Estimates of fifteen variable stars in Vela and Puppis (Errata: 10 146)

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Estimates of fifteen variable stars in Vela and Puppis, by *J. de Kort.*

The present estimates of variable stars were made with a ten times enlarging eyepiece on plates taken at Johannesburg by Dr H. VAN GENT and Dr A. DE SITTER with the Franklin-Adams instrument. The plates cover a field of 10° × 10° with Boss P.G.C. 2267 as centre.

The main results are collected in Table 1. In the sixth column the following abbreviations are used: Hzg for E. HERTZSPRUNG [1]), In for R. INNES [2]), dK for the writer, Pl for L. PLAUT [3]). The Julian Days are given in heliocentric mean astronomical time Greenwich. The phases, unless otherwise stated,

TABLE 1.

	α (1875·0)	δ (1875·0)	type	period	(m.e.) unit: last place	reciprocal period	found by	maxi-mum		minimum		J.D. central epoch —2420000		(m.e.)	m.e. of estimate
	h m s	° ′		d	±	d⁻¹		m	s	m	s		d	d ±	± s
a	7 59 45·2	—48 06·5	long-per.	201	—	—	dK	13·5	2·0	[15·6:	[17·0	max	6516	—	—
b	8 04 30·2	—43 37·7	long-per.	461	—	—	In	12·0	—1·2	16·0:	38·1	max	4802	—	—
c	8 04 43·4	—46 09·1	long-per.	303	—	—	Hzg	11·7	—2·0	16·2	29·0	max	7383	—	—
d	8 08 24·4	—48 38·4	Algol	2·710900	13	·3688116	dK	12·9	6·0	[14·9:	[33·2	min	6393·910	·024	1·3
e	8 09 17·7	—47 45·2	long-per.	118·5	—	—	dK	11·1	5·4	11·7	8·3	max	6659	—	—
f	8 11 17·3	—45 23·8	W UMa	2× ·1672038	9	2·9903633	dK	13·8	6·1	14·2	13·9	min	6307·690	·001	2·3
g	8 14 01·7	—45 00·2	W UMa	·26498597	23	3·773792	In	12·9	3·4	13·8	10·9	4 br	—	·0016	1·6
h	8 18 09·3	—46 54·4	δ Cep	3·372462	23	·2965185	dK	14·0	1·9	15·1:	16·9	ris br	6339·204	·013	2·4
i	8 23 48·5	—39 39·4	pec. Algol	7·72461	27	1·294563	dK	12·1	1·2	13·0	7·8	min	6141·36	·018	—
k	8 25 13·7	—41 08·9	pec. nova	—	—	—	dK	13·2	—	14·3	—	—	—	—	—
l	8 31 05·6	—48 16·0	W UMa	2× ·1510482	6	3·310201	dK	14·0	16	15·1	43	min	6288·617	·003	5·6
m	8 35 41·2	—42 23·1	W UMa	·5162856	12	1·936912	dK	10·5	1·5	11·2	7·4	4 br	—	·004	1·1
n	8 40 29·8	—44 31·8	Algol	4·2308	—	·23636	Pl	12·5	8	13·4	31	min	6183·48	—	3·2
o	8 41 21·8	—46 49·6	W UMa	·4905399	17	2·038569	Pl	14·0	8	15·3	31	ris br	6400·657	·003	2·5
p	8 43 35·7	—42 11·8	Algol	1·344807	6	·743601	dK	13·2	6	15·0	23	des br	6459·522	·002	—

have been computed as follows: Phase = (J.D.—2420000) × the reciprocal period given in Table 1. The epochs were defined in various ways, which are briefly indicated in the ninth column. Generally the sharpest definition which was possible, given the character of the variation and the accuracy of the observations, was selected.

The photographic magnitudes given are to be considered as provisional only. They were obtained in the following way. Photographic magnitudes of, on the average, two comparison stars were derived from star counts with the aid of the quantities log $N_{m, \beta, \lambda}$ given in *Groningen Publ.* **43**. Of the fainter comparison stars no magnitudes were determined in this way, the faintest magnitude actually obtained with our counts being $14^m{\cdot}6$. These magnitudes fix the zero points of our estimates. The scale has been derived from estimates on plates taken with a coarse grating ($\Delta m = {}^m{\cdot}97$) in front of the objective. Some of the magnitudes at low brightness will be systematically too bright. When this effect is probably more pronounced, the magnitudes are marked by a colon. In cases where the variable was invisible on the plate, it has been indicated that its brightness is fainter than the faintest visible comparison star. The photographic magnitudes for star *k* were obtained in a different way described below. The values derived from star counts are $13^m{\cdot}3$ and $13^m{\cdot}6$ for the comparison stars a and c respectively.

The mean error of a single estimate was usually derived by means of the expression $\sqrt{\Sigma(\Delta s)^2/2n}$, where Δs is the difference in brightness between two observations following each other in phase and n the number of differences.

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1) Unpublished discovery.
2) *U.O.C.* No. 35, 276 (1916), cf. R. PRAGER, *Astr. Abh.* **9**, 3 (1934).
3) Unpublished discoveries.

