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COMMUNICATIONS FROM THE OBSERVATORY AT LEIDEN

Six new variable stars in the η Carinae region, by *P. Th. Oosterhoff.*

The variables of the present note have been discovered by the writer on plates taken with the Franklin-Adams camera at Johannesburg. They were estimated with the aid of a 10 × eye piece on all available Franklin-Adams plates and on a small number of plates which were taken recently at Johannesburg with the new Rockefeller twin astrograph of the Leiden Observatory.

The main results are collected in Table 1.

The epoch given in the fifth column refers to primary minimum for the eclipsing variables and to maximum for the RR Lyrae and δ Cephei type variables. For some of the variables more accurate epochs derived for a special phase are given below. The sixth column contains the best period which could be derived. The reciprocal period in the eighth column was actually used for the computation of the phases according to the formula:

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

The mean error of one estimate given in the tenth column has been computed from the differences in steps between successive observations according to phase. The following column contains a provisional value for the range of the light variation derived from the data of Table 2. The photographic magnitudes of the last two columns are rather uncertain.

The size of the diagrams in Figure 1, on which the variables and the comparison stars are marked, is $7' \times 7'$.

FIGURE 1.

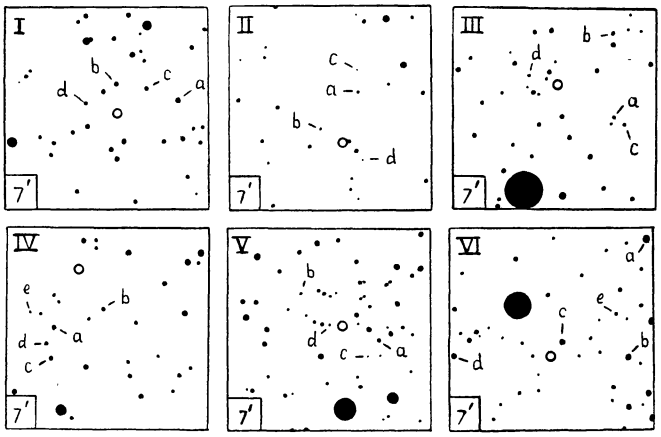


TABLE 1.

star	α (1875)	δ (1875)	type	epoch *) −2420000	period	mean error of period	reciprocal period used	number of observations	mean error of one estimate	range	m_{pg} of max.	m_{pg} of min.
	h m s	° ′		d	d	d	d^{-1}		s	m m	m	m
I	10 23 43·2	− 57 6·5	W UMa	4282·1840	·6629146	± ·0000013	1·508490	768	± ·75	·5 ·2	13·8	14·3
II	10 26 43·9	− 61 44·9	RR Lyr	4650·364	·6620123	± ·0000009	1·5105507	655	± ·92	·9	14·0	14·9
III	10 30 39·7	− 56 50·9	Algol	4560·507	2·583908	± ·000012	·3870107	716	± ·74	·35 ·15	14·0	14·4
IV	10 44 21·0	− 63 30·7	δ Cep	4561·28	5·10179	± ·00006	·196013	625	± ·84	·9	14·1	15·0
V	10 48 47·8	− 60 57·1	Algol	5377·345	2·808617	± ·000004 **)	·3560471	808	± ·86	>1·0 ·06	14·3	>15·3
VI	10 50 10·1	− 59 52·9	δ Cep	4537·21	5·33625	± ·00008	·1874104	839	± ·76	·9	12·9	13·8

*) For variables I, III and V the epoch of primary minimum, for the remaining variables the epoch of maximum is given.
**) Estimated mean error.

TABLE 2.

	I	II	III	IV	V	VI
	s m	s m	s m	s m	s m	s m
a	— 4·9 — ·40	·0 ·00	·0 ·00	·0 ·00	·0 ·00	·0 ·00
b	·0 ·00	+ 1·6 + ·22	+ 3·1 + ·38	+ 3·7 + ·59	+ 4·7 + ·67	+ 3·9 + ·48
c	+ 2·7 + ·53	+ 4·9 + ·85	+ 5·4 + ·88	+ 5·9 + ·95	+ 5·5 + ·92	+ 4·9 + ·56
d	+ 4·2 + ·61	+ 5·8 +1·20	+ 7·1 + ·99	+ 7·2 +1·11	+ 6·5 + ·92:	+ 7·3 + ·95
e				+ 9·0 +1·51		+ 9·7 +1·37
$1^s·0$ =	$m·12$	$m·20$	$m·15$	$m·16$	$m·15$	$m·14$

The differences in steps and in magnitude between the comparison stars are given in Table 2. The latter values were derived from the measurement of the comparison stars on three Rockefeller plates in the Schilt microphotometer. The galvanometer readings were then turned into provisional magnitudes by means of WESSELINK's table in *B.A.N.* No. 318.

