BULLETIN OF THE ASTRONOMICAL INSTITUTES OF THE NETHERLANDS

COMMUNICATIONS FROM THE OBSERVATORY AT LEIDEN

Notes on six variable stars estimated by W. E. Kruytbosch †, with remarks by *Ejnar Hertzsprung*.

Among the effects of the late W. E. Kruytbosch are still found a number of estimates of variable stars in the constellations Norma and Ara, which material gives rise to further remarks. Six of these objects are discussed below. The variability of the first 3 of these stars was discovered by P. Th. Oosterhoff. The six objects are:
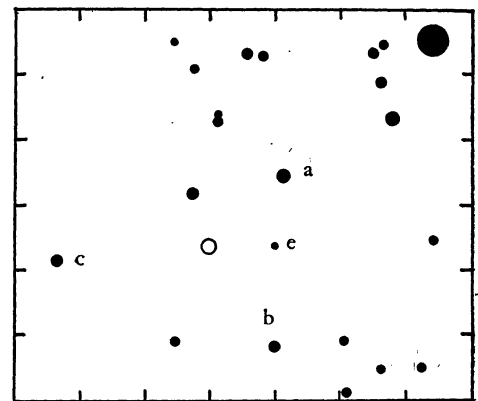
	α (1875)			δ (1875)		
I	15	53	7	− 55	55	·6
II	16	13	45	− 53	37	·3
III	16	15	27	− 55	2	·6
UW Nor	16	17	33	− 52		·1
WZ Ara	16	28	36	− 57	38	·2
R Ara	16	29	22	− 56	44	·4
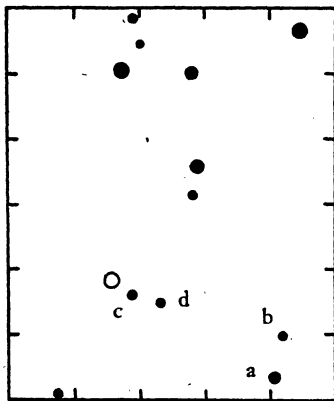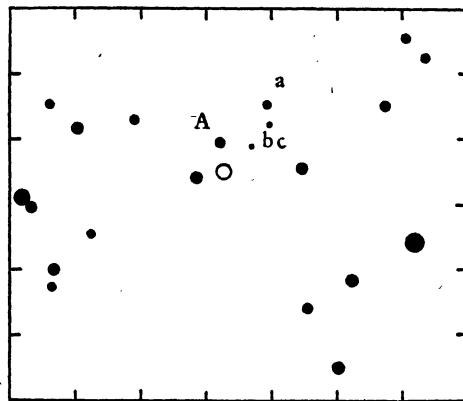
I   II   III

The height of the diagrams is 6′.

I. This faint eclipsing variable was estimated on 277 plates by W. E. Kruytbosch, who found the star markedly below normal brightness on 3 nights. The period could not yet be derived. On later plates the star was found faint on one occasion. The 4 epochs of minimum thus available are:

J.D. hel.	E	O−C
d		d
2425411·467	0	− ·006
52·386	7	11
6118·490	121	− 6
8064·273	454	2

These observations are satisfied by the period $5^{d}·843168$, but it is possible that the true period is half this value as the star was found slightly fainter than normal on J.D. 2425864·237 and there are no observations which exclude the period $2^{d}·92$. The

eclipse does not seem to last for much more than $^{d}·18$. The range is still uncertain, but may be about $^{m}·7$, viz. from $15^{m}·1$ to $15^{m}·8$.

II. This star is so faint that it was only estimated on 138 plates by W. E. Kruytbosch. It will be of
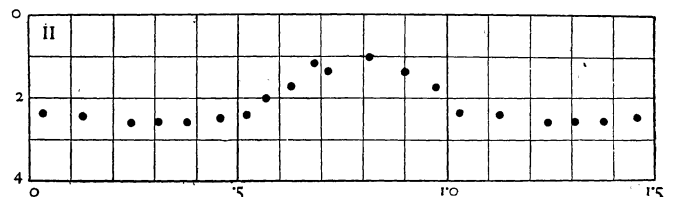
interest to see if the elements derived from such scanty material are valid. The comparison stars used are A $^{s}·00$, a $1^{s}·14$, b $2^{s}·02$ and c $2^{s}·74$ [1]. The star

[1] The comparison stars b and c could not be identified with certainty.

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appears to be of the δ Cephei type with a period of $23^d \cdot 5$. The phases were calculated from the formula: phase $= \cdot 04255$ (J.D. hel. $- 2420000$). Mean values of phase and brightness are:

n	phase	brightness	n	phase	brightness
	P	s		P	s
10	·031	2·38	10	·569	2·02
10	·129	2·44	10	·629	1·71
10	·244	2·68	10	·683	1·18
10	·308	2·59	10	·717	1·36
10	·379	2·59	10	·817	1·03
10	·458	2·49	9	·901	1·36
10	·522	2·41	9	·977	1·76

If the lightcurve is supposed to be symmetrical the phase of the maximum is found to be ·791, corresponding to a mean epoch of J.D. 2425729·52. The mean error of a single estimate is $\pm$ $^s \cdot 5$. The brightness in steps varies from $1^s \cdot 0$ to $2^s \cdot 6$, while I estimate the limits of magnitude to be about 15^m and 16^m.