TABLE 2.

a

	m	s
a	13·2	·0
b	13·8	4·0
c	14·3	8·1
d	14·9	12·5
e	15·6:	17·0

b

	m	s
A	12·1	·0
a	12·6	4·3
b	13·0	9·4
c	13·5	14·5
d	14·1	20·5
e	14·7	25·5
f	15·3	30·0
g	15·6	33·7
h	16·1	38·9

c

	m	s
a	12·0	·0
b	12·8	5·4
c	13·5	10·0
d	14·3	15·7
e	15·1	21·2
f	15·8	25·7

d

	m	s
A	12·4	·0
a	12·7	4·2
b	13·0	7·9
d	13·3	12·9
e	13·7	18·2
f	13·9	21·5
g	14·2	26·5
h	14·5:	29·6
i	14·7:	33·2

e

	m	s
a	10·0	·0
b	11·2	5·7
c	12·3	11·3

f

	m	s
b	13·7	3·9
c	14·0	8·9
d	14·2	13·4
e	14·5	18·6
f	14·7	22·9

	m	s′
g	13·8	4·0
h	14·1	8·1
i	14·5	11·9
l	14·9	15·4

g

	m	s
a	12·6	·0
b	13·2	6·1
c	14·0	12·9

h

	m	s
A	13·9	·0
a	14·1	3·3
b	14·4	6·9
c	14·7	11·0
d	15·1	15·7
e	15·4:	20·2

i

	m	s
f	11·9	·0
g	12·5	4·2
h	13·1	8·7
e	13·6	11·7

k

	m
a	13·1
b	13·5
c	13·7
d	14·0
e	15·1

l

	m	s
a	13·8	11·2
b	14·2	19·7
c	14·5	27·9
d	14·9	38·6
e	15·2	47·2

m

	m	s_L
a	10·3	·0
b	10·8	7·2
c	11·1	7·2
d	11·5	12·5

	s_O	s_K
a	·0	·0
b	2·7	2·9
c	4·4	6·2
d	8·4	9·9

n

	m	s
a	12·2	·0
b	12·4	6·0
c	12·9	17·7
d	13·4	30·7
e	13·7	40·0

o

	m	s
a	13·6	·0
b	13·9	5·7
c	14·3	13·7
d	14·8	21·4
e	15·3	32·1

p

	m	s
a	12·5	·0
b	13·0	4·1
c	13·4	8·0
d	13·8	12·5
e	14·2	16·6
f	14·7	20·7

The brightness of the comparison stars, the observed epochs compared with an ephemeris and the mean light curves are given in the Tables 2, 3 and 4 respectively. Estimates marked as uncertain when made have been omitted from most of the mean light curves.

In Figure 1 the angular size of each diagram is indicated in the lower right corner or along one of the sides.

In Figure 2 each division on the line of abscissae represents one tenth of a period. The phases $^{P}{\cdot}5$ and $^{P}{\cdot}0$ are marked by larger divisions.

Remarks on individual variables.

a. The period was derived from the observed maxima as well as from the branches. The maxima differ in width and their dispersion in brightness is of the order of $\pm\ ^{m}{\cdot}4$. The minimum brightness probably is below the limit of even the best plates. The mean light curve is, for its observed upper part, approximately of the type α_3 according to LUDENDORFF (*Hb. d. Ap.* **7**, 627, 1934). It was used to reduce the observed epochs to the nearest time of maximum.

b. This star has a faint southern companion visible on the sharpest plates. I always endeavoured to estimate the combined brightness of the pair. The apparent range is, probably, not much influenced by the presence of the companion. The mean light curve is of LUDENDORFF's type α_2. The first of the epochs of maximum given is one of INNES' observations, the second being found on The Photographic Map of the Sky South of −19° (1875), (cf. *U.O.C.* No. 38) −46°, 42.

Three old minima at J.D. 2418765, 2419513 and 2421006, the first of which is found on Plate 3 of *H.A.* **72**, No. 3, the second on Franklin–Adams Chart No. 32 and the last of which is given by INNES, agree well with the ephemeris.

c. This long-period variable of type β_2, according to LUDENDORFF's classification, was independently rediscovered by the writer. The comparison star designed as a is the star CPD−46° 2167 ($10^{m}{\cdot}2$). The period was computed from observations on five rising branches; the times in Table 3 are those of the computed next following maximum. They are in good agreement with a maximum found on F.-A. Chart No. 32 (J.D. 2419513) and with a minimum on the Union Observatory Map −46°, 42.

d. The period of this Algol star has been determined by least squares from points on the rising branch of the primary minimum, assuming an increase in brightness of one step in $^{d}{\cdot}00602$. If we reduce them with the aid of this assumption to a brightness of 37^{s}, we obtain the epochs of Table 3. In the mean light curve the phase is $^{d-1}{\cdot}3688116 \times$ (J.D.−2426393·910), taken without regard to sign. A secondary minimum appears to be present of $^{s}{\cdot}9$ depth and of the same width as the primary, the range of which is of the order of 30^{s}.

e. The variable is CPD −47° 1986 ($9^{m}{\cdot}6$) = H.D. 69068 (m_{pg} $10^{m}{\cdot}2$, Sp Mb). The comparison stars are CPD −48° 1552 ($8^{m}{\cdot}8$) = H.D. 68809 (m_{pg} $9^{m}{\cdot}2$ Sp K0), CPD −47° 1971 ($9^{m}{\cdot}6$) = H.D. 68923 (m_{pg} 10·2, Sp G5) and CPD −47° 1979 ($9^{m}{\cdot}9$). The epochs given in Table 3, though mostly derived from rising and descending branches, have been reduced to the epoch of maximum. The residuals O−C will, therefore