The designation J. D., as used in this note, stands for J.D.Hel.M.A.T.Gr.

Remarks about the individual variables.

I: This variable is of the W UMa type. The period has been derived by least squares from observations near primary minimum. The epochs used and the residuals are tabulated in Table I *a*. The mean light curve is given in Table I *b* and Figure I. There exists a pronounced difference in depth between the two minima. The maxima seem to be slightly asymmetrical being brighter towards primary minimum, but the observations are not decisive. The mean phase of primary minimum was found to be ·632.

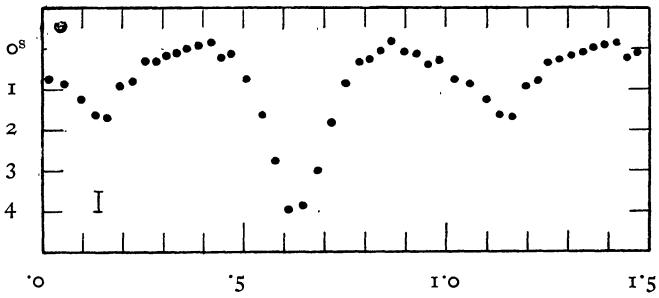
TABLE I*a*.

J.D.— 2420000	E	O—C
d		d
0327·248	0	+ ·012
3813·505	5259	+ ·001
3815·472	5262	— ·021
3817·487	5265	+ ·005
3841·344	5301	— ·003
3845·329	5307	+ ·005
3857·260	5325	+ ·004
3878·465	5357	— ·005
3884·429	5366	— ·007
3886·447	5369	+ ·022
3902·335	5393	·000
3904·322	5396	— ·001
3908·287	5402	— ·014
3985·203	5518	+ ·004
3987·201	5521	+ ·013
4169·470	5796	— ·019
4177·430	5808	— ·014
4282·202	5966	+ ·017
4537·402	6351	— ·005
4586·452	6425	— ·011
5330·244	7547	— ·009
5377·310	7618	— ·010
5686·245	8084	+ ·007
5745·254	8173	+ ·017
7633·228	11021	+ ·010

TABLE I*b*.

mean phase	mean brightness	*n*
P	s	
·0173	+ ·74	24
·0570	+ ·85	,,
·0959	+ 1·25	,,
·1299	+ 1·63	,,
·1598	+ 1·70	,,
·1941	+ ·92	,,
·2252	+ ·79	,,
·2549	+ ·31	,,
·2822	+ ·32	,,
·3088	+ ·17	,,
·3340	+ ·10	,,
·3593	— ·02	,,
·3884	— ·08	,,
·4190	— ·15	,,
·4451	+ ·23	,,
·4705	+ ·11	,,
·5050	+ ·75	,,
·5438	+ 1·62	,,
·5767	+ 2·75	,,
·6088	+ 3·94	,,
·6449	+ 3·85	,,
·6813	+ 3·00	,,
·7145	+ 1·82	,,
·7495	+ ·84	,,
·7838	+ ·33	,,
·8090	+ ·26	,,
·8375	+ ·04	,,
·8636	— ·19	,,
·8955	+ ·06	,,
·9272	+ ·12	,,
·9565	+ ·38	,,
·9809	+ ·29	,,

FIGURE I.



II: The variable is of the RR Lyr type. A provisional period was derived from the observations near maximum, yielding: $^d·6620158 \pm {}^d·0000043$ (m. e.). Phases were computed for the observations on the ascending branch of the light curve with the corresponding reciprocal period $1^{d-1}·510538$. The ascending branch proved to be practically rectilinear between phases ·43 and ·49. The J.D. of each observation within this interval was then reduced to brightness $2^s·0$ and the new epochs were used for a final solution of the period. Observations at the same epoch were combined, the assigned relative weight being equal to the number of observations. The resulting elements are:

$$\text{J.D. } 2424650^d·3017 + {}^d·6620123\ E$$
$$\pm\ 22 \qquad \pm\ 9 \quad \text{(m.e.)}$$

The epochs and their residuals from these elements are listed in Table II*a*. The mean light curve is given in Table II*b* and Figure II.

