	+ ·16
·48587	·8787	+ ·11
·48725	·9014	+ ·12
·48864	·9241	+ ·28
·49002	·9467	+ ·24
·49141	·9695	+ ·26
·49279	·9921	+ ·16
·49418	·0149	+ ·22
·49556	·0375	+ ·24
·49695	·0603	+ ·21
·49833	·0829	+ ·19
·49972	·1057	+ ·29
·50110	·1283	+ ·40
·50249	·1510	+ ·41
·50387	·1736	+ ·35
·50526	·1964	+ ·41
·50664	·2190	+ ·31
·50803	·2418	+ ·31
plate 3732		
8423·51634	·3779	+ ·26
·51773	·4007	+ ·16
·51911	·4233	+ ·08
·52050	·4461	— ·09
·52188	·4687	— ·29
·52327	·4915	— ·39
·52465	·5141	— ·49
·52604	·5369	— ·44
·52742	·5595	— ·49
·52881	·5822	— ·38
·53019	·6048	— ·37
·53158	·6276	— ·30
·53296	·6502	— ·25
·53435	·6730	— ·22
·53573	·6956	— ·09
·53712	·7184	— ·06
·53850	·7410	— ·08
·53989	·7638	+ ·01
·54127	·7864	+ ·06
·54266	·8091	+ ·03
·54404	·8318	+ ·04
·54543	·8545	+ ·15
·54681	·8771	+ ·21
·54958	·9225	+ ·26

TABLE 4 *(continued)*.

J. D. Hel. M.A.T. Grw. — 2420000	phase	magnitude
plate 3732		
d	P	m
8423·55235	·9679	+ ·27
·55374	·9907	+ ·35
·55512	·0133	+ ·31
·55651	·0360	+ ·24
·55789	·0587	+ ·38
·55928	·0814	+ ·32
·56066	·1040	+ ·33
·56343	·1494	+ ·22
·56482	·1722	+ ·31
·56759	·2176	+ ·35
plate 3792		
8451·46894	·3284	+ ·21
·47033	·3512	+ ·20
·47171	·3738	+ ·19
·47310	·3966	+ ·11
·47448	·4192	— ·03
·47587	·4419	— ·15
·47725	·4645	— ·28
·47864	·4873	— ·48
·48002	·5099	— ·58
·48141	·5327	— ·54
·48279	·5553	— ·48
·48418	·5781	— ·47
·48556	·6007	— ·40
·48695	·6235	— ·34
·48833	·6461	— ·30
·48972	·6688	— ·27
·49110	·6915	— ·20
·49249	·7142	— ·07
plate 3825		
8501·21829	·3774	+ ·24
·21967	·4000	+ ·06
·22106	·4228	+ ·04
·22244	·4454	— ·09
·22383	·4681	— ·25
·22521	·4907	— ·47
·22660	·5135	— ·56
·22937	·5589	— ·58
·23075	·5815	— ·62
·23214	·6043	— ·41
·23352	·6269	— ·43
·23491	·6497	— ·34
·23629	·6723	— ·19
·23768	·6950	— ·27
·23906	·7177	— ·01
plate 3826		
8501·27092	·2396	+ ·19
·27230	·2622	+ ·34
·27369	·2850	+ ·30
·27507	·3076	+ ·23
·27646	·3304	+ ·22
·27784	·3530	+ ·17
·27923	·3758	+ ·22
·28061	·3984	+ ·12
·28200	·4211	— ·05
·28338	·4438	— ·12
·28477	·4665	— ·36
·28616	·4893	— ·53
·28754	·5119	— ·46
·28893	·5347	— ·53
·29031	·5573	— ·48
·29170	·5801	— ·54
d	P	m
8501·29308	·6027	— ·49
·29447	·6254	— ·38
·29585	·6481	— ·26
plate 4073		
8774·50363	·6406	— ·25
·50501	·6632	— ·28
plate 4095		
8782·49307	·5325	— ·53
·49445	·5551	— ·49
·49584	·5779	— ·52
·49722	·6005	— ·45
·49861	·6232	— ·41
·49999	·6458	— ·42
·50138	·6686	— ·29
·50276	·6912	— ·21
·50415	·7140	— ·16
·50553	·7366	— ·11
·50692	·7594	— ·06
·50830	·7820	+ ·02
·50969	·8048	— ·02
·51107	·8274	+ ·15
·51246	·8501	+ ·06
·51384	·8728	+ ·12
·51523	·8955	+ ·22
·51661	·9183	+ ·18
·51800	·9409	+ ·18
·51938	·9635	+ ·26
·52077	·9863	+ ·22
·52215	·0089	+ ·30
·52354	·0317	+ ·27
·52493	·0544	+ ·29
·52631	·0770	+ ·33
·52770	·0998	+ ·28
·52908	·1224	+ ·28
·53047	·1452	+ ·39
·53185	·1678	+ ·37
·53324	·1906	+ ·28
plate 4096		
8782·54708	·4173	+ ·07
·54847	·4409	+ ·03