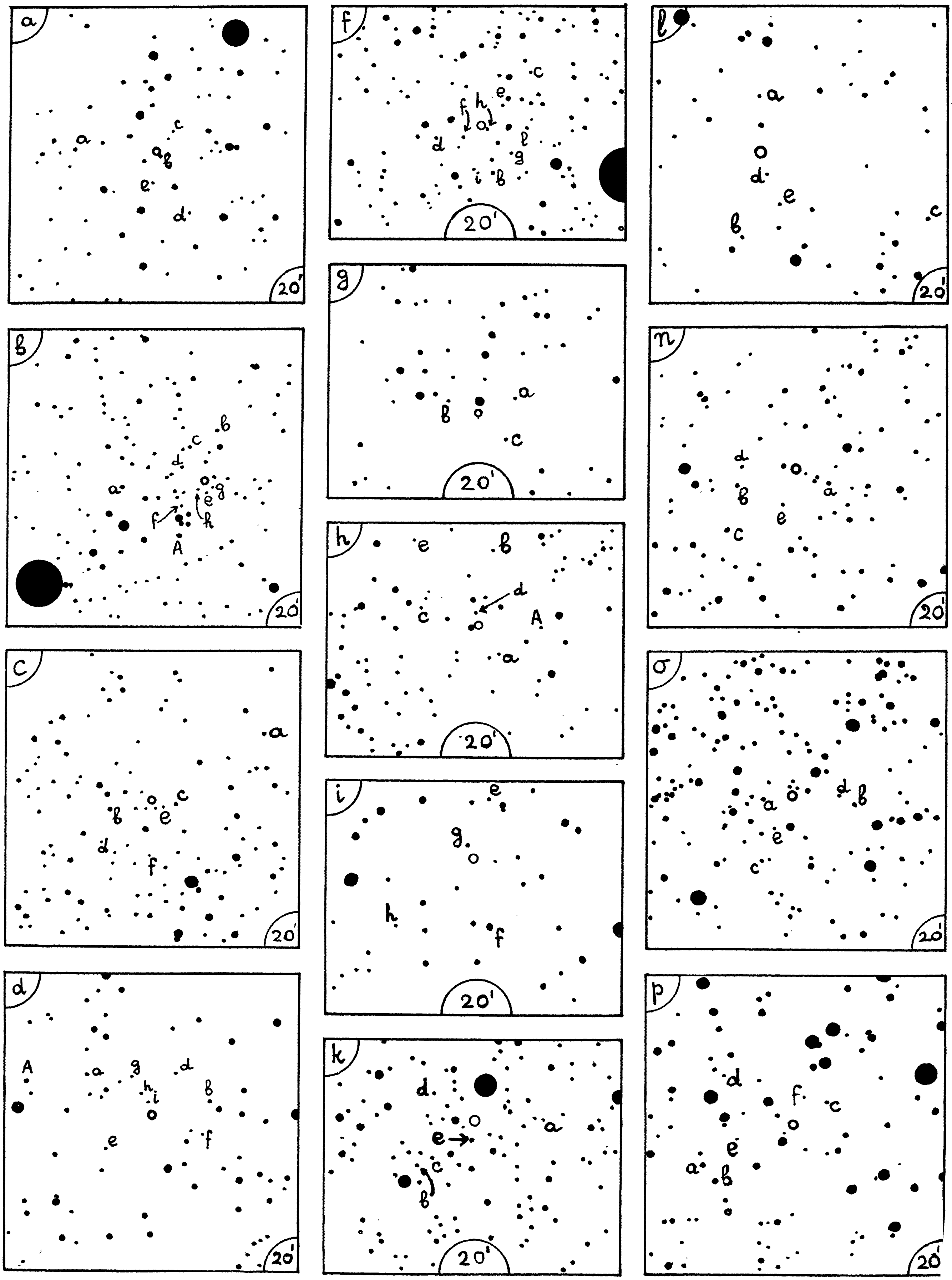

Figure 1.

TABLE 3.