J.D.—2420000	prov. magn.	number of plates	J.D.—2420000	prov. magn.	number of plates	J.D.—2420000	prov. magn.	number of plates
d	m'	n	d	m'	n	d	m'	n
5423·49	invis.	2	5808·30	invis.	2	6094·62	invis.	2
35·29	·25	2	21·24	·40	2	6118·49	·09	2
37·45	·41	1	22·22	·52	2	20·53	·31	2
38·35	·39	3	24·28	1·21	2	22·54	·45	2
41·39	·84	3	25·31	1·43	1	23·51	·48	2
42·43	1·16	3	31·27	invis.	1	25·47	·76	2
43·38	1·38	9				26·52	1·19	2
44·35	1·53	2				29·41	invis.	2
45·41	invis.	6						

The star was found of brightness 1·36 m' on one later plate taken at J.D. 2426453·50.

In order to obtain the ordinary photographic magnitude about 13 should be added to m'.

UW Normae

This eclipsing variable star was announced by W. E. KRUYTBOSCH in B.A.N. No. 202, at which time the star had been noted distinctly below normal brightness in one night only. On a later plate taken on J.D. 2426090 the star was again found faint. In addition KRUYTBOSCH had estimated the star in decreasing light on the last plate out of 11 from J.D. 2425411. Measures by C. J. KOOREMAN in the Schilt photometer confirmed these observations. Together with a few other plates the following results were derived in the scale of B.A.N. No. 202, p. 16:

J.D. hel.—2420000		phase	J.D. hel.—2420000		phase
	m'	P		m'	P
5411·3804	·02	·6825	5445·4462	·67	·6968
·4019	—·02	·6850	·4684	·66	·6994
·4234	·15	·6875	6090·3947	·74	·6982
·4455	·28	·6901	·6398	—·17	·7271
·4670	·50	·6927	8042·2988	—·11	·7125
5437·4478	—·14	·7543	·3203	—·16	·7151
5445·3570	·10	·6863	8364·3693	·11	·6656
·3792	·30	·6889	·3912	—·23	·6682
·4013	·39	·6915	8398·2704	·00	·6606
·4234	·47	·6941	·2919	—·36	·6631

Later plates indicate a small correction to the period, the most probable value of which is $23^d \cdot 54$. The flatness of the minimum as shown by the diagram may well be spurious as the images in that part of the lightcurve are too faint for reliable estimates.

III. This variable appears to belong to the SS Cygni class. On the great majority of the plates examined the star was invisible, but on three occasions it appeared during respectively 10, 5 and 9 nights. In all three cases the brightness of the star was decreasing. The comparison stars used by W. E. KRUYTBOSCH are a $8 \cdot 0$, b $2^8 \cdot 2$, c $4^8 \cdot 2$, d $5^8 \cdot 0$ and e $5^8 \cdot 5$ or, expressed in provisional magnitudes as measured by C. J. KOOREMAN in the Schilt photometer, a ·00, b ·54, c 1·06 and e 1·43 m'. The comparison star d has a close companion, which disturbs the measures in the photometer [1].

The three appearances observed are as follows:

From these observations the following three epochs of minimum were derived: J.D. hel. 2425411·54, 5445·47 and 6090·39. The two intervals 33·93 and 644·92 are in the proportion of 1 : 19. The corresponding period is $33^d \cdot 943$ with an estimated mean error of $\pm$ $^d \cdot 002$. As the real period could be a fraction of this I asked for more observations from the Harvard Observatory, and I am indebted to Miss HOFFLEIT for four additional epochs of minimum. The 7 minima thus available are given in the ac-

Epochs of UW Normae

Min. at J.D.—2420000	E	O—C
d		d
5411·54	0	$+ \cdot 01$
5445·46	4	0
5776·18	43	0
6089·94	80	$- 2$
7192·34	210	$+ 1$
7277·14	220	$- 2$
8337·14	345	$+ 1$

[1] The bright star in the upper righthand corner of the diagram of the surroundings of the variable is CPD—$54° 7650$, $9^m \cdot 2$.

companying table. They yield according to least squares the ephemeris:

Min. at J.D. $2426506^{d}\cdot222 + 8^{d}\cdot48601 \times E$
$$\pm \ \cdot006 \pm \ \cdot00010$$

The phases were calculated from the formula:
$$\text{phase} = {}^{d^{-1}}\cdot117841 \ (\text{J.D.} - 2420000)$$

WZ Arae

This variable has been estimated by W. E. KRUYT-BOSCH on 291 plates, but no period was derived. The present writer looked the plates over again and added 44 later ones. As the determination of the period still remained ambiguous a number of selected plates were measured in the Schilt photometer by C. J. KOORE-MAN. It was then found that all the observations were satisfied by the period $14^{d}\cdot1423$. The phases were calculated from the formula: phase $= \cdot07071$ (J.D. hel. $- 2420000$). The provisional magnitudes measured by KOOREMAN on 17 plates near minimum are:

J.D. hel. −2420000	$\Delta m'$	phase	J.D. hel. −2420000	$\Delta m'$	phase
	m'	P		m'	P
5417·4166	·28	·0635	5714·5654	·32	·0769
·4388	·32	·0671	·5874	·37	·0785
45·3570	·36	·0412	42·3760	·28	·0434
·3792	·19	·0428	6010·5781	·00	·0080
·4013	·31	·0443	·6001	·00	·0095
·4234	·32	·0459	67·4976	·26	·0328
·4462	·25	·0475	·5194	·16	·0343
·4684	·31	·0491	·6323	·21	·0423
5685·5396	·08	·0245	8062·2467	·21	·0815
5714·5654	·32	·0769	·2682	·18	·0830
·5874	·37	·0785	8402·2699	−·18	·1245

At maximum light the provisional magnitude is $\Delta m' = m'_{v} - m'_{a} = - \cdot035$ and the ephemeris is: min. at J.D. $2426067^{d}\cdot70 + 14^{d}\cdot1423 \times E$.
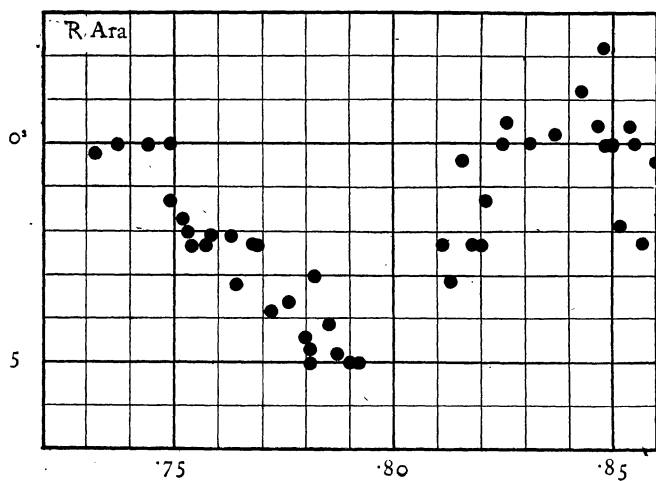
R Arae

As mentioned in *B.A.N.* No. 181, p. 140 W. E. KRUYTBOSCH estimated R Arae on 180 Franklin-Adams plates in order to check the period. In combination with additional material the present writer made naked eye estimates of this variable on 337 plates. As comparison stars were used a = CPD $- 55°7079$, $^{s}\cdot00$, b $= - 55°7462$, $^{s}\cdot23$ and c = CPD $- 56°7703$, $^{s}\cdot50$.

The following epoch of minimum was derived from observations on the descending and ascending branch of the lightcurve: J.D. hel. $2425818^{d}\cdot028 \pm {}^{d}\cdot007$ (m.e.), which does not indicate any change of period since the observations by ALEXANDER W. ROBERTS about 40 years ago. The period derived from these Franklin-Adams plates alone is $4^{d}\cdot42509 \pm {}^{d}\cdot00005$ (m.e.). In addition the star was found faint on J.D. hel. $2428402\cdot28$.

The normal epoch given by ROBERTS, $2415025\cdot316$, does not properly represent his observations, of which there are none after 1899, as it is thus not independent of the uncertainty in the period.

The most probable value of the period is $4^{d}\cdot42507 \pm {}^{d}\cdot00003$ (m.e.).

Epochs of R Arae

J.D. hel. − 2420000	bright-ness	fraction of day reduced to $^{s}\cdot23$	E	kind of branch	O—C
d	s	d	d		d
5406·329	·00	·431	0	− 1	+ ·050
15·244	·32	·204	2	− 1	− 27
·266	·23	·266	2	− 1	+ 35
·280	·38	·214	2	− 1	− 17
·295	·36	·238	2	− 1	+ 7
·318	·47	·211	2	− 1	− 20
·450	·23	·450	2	+ 1	− 9
·473	·04	·389	2	+ 1	− 70
·496	·13	·451	2	+ 1	− 8
37·448	·30	·417	7	− 1	+ 61
5720·520	·17	·546	71	− 1	− 16
·541	·23	·541	71	− 1	− 21
38·489	·31	·525	75	+ 1	+ 35
·512	·23	·512	75	+ 1	+ 21
91·372	·21	·381	87	− 1	+ 18
·394	·23	·394	87	− 1	+ 31
5831·276	·50	·156	96	− 1	− 33
53·279	·20	·293	101	− 1	− 22
·302	·21	·310	101	− 1	− 4
6012·564	·13	·608	137	− 1	− 10
·586	·23	·586	137	− 1	− 31
6123·504	·23	·504	162	+ 1	+ 31
7663·250	·44	·158	510	− 1	− 17
·272	·41	·192	510	− 1	+ 18