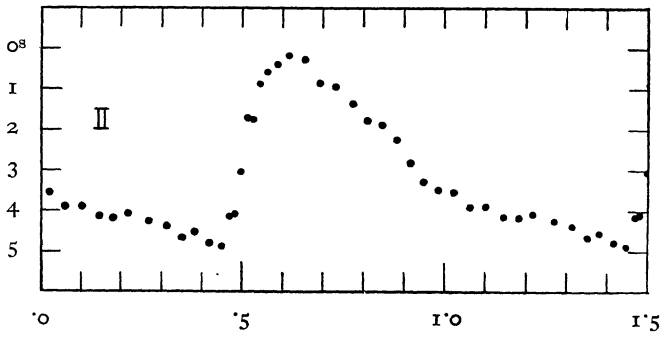
TABLE II*a*.

J.D.— 2420000	weight	E	O—C
d			d
3813·535	3	0	+ ·017
3815·506	1	3	+ ·002
3817·460	1	6	— ·030
3841·326	2	42	+ ·003
3845·295	2	48	·000
3876·406	2	95	— ·003
3878·406	1	98	+ ·011
3880·372	1	101	— ·009
3900·239	2	131	— ·003
3933·334	1	181	— ·008
3935·300	1	184	— ·028
3937·332	2	187	+ ·018
3939·307	2	190	+ ·006
3941·292	1	193	+ ·005
3943·278	2	196	+ ·005
3945·284	1	199	+ ·025
3955·178	1	214	— ·011
4187·545	1	565	— ·010
4201·456	1	586	— ·001
4205·424	1	592	— ·005
4262·356	1	678	— ·007
4264·359	1	681	+ ·010
4284·191	1	711	— ·018
4650·314	1	1264	+ ·012
5562·548	1	2642	— ·007
5570·513	1	2654	+ ·014
5686·335	2	2829	— ·016
5731·344	2	2897	— ·024
5950·504	1	3228	+ ·010
6123·281	1	3489	+ ·002
6826·338	1	4551	+ ·002
9280·423	2	8258	+ ·007
9282·404	2	8261	+ ·002

TABLE II*b*.

mean phase	mean brightness	*n*
P	s	
·0210	3·54	25
·0607	3·92	25
·1006	3·90	25
·1447	4·14	25
·1789	4·18	25
·2160	4·08	25
·2677	4·26	25
·3130	4·38	25
·3504	4·67	25
·3805	4·55	25
·4168	4·78	25
·4462	4·88	13
·4675	4·16	13
·4807	4·09	13
·4962	3·05	13
·5124	1·72	13
·5265	1·76	13
·5452	·87	13
·5613	·59	13
·5872	·42	13
·6150	·17	13
·6549	·28	25
·6932	·86	25
·7288	·93	25
·7731	1·37	25
·8093	1·79	25
·8447	1·88	25
·8801	2·25	25
·9145	2·83	25
·9484	3·30	25
·9838	3·50	25

FIGURE II.



III: This variable caused some difficulty in the determination of the period. When the estimates were made the writer had the conviction that the variable is of the Algol type. From a long series of observations during one night the duration of the minimum was found to be about ^{d}·2. The frequency distribution of the estimates, given below, indicates that the mean error of an estimate is only little smaller than the total range of the light variation.

steps	·5	1·0	1·5	2·0	2·5	3·0	3·5
	·9	1·4	1·9	2·4	2·9	3·4	3·9
n	1	3	9	23	33	251	194

steps	4·0	4·5	5·0	5·5	6·0	6·5	7·0
	4·4	4·9	5·4	5·9	6·4	6·9	7·4
n	73	86	31	1	6	3	1

A number of spurious minima will therefore hamper the determination of the period. Two multiples of the period could however be determined with certainty. The best minima are indicated by an asterisk in Table III*a*. They yield the intervals 61^{d}·97 and 92^{d}·99. Thus 30^{d}·99 must be a multiple of the period. A more extensive list of minima provides several multiples of the interval 21^{d}·97. By the aid of these two intervals the period was found to be 1^{d}·29. A least squares solution gives the following elements:

$$\text{J.D. } 2424560^{d}\cdot50 + 1^{d}\cdot291954\ E \pm 6 \text{ (m.e.)}$$

The epochs used and the residuals from these elements are shown in Table III*a*. A difference in depth between the even and odd minima proves that this period has to be doubled.