J.D.	E	O−C
a		
d		d
2425713	−4	+1
5910	−3	−3
6110	−2	−4
6320	−1	+5
6510	0	−6
7530	+5	+9
7720	+6	−2
b		
d		d
2413282	−25	+ 5
2422019	− 6	−17
5692	+ 2	−32
6175	+ 3	−10
7561	+ 6	− 7
8523	+ 8	+33
8980	+ 9	+29
c		
d		d
2426157	−4	−14
6481	−3	+ 7
7715	+1	+29
7979	+2	−10
8280	+3	−12
d		
d		d
2425968·292	−157	−·006
6063·184	−122	+·004
6063·187	−122	+·008
6063·179	−122	−·001
6090·298	−112	+·010
6090·296	−112	+·008
6266·491	− 47	−·007
6266·487	− 47	−·010
6410·162	+ 6	−·013
6410·179	+ 6	+·004
7516·232	+414	+·009
7516·216	+414	−·005
e		
d		d
2425715	− 8	+ 4
5945	− 6	− 3
6065	− 5	− 1·5
6305	− 3	+ 1·5
6415	− 2	− 7
7525	+ 7	+35·5
7715	+ 9	−10·5
7815	+10	−19
f		
d		d
2425713·282	−3555	+·001
5719·294	−3519	−·006
6028·285	−1671	−·008
6030·454	−1658	−·013
6057·377	−1497	−·010
6063·237	−1462	−·002
6091·323	−1294	−·007
6115·241	−1151	+·001
6118·249	−1133	·000
6123·275	−1103	+·010
6264·554	− 258	+·002
6265·571	− 252	+·016
6266·573	− 246	+·014
6270·557	− 222	−·015
6270·579	− 222	+·007
6273·587	− 204	+·005
d		d
2426303·502	− 25	−·009
6310·522	+ 17	−·012
6324·408	+ 100	−·004
6337·443	+ 178	−·010
6338·295	+ 183	+·007
6362·367	+ 327	·000
6388·319	+ 482	+·036
6437·261	+ 775	−·012
6513·202	+1229	+·018
7519·255	+7246	+·005
7802·479	+8940	−·014
g		
d		d
2425950·435	− 4106	+·008
5971·366	− 3948	+·005
5973·493	− 3932	+·012
5974·413	− 3925	+·005
5997·314	− 3752	−·015
6010·324	− 3654	+·010
6029·257	− 3511	−·004
6036·298	− 3458	+·015
6066·226	− 3232	·000
6086·364	− 3080	−·001
6094·318	− 3020	+·003
6115·241	− 2862	−·007
6117·241	− 2847	+·006
6249·590	− 1848	−·006
6305·496	− 1426	−·012
6309·484	− 1396	+·001
6337·309	− 1186	+·002
6337·443	− 1185	+·004
6388·297	− 801	−·020
6410·317	− 635	+·007
6412·300	− 620	+·002
6420·256	− 560	+·009
6510·208	+ 119	−·002
6835·227	+ 2572	+·012
7515·427	+ 7706	−·007
7516·222	+ 7712	−·007
7516·350	+ 7713	−·012
7802·414	+ 9872	·000
9050·227	+19290	−·006
h		
d		d
2425742·301	−177	+·023
5742·299	−177	+·021
5951·310	−115	−·061
6005·357	− 99	+·027
6005·217	− 99	−·113
6015·473	− 96	+·025
6015·495	− 96	+·047
6086·319	− 75	+·049
6305·436	− 10	−·044
6305·513	− 10	+·033
6305·485	− 10	+·005
6305·527	− 10	+·047
6511·104	+ 51	−·096
6511·221	+ 51	+·021
7809·612	+436	+·014
7809·600	+436	+·002
i		
d		d
2425971·34	− 22	−·08
5971·37	− 22	−·06
5971·43	− 22	+·01
5971·46	− 22	+·03
6002·43	− 18	+·11
6002·46	− 18	+·13
d		d
2426087·27	− 7	−·02
6087·34	− 7	+·05
6118·25	− 3	+·06
6118·27	− 3	+·08
6141·19	0	−·17
6249·59	+ 14	+·08
6249·61	+ 14	+·10
6303·46	+ 21	−·12
6303·48	+ 21	−·10
6303·50	+ 21	−·08
6303·52	+ 21	−·06
6396·31	+ 33	+·03
6396·34	+ 33	+·06
6396·36	+ 33	+·08
7516·22	+178	−·12
7516·33	+178	−·03
7516·35	+178	·00
l		
d		d
2425712·371	− 3815	+·003
5714·304	− 3802	−·028
5742·271	− 3617	−·005
5923·531	− 2417	−·003
5928·353	− 2385	−·014
6036·505	− 1669	−·013
6039·247	− 1651	+·010
6057·377	− 1531	+·015
6063·260	− 1492	+·007
6065·229	− 1479	+·012
6087·272	− 1333	+·002
6093·328	− 1293	+·016
6116·274	− 1141	+·003
6126·236	− 1075	−·004
6126·258	− 1075	+·018
6266·573	− 146	+·009
6268·531	− 133	+·003
6299·484	− 72	−·009
6306·424	+ 118	−·017
6306·446	+ 118	+·005
6310·368	+ 144	·000
6310·500	+ 145	−·019
6310·522	+ 145	+·003
6324·408	+ 237	−·008
6324·430	+ 237	+·014
6338·318	+ 329	+·006
6396·309	+ 713	−·006
6510·208	+ 1467	+·003
7515·427	+ 8122	−·004
7516·350	+ 8128	+·013
7809·357	+10068	−·016
m		
d		d
2425713·30	−4848	+·04
5731·32	−4778	−·02
6012·47	−3689	+·01
6064·32	−3488	−·03
6094·31	−3372	+·02
6102·31	−3341	+·02
6117·25	−3283	−·01
6304·42	−2558	+·01
6305·44	−2554	·00
6309·56	−2538	−·02
6337·46	−2430	+·01
6382·37	−2256	−·01
6412·31	−2140	−·01
7520·30	+2152	+·03
7809·39	+3272	·00
7834·95	+3371	+·01
8182·96	+4719	+·04
8300·88	+5176	−·01
d		d
2428307·87	+5203	·00
8519·00	+6021	−·02
8549·22	+6138	·00
8580·44	+6261	−·03
n		
d		d
2425742·28	−105	+·06
5997·35	− 44	+·01
6014·33	− 40	+·07
6090·36	− 22	−·05
6141·19	− 10	+·01
6310·40	+ 30	·00
6382·35	+ 47	+·01
6454·21	+ 64	−·05
6509·22	+ 77	−·05
o		
d		d
2425712·378	−1403	+·006
5742·306	−1342	+·011
5769·417	− 879	+·002
5769·420	− 879	+·005
5771·380	− 875	+·003
5772·355	− 873	−·003
5797·371	− 822	−·004
6028·288	− 759	+·009
6029·256	− 757	−·006
6030·241	− 755	·000
6276·488	− 253	−·004
6303·478	− 198	+·005
6303·467	− 198	−·006
6306·415	− 192	−·002
6337·310	− 129	−·010
6337·316	− 129	−·004
6338·279	− 127	−·022
6387·340	− 27	−·015
6387·362	− 27	+·006
6388·331	− 25	−·004
6417·274	+ 34	−·004
6417·288	+ 34	+·010
6420·255	+ 40	+·035
6439·340	+ 79	−·012
6439·340	+ 79	−·012
6835·220	+ 886	+·002
6835·224	+ 886	+·005
7807·461	+2868	−·006
7809·433	+2872	+·003
7809·440	+2872	+·009
p		
d		d
2425971·363	−363	+·005
5971·356	−363	−·002
6030·529	−319	·000
6115·249	−256	−·002
6115·262	−256	+·011
6146·192	−233	−·004
6264·549	−145	+·019
6264·533	−145	+·003
6299·501	−119	+·011
6303·507	−116	−·017
6303·518	−116	−·006
6396·322	− 47	+·006
6396·308	− 47	−·008
6439·345	− 15	−·006
6439·367	− 15	+·016
6501·202	+ 31	−·009
6501·215	+ 31	+·004
7430·465	+722	+·011
7519·234	+788	+·004
7519·233	+788	+·003