·54986	·4629	— ·21
·55124	·4855	— ·42
·55263	·5083	— ·56
·55401	·5309	— ·52
·55540	·5536	— ·57
·55678	·5762	— ·46
·55817	·5990	— ·46
·55955	·6216	— ·28
·56094	·6444	— ·33
·56232	·6670	— ·23
·56371	·6898	— ·20
·56509	·7124	— ·15
·56648	·7352	— ·04
·56786	·7578	+ ·02
·56925	·7805	+ ·06
·57063	·8031	+ ·09
·57202	·8259	+ ·19
·57340	·8485	+ ·16
plate 4097		
8784·36155	·1440	+ ·31
·36293	·1666	+ ·28
·36432	·1894	+ ·23
d	P	m
8784·36570	·2120	+ ·27
·36709	·2347	+ ·35
·36847	·2574	+ ·29
plate 4596		
9195·30997	·7563	— ·09
·31153	·7819	— ·03
·31309	·8074	·00
·31465	·8330	+ ·06
·31620	·8584	+ ·13
·31846	·8954	+ ·14
·32001	·9208	+ ·18
·32157	·9464	+ ·22
·32313	·9719	+ ·42
·32469	·9975	+ ·21
·32625	·0230	+ ·29
·32780	·0484	+ ·30
·32936	·0740	+ ·34
·33092	·0996	+ ·29
·33248	·1251	+ ·25
·33404	·1507	+ ·33
·33560	·1762	+ ·39
·33715	·2016	+ ·32
·33871	·2272	+ ·30
·34027	·2527	+ ·22
·34183	·2783	+ ·20
·34339	·3039	+ ·21
·34650	·3548	+ ·18
·34806	·3804	+ ·24
·34962	·4059	+ ·11
·35118	·4315	+ ·01
·35274	·4570	— ·18
·35430	·4826	— ·38
·35585	·5080	— ·47
·35741	·5335	— ·53
·35897	·5591	— ·49
·36053	·5847	— ·45
·36209	·6102	— ·44
·36364	·6356	— ·37
·36520	·6612	— ·26
·36676	·6867	— ·25
·36832	·7123	— ·15
·36988	·7378	— ·04
·37143	·7632	— ·02
plate 4606		
9201·28344	·6203	— ·43
·28500	·6459	— ·37
·28655	·6713	— ·28
·28811	·6968	— ·27
·28967	·7224	— ·20
·29123	·7480	— ·15
·29279	·7735	— ·05
·29434	·7989	+ ·03
·29746	·8500	+ ·06
·29902	·8756	+ ·12
·30058	·9005	+ ·16
·30214	·9267	+ ·15
·30369	·9521	+ ·20
·30525	·9777	+ ·18
·30681	·0032	+ ·26
·30837	·0288	+ ·32
·30993	·0543	+ ·24
·31148	·0797	+ ·30
·31304	·1053	+ ·28
·31460	·1308	+ ·26
d	P	m
9201·31616	·1564	+ ·37
·31772	·1819	+ ·31
·31928	·2075	+ ·35
·32083	·2329	+ ·38
·32239	·2585	+ ·23
·32395	·2840	+ ·21
·32551	·3096	+ ·18
·32707	·3351	+ ·21
·32863	·3607	+ ·15
·33018	·3861	+ ·15
·33174	·4116	+ ·06
·33330	·4372	— ·10
·33486	·4628	— ·25
·33642	·4883	— ·51
·33797	·5137	— ·55
·33953	·5393	— ·58
·34109	·5648	— ·55
·34265	·5904	— ·48
·34421	·6159	— ·43
plate 5117		
9568·29875	·4718	— ·23
·30014	·4946	— ·38
·30152	·5172	— ·45
·30291	·5400	— ·47
·30429	·5626	— ·44
·30568	·5853	— ·41
·30706	·6079	— ·32
·30845	·6307	— ·30
·30983	·6533	— ·26
·31122	·6761	— ·17
·31261	·6989	— ·09
·31399	·7215	— ·06
·31538	·7442	— ·05
·31676	·7669	+ ·03
·31815	·7896	+ ·06
·31953	·8122	+ ·02
·32092	·8350	+ ·22
·32230	·8576	+ ·19
·32369	·8804	+ ·20
·32507	·9030	+ ·20
plate 5127		
9589·27957	·2028	+ ·36
·28095	·2254	+ ·27
·28234	·2482	+ ·27
·28372	·2708	+ ·17
·28511	·2936	+ ·12
·28649	·3162	+ ·12
·28788	·3390	+ ·23
·28926	·3616	+ ·10
·29203	·4070	— ·04
·29342	·4297	·00
·29480	·4524	— ·15
·29619	·4751	— ·35
·29757	·4977	— ·45
·29896	·5205	— ·47
·30034	·5431	— ·61
·30173	·5659	— ·46
plate 5390		
9880·40281	·7063	— ·06
·40419	·7289	— ·14
·40558	·7517	+ ·03
·40696	·7743	+ ·05
·40835	·7971	+ ·08