The mean light curve computed with the reciprocal period $^{d-1}$·3870107 is given in Table III*b* and Figure III. The mean phase of primary minimum is ·965.

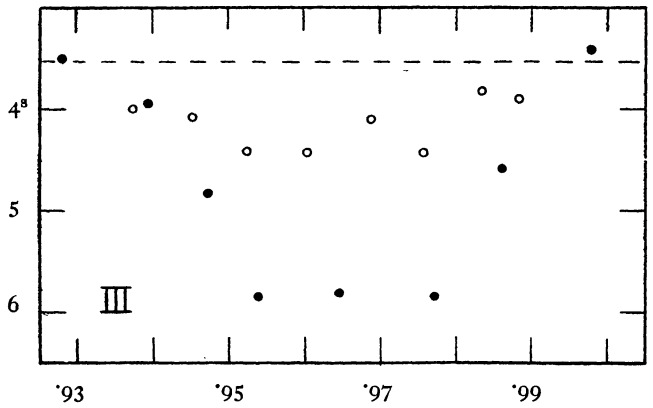
TABLE III*a*.

J.D.— 2420000	E	O—C
d		d
3790·47	0	— ·03
3816·36 *	20	+ ·02
·38 *	20	+ ·04
3878·32 *	68	— ·03
·34 *	68	— ·01
3883·49	72	— ·03
3887·43	75	+ ·04
3935·24	112	+ ·04
3940·31	116	— ·05
3944·23	119	— ·01
3966·23	136	+ ·03
4201·34 *	318	·00
·36 *	318	+ ·02
·39 *	318	+ ·05
4206·47	322	— ·04
4263·41	366	+ ·06
4285·24	383	— ·08
4294·34 *	390	— ·02
·36 *	390	·00
4538·51	579	— ·03
4560·47	596	— ·03
5745·29	1513	+ ·07
6126·30 *	1808	— ·05
·36 *	1808	+ ·01
·39 *	1808	+ ·04
6449·32	2058	— ·02
7604·33	2952	— ·01
8224·43	3432	— ·05
8272·30	3469	+ ·02
9108·21	4116	+ ·03

TABLE III*b*.

mean phase	mean brightness	*n*
P	s	
·0256	3·43	28
·0740	3·60	29
·1170	3·58	29
·1551	3·33	29
·1968	3·47	29
·2407	3·41	29
·2750	3·70	29
·3187	3·62	29
·3619	3·67	29
·4079	3·53	28
·4372	4·00	6
·4452	4·08	6
·4522	4·42	6
·4602	4·43	6
·4685	4·12	6
·4757	4·43	6
·4833	3·83	6
·4882	3·92	6
·5176	3·46	27
·5549	3·42	27
·5934	3·67	28
·6231	3·52	28
·6499	3·56	28
·6896	3·32	28
·7242	3·53	28
·7715	3·69	28
·8132	3·51	28
·8444	3·65	28
·8694	3·52	27
·9008	3·36	27
·9278	3·50	6
·9393	3·95	6
·9472	4·83	6
·9538	5·85	6
·9644	5·83	6
·9770	5·85	6
·9860	4·58	6
·9977	3·42	6

FIGURE III.



(Open circles: secondary minimum shifted half a period).

IV: This star is a δ Cephei type variable. From 25 maxima the period $5^d{\cdot}10170 \pm {}^d{\cdot}00014$ (m.e.) was derived. The mean light curve computed with the corresponding reciprocal period is given in Table IV*b* and Figure IV. It is typical for this period. The ascending branch is practically rectilinear between phases ·91 and ·00, one step corresponding with $^d{\cdot}108$. The observations within this interval were all reduced to a brightness of $6^s{\cdot}4$. Observations of the same night were combined to a single epoch, the assigned relative weight being equal to their number. The elements derived from these epochs are:

J. D. $2424560^d{\cdot}686 + 5^d{\cdot}10179\ E$
$\pm 15 \quad \pm 6$ (m.e.)

The details of this solution are given in Table IV*a*.