TABLE 4.

d

n	P	s
3	·011	30·0
3	·017	29·7
5	·023	25·1
5	·035	19·3
6	·051	12·5
6	·065	8·7
6	·075	7·3
10	·088	6·1
15	·104	5·8
15	·118	6·2
15	·137	6·0
15	·153	6·6
15	·169	6·0
15	·191	5·6
15	·213	6·0
15	·238	6·2
15	·256	6·0
15	·275	6·2
15	·304	6·1
15	·341	5·9
15	·367	5·6
15	·387	6·1
15	·407	6·4
20	·422	6·1
20	·455	6·6
20	·490	6·9

f

n	P	s
20	·046	6·1
20	·121	6·4
20	·187	8·1
20	·263	12·7
20	·340	10·6
20	·394	9·4
20	·440	7·3
20	·494	6·5
20	·543	6·4
20	·609	6·9
20	·686	8·2
20	·748	11·0
20	·795	13·4
20	·847	9·6
20	·899	7·6
25	·968	6·4

g

n	P	s
15	·007	3·7
10	·054	4·3
10	·091	6·2
10	·118	6·7
11	·162	8·9
6	·190	9·5
10	·215	7·9
10	·259	5·4
10	·285	5·2
10	·315	3·9
10	·344	3·7
10	·371	3·5
10	·406	3·4
10	·436	3·5
10	·456	3·6
10	·489	3·8
10	·519	4·2
10	·551	4·6
10	·582	5·8
10	·615	7·7
7	·644	9·2
8	·672	10·9
7	·687	10·2
10	·718	9·0
10	·752	6·8
10	·778	5·5
10	·814	4·3
20	·865	4·0
20	·923	3·7
10	·967	3·8

h

n	P	s
20	·045	13·8
20	·103	14·6
20	·143	16·0
20	·202	15·9
20	·282	15·9
20	·356	16·7
20	·415	16·4
20	·476	16·9
20	·549	16·8
20	·611	16·4
6	·647	16·1
5	·667	14·3
5	·690	10·1
5	·696	8·4
5	·706	6·4
10	·722	4·1
10	·758	1·9
10	·792	4·1
10	·822	5·8
20	·864	8·0
20	·902	12·0
20	·966	11·8

i

J.D. 2425700—2426200

n	P	s
2	·023	6·2
6	·040	8·0
4	·055	4·2
4	·083	·8
11	·155	1·2
9	·284	2·6
12	·376	3·1
11	·426	3·8
13	·452	3·7
12	·532	3·6
13	·644	3·3
11	·693	2·4
10	·776	2·2
8	·829	2·2
12	·923	1·7
7	·958	2·3
6	·982	2·0

J.D. 2426200—2426700

n	P	s
3	·003	1·2
4	·026	7·5
5	·048	7·7
13	·142	2·4
15	·271	3·1
10	·416	3·8
14	·520	2·7
15	·638	2·5
8	·752	2·0
14	·824	1·7
12	·923	1·8
4	·978	1·5

J.D. 2426700—2429100

n	P	s
4	·060	2·6
6	·084	2·6
6	·291	2·8
4	·428	3·1
7	·556	2·3
10	·623	2·7
4	·696	3·3
8	·804	2·7
6	·858	2·3
9	·932	3·1
4	·959	2·8
4	·965	2·9
5	·981	1·5

l

w	P	s
29	·011	28·8
28	·045	36·1
29	·086	41·1
30	·134	36·8
29	·188	26·1
30	·246	19·7
30	·302	17·4
30	·349	17·6
30	·389	20·0
29	·429	19·4
29	·462	22·0
28	·499	24·7
29	·537	31·5
28	·596	35·9
28	·643	29·1
29	·683	24·1
29	·730	22·2
29	·775	18·2
30	·825	18·5
29	·868	18·4
27	·911	19·9
30	·959	24·2

m

n	P	s_K	s_O
10	·017	5·3	2·9
10	·042	6·6	4·0
11	·076	6·3	5·0
10	·107	7·4	5·6
10	·131	6·8	5·0
10	·155	6·9	4·8
10	·183	4·8	3·3
10	·205	3·1	2·1
10	·231	3·7	2·4
10	·252	2·8	1·7
10	·272	3·1	1·3
10	·298	2·2	1·1
10	·334	1·3	1·2
10	·362	1·9	1·0
10	·389	1·6	·6
10	·418	2·1	1·8
10	·452	2·3	1·3
10	·475	2·9	1·5
10	·505	3·9	2·3
10	·554	5·7	3·7
10	·590	6·1	4·7
10	·623	6·1	5·6
10	·656	6·2	4·4
10	·683	4·6	3·3
10	·711	4·1	3·3
10	·739	3·5	2·4
10	·772	2·7	1·6
10	·797	2·0	1·6
10	·822	2·2	1·3
10	·855	2·0	1·1
10	·892	2·0	·9
10	·921	2·0	1·3
10	·946	2·1	1·4
10	·979	3·9	1·7

n	P	s_L
10	·030	5·8
10	·082	8·5
10	·180	5·4
10	·280	3·7
10	·347	2·3
10	·420	2·8
10	·495	5·2
10	·543	6·6
10	·603	7·6
10	·670	6·2
10	·728	4·6
10	·767	3·6
10	·838	2·8
10	·912	3·6
10	·958	4·7