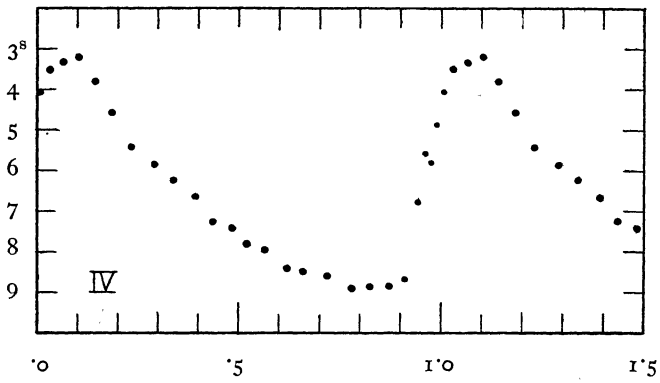
TABLE IV*a*.

J.D.— 2420000	weight	E	O—C
d			d
3790·47	2	0	+ ·15
3841·29	3	10	— ·04
3877·14	2	17	+ ·09
3882·17	1	18	+ ·02
3887·30	3	19	+ ·05
3902·59	2	22	+ ·03
3928·05	4	27	— ·01
3933·14	3	28	— ·03
3938·21	3	29	— ·06
3943·45	1	30	+ ·08
4198·45	7	80	— ·01
4285·16	4	97	— ·03
4560·66	2	151	— ·03
4642·18	2	167	— ·14
5652·50	2	365	+ ·03
8341·16	2	892	+ ·05
9096·16	2	1040	— ·02

TABLE IV*b*.

mean phase	mean bright-ness	*n*
P	s	
·0064	4·05	10
·0306	3·51	30
·0644	3·33	30
·1023	3·20	30
·1410	3·80	30
·1836	4·56	30
·2306	5·42	30
·2880	5·85	30
·3379	6·23	30
·3924	6·65	30
·4352	7·25	30
·4837	7·41	30
·5186	7·82	30
·5657	7·96	30
·6192	8·40	30
·6594	8·48	30
·7190	8·62	30
·7799	8·91	31
·8245	8·87	33
·8716	8·85	21
·9099	8·68	10
·9410	6·78	10
·9597	5·58	10
·9769	5·80	10
·9910	4·87	10

FIGURE IV.



V: This variable is of the Algol type. Its range is considerable, but could not be determined as the star is invisible on the plates near minimum. From 27 minima the period was found to be: $2^d{\cdot}808595 \pm {}^d{\cdot}000010$ (m.e.). Phases were computed for the observations near minimum with the reciprocal period $^{d-1}{\cdot}3560499$. From a plot of these observations it became evident that the period needed a positive correction. This has been derived in a graphical way, the corrected period being $2^d{\cdot}808617$ with an estimated mean error of $\pm {}^d{\cdot}000004$. Phases were then computed with the corresponding reciprocal period and a mean light curve was formed, which is given in Table V*a* and Figure V. The mean phase of minimum is ·588. As a secondary minimum was indicated a new mean light curve was formed by counting the phase for each observation from primary minimum without regard to sign. This light curve is given in Table V*b* and is also shown in Figure V.

TABLE V*a*.

mean phase	mean brightness	*n*
P	s	
·0037	3·11	43
·0542	3·06	43
·1101	3·40	43
·1570	3·01	43
·2034	3·05	43
·2499	3·08	43
·3076	2·92	43
·3615	2·88	43
·4225	2·98	43
·4984	3·17	43
·5354	3·32	10
·5439	4·04	10
·5533	5·31	10
·5617	6·61	10
·5721	> 8·80	10
·5806	> 9·40	10
·5903	> 9·30	10
·5978	> 9·25	10
·6099	8·55	10
·6216	5·21	10
·6346	3·91	10
·6470	3·37	10
·6836	3·29	43
·7425	2·78	43
·7878	3·14	43
·8430	2·72	43
·8998	3·05	43
·9569	2·92	43

TABLE V*b*.

mean phase	mean brightness	*n*
P	s	
·0037	> 9·37	15
·0093	> 9·33	15
·0175	> 8·83	15
·0257	7·24	15
·0327	5·33	15
·0412	4·37	15
·0489	3·56	15
·0565	3·55	15
·0928	3·19	86
·1582	2·93	86
·2132	2·92	86
·2676	2·87	86
·3258	3·05	86
·3773	3·02	86
·4233	3·03	86
·4585	3·09	43
·4866	3·40	43