n

n	P	s
30	·109	7·3
30	·200	7·1
30	·317	8·5
30	·388	8·6
10	·450	9·2
6	·485	13·0
5	·514	23·0
5	·519	26·3
5	·527	31·2
4	·534	31·1
5	·541	25·7
5	·549	24·1
5	·565	16·5
5	·575	11·1
5	·591	9·1
5	·609	7·1
10	·624	8·4
30	·696	7·6
30	·777	8·1
30	·833	7·8
30	·900	6·9
30	·996	8·6

o

n	P	s
8	·004	30·1
7	·019	28·8
6	·033	24·7
5	·045	18·9
8	·063	17·6
8	·080	15·5
8	·097	12·8
30	·141	8·5
30	·224	6·8
30	·319	7·5
30	·404	9·8
10	·453	13·5
10	·473	12·3
10	·495	12·4
10	·522	15·6
10	·556	10·3
30	·626	9·4
30	·740	8·1
29	·854	10·1
6	·919	15·6
6	·939	20·2
7	·962	27·2
5	·984	30·9

p

n	P	s
10	·012	6·0
10	·050	5·4
10	·081	5·5
10	·105	5·4
10	·135	5·3
10	·172	5·2
10	·219	5·5
10	·257	5·6
6	·279	6·8
9	·296	11·3
8	·310	13·5
4	·327	18·9
2	·342	23·2
4	·354	17·8
5	·371	13·0
3	·391	7·8
4	·405	5·5
10	·426	5·5
10	·452	5·2
10	·484	5·4
10	·512	5·1
10	·542	4·9
10	·576	5·3
10	·604	5·5
10	·632	5·0
10	·663	5·4
10	·686	5·8
10	·708	5·6
10	·725	5·6
10	·745	5·6
10	·764	5·4
10	·797	5·6
10	·818	5·7
10	·850	5·5
10	·879	5·6
10	·902	5·3
10	·944	5·7
10	·980	5·0

show also the systematic errors probably inherent in this reduction. The light curve corresponds to LUDENDORFF's type β_3. The small range (^{m}·9), however, is somewhat exceptional. It makes a comparison with older observations uncertain.

f. The determination of the present period caused some difficulties, not so much because of its shortness compared with the interval of one day, as the available plates have been taken at widely different hour angles, but on account of the small range, which is the reason that each observation gives only a rough determination of the phase. The variable was, therefore, estimated once more on the same plates with a different set of comparison stars. The epochs given in the table are those of the most certain minima only. Though we find no difference between even and odd minima, we have to double the apparent period.

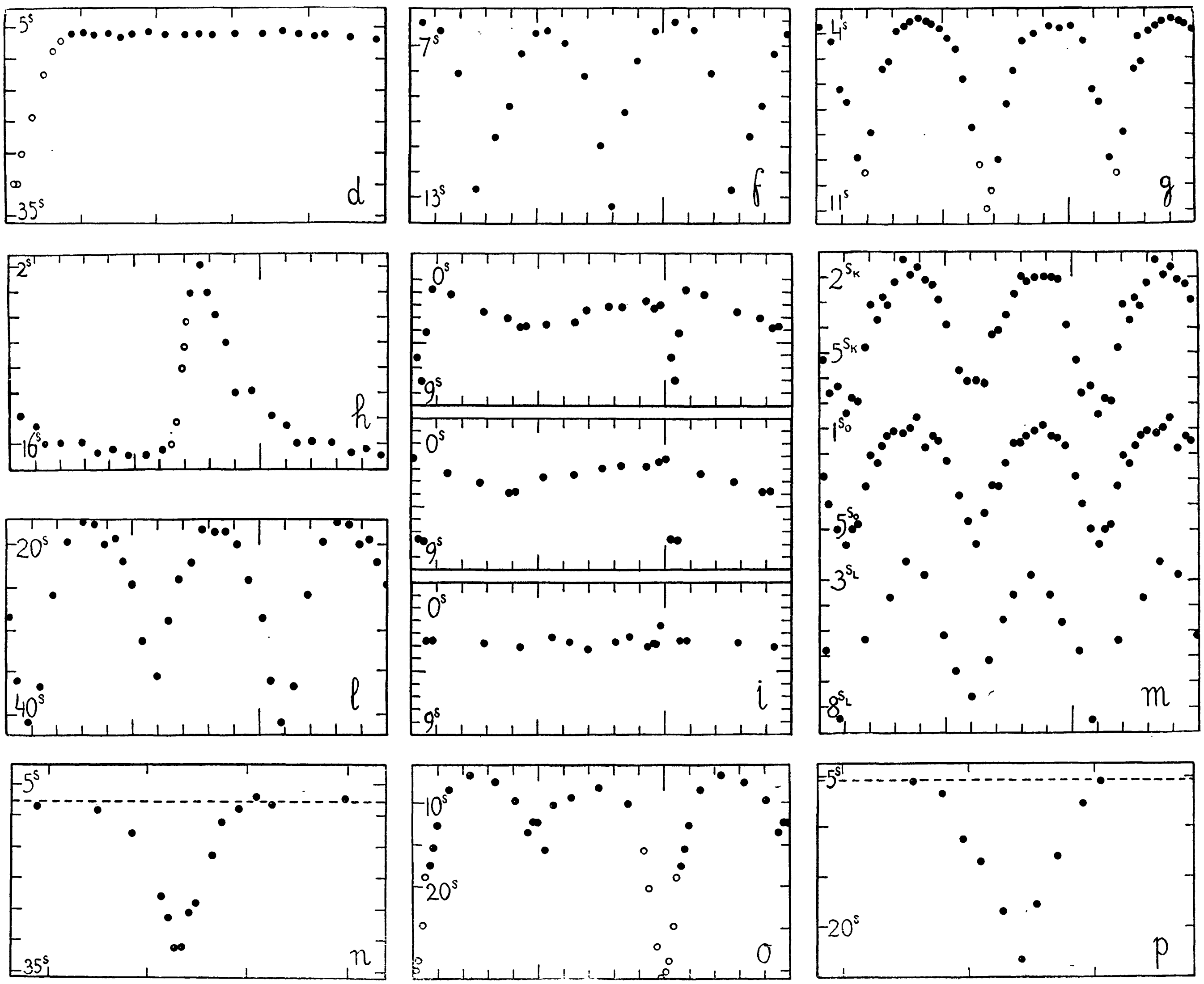

FIGURE 2.

g. The period was derived from the four branches of the light curve by least squares. The following equations of condition were adopted:

$$\alpha_1 E_1 + \alpha_2 E_2 + \alpha_3 E_3 + \alpha_4 E_4 + tP = u,$$

where u is the time of an observation on one of the branches, reduced to a fixed brightness by means of the adopted slope of the branch. Further α_1 is unity for a point situated on the first branch, α_2, α_3, α_4 then being taken zero, etc. This procedure has the advantage of yielding values for the epochs and the period, the errors of which are independent, if the central epoch is used in each case. From these one can easily obtain the values, together with their mean errors, of the epochs of minimum or their difference in time, or of the widths of the minima, by applying the well known rules for independent errors.

The results of the solution are:

			d	d	
central epoch of descending branch, primary minimum	$= E_1$	=	2426710·6479	± ·0016	(m.e.)
,, ,, ,, rising ,, ,, ,,	$= E_2$	=	2426383·4374	± ·0015	(m.e.)
,, ,, ,, descending ,, secondary ,,	$= E_3$	=	2426526·3537	± ·0016	(m.e.)
,, ,, ,, rising ,, ,, ,,	$= E_4$	=	2426519·5029	± ·0016	(m.e.)
period	$= P$	=	·26498597	± ·00000023	(m.e.)
mean error of unit weight (1 estimate)				± ·0075.	

Phases of the epochs: $25324^{P}\cdot589$, $24089^{P}\cdot765$, $24629^{P}\cdot101$, $24603^{P}\cdot248 \pm^{P}\cdot006$ (m.e.). The epochs are for brightness $6^{s}\cdot1$. In Table 3 some observed minima are compared with an ephemeris computed with half the orbital period.

h. The shape of the minimum of this δ Cephei variable remains uncertain, the variable during that phase being near the limit of most of the plates. From the residuals in Table 3 there is no indication that the variation is not regular [1].

i. This Algol variable shows a remarkable shape of the light curve for the phase interval between the principal minima. The mean light curve is given for three intervals of time, viz. J.D. 2425700—2426200, J.D. 2426200—2426700, J.D. 2426700—2429100. It seems that a small shift in phase of the secondary light variation relative to the principal minimum has taken place from the first to the second interval and that its amplitude has vanished in the third interval. No attempt will be made here to explain these features. An explanation by a systematic hour angle error is excluded by the distribution of hour angles over phase.

The principal minimum shows no perceptible changes. It remained unobserved during the third interval. It may be added that in the third interval of time about 30 plates have been included which were taken with the variable near the centre. On the ordinary plates the image is about 1 cm distant from the northern edge.

k. On seven plates this variable has been compared in the Schilt microphotometer with its comparison stars and these again with a number of stars in the S.A. No. 172 occurring on the same plates at about the same distance from the centre, the result indicating a nova-like light variation.

J.D.		var
d		m
2425893·55	(normal brightness)	14·34
6388·30		13·69
6388·32		14·12
7713·55		14·03
7713·57		13·97
7713·59		13·18
7713·61		14·00

The star has been estimated on all the available plates and shows only slight variations in brightness. It is always found intermediate in brightness between the comparison stars d and e, with the following exceptions:

At J.D. 2427713·59, on a 30 min. exposure, it is about $1^{m}\cdot2$ brighter than normal, but immediately before and after this exposure the observed brightening is only one third of a magnitude. The true amplitude was, therefore, probably much larger; it may well have reached 2 magnitudes. No observations of the variable have been made during this night besides the four mentioned above. The next preceding and the next following plates are taken sixteen days before and eighty-eight days after this date respectively. In the vicinity of these dates occasional maxima are observed similar to the maximum noted on J.D. 2426388. This perturbation period, as we may call it, extends from J.D. 2427513 to J.D. 2427808.

On all the plates explicitly mentioned the aspect of the star's image is quite normal. Moreover the perturbation period seems to corroborate the reality of the greater change in brightness.

l. The orbital period of the present W UMa system is among the shortest known. The mean light curve represents weighted means of the estimates, weight 2 being given to a good estimate. The primary minimum (odd values of *E*) is somewhat deeper than the secondary.

m. This variable is CPD $-42°$ 2793 ($9^{m}\cdot4$). The stars $-42°$ 2781 ($9^{m}\cdot2$), $-42°$ 2779 ($9^{m}\cdot2$), $-42°$ 2784 ($9^{m}\cdot7$), $-42°$ 2782 ($9^{m}\cdot9$) were used as comparison stars and named a, b, c, d respectively. The star was estimated again on the same plates by Dr Oosterhoff. Afterwards the late Rev. W. O'Leary S.J. kindly made, at my request, 149 estimates on plates of the SX Velorum field, obtained at Riverview College Observatory, Sydney. These plates have been taken during the years 1934—1937 and nearly all our plates are anterior to them. Nevertheless O'Leary's observations yield a good confirmation of the period owing to the considerable difference in longitude between Johannesburg and Sydney.

In Table 4 s_O, s_L and s_K denote estimates by Oosterhoff, O'Leary and the writer respectively. O'Leary estimates the stars b and c of about equal brightness Approximately $s_K = \cdot68 + 1\cdot2\ s_O = -\cdot 1\cdot4 + 1\cdot08\ s_L$

The two minima alternate at unequal intervals This appears in two ways.

First, according to the method described for star *g* the following elements have been found from th writer's estimates:

[1] Cf. *B.A.N.* No. 278, 334 (1936); *Riverview Publ.* No. 2, 28 (1936).

central epoch of descending branch, primary minimum	^{d}2426469·566	$\pm$ ^{d}·005	(m.e.)
,, ,, ,, rising ,, ,, ,,	2426537·834	$\pm$ ·004	(m.e.)
,, ,, ,, descending ,, secondary ,,	2426607·174	$\pm$ ·004	(m.e.)
,, ,, ,, rising ,, ,, ,,	2426531·906	$\pm$ ·004	(m.e.)
period	·5162856	$\pm$ ·0000012	(m.e.)
mean error of unit weight		$\pm$ ·019	

The epochs are computed for those points on the branches, where $s_K = 3{\cdot}6$, a linear change in magnitude being adopted. The phases corresponding to the four epochs are $12530^{P}{\cdot}980$, $12663^{P}{\cdot}209$, $12797^{P}{\cdot}515$, $12651^{P}{\cdot}727$. The phase interval from the midst of primary minimum to the midst of secondary minimum is, with these data, $^{P}{\cdot}526 \pm {}^{P}{\cdot}008$. Not only OOSTERHOFF's but also O'LEARY's light curve well agrees with this deviation of the minima. The period computed from the primary minimum alone is $^{d}{\cdot}5162862 \pm {}^{d}{\cdot}0000016$ (m.e.), from the secondary alone it is $^{d}{\cdot}5162851 \pm {}^{d}{\cdot}0000024$ (m.e.). Thus no motion of the apsides is shown at present. With the aid of older series of observations it will be easily discerned whether the line of the apsides has rotated.

Secondly, the lines of symmetry, determined in much the same way as described in *B.A.N.* No. 166, 39 (1929) from my own light curve, are at $^{P}{\cdot}096 \pm {}^{P}{\cdot}001$ [1]) for the primary and at $^{P}{\cdot}616 \pm {}^{P}{\cdot}003$ for the secondary minimum, the interval being $^{P}{\cdot}520 \pm {}^{P}{\cdot}004$ (m.e.).

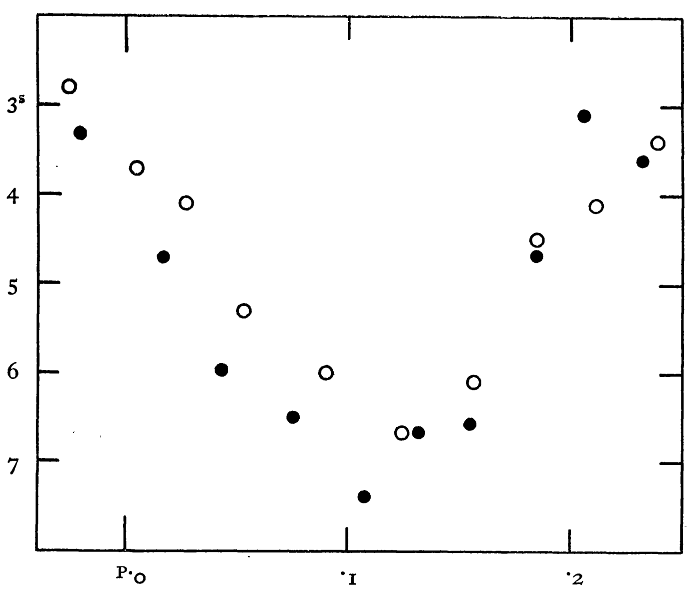

FIGURE 3.
Dots: primary minimum, circles: secondary minimum.

In Figure 3 the three available light curves, reduced to the scale s_K, have been combined. The secondary minimum is displaced by $^{P}{\cdot}5$, to show its deviation from the half-way position.

We find $e|\cos\omega|.\ (1 + \frac{1}{2}\operatorname{cotg}^2 i) = {\cdot}035$.

In Table 3 observations near minimum are compared with an ephemeris computed with the period $^{d}{\cdot}2581428$ and the epoch J.D. $2426964^{d}{\cdot}746$.

n. The reciprocal period $^{d-1}{\cdot}23636$ was used for this Algol star. It fitted the descending and rising branches better than the solution obtained by means of the method of least squares from the observations of low brightness. I estimate its uncertainty to be about one part in ten thousand.

o. The period was improved by a solution based on points on the rising branch of the primary minimum. The epochs given are reduced to that point of the branch where the brightness is 18^{s}.

p. The period was derived from a solution based on points on the descending branch, the epochs being given for a brightness of 14^{s}. There is, perhaps, an indication of ellipticity of the equatorial sections of the stars, the observed semi-amplitude outside the eclipses being of the order of $^{s}{\cdot}3$.

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1) In order to derive the mean error we shall shortly recapitulate the procedure which has been followed. Let $s(P)$ express the relation between brightness and phase as defined by N points of the light curve. The points are equidistant in phase, the constant phase interval being Δ. We first reflect the points against a vertical line $P = P_1$. Suppose now n differences $s(P_1 + \Delta) - s(P_1 - \Delta)$, $s(P_1 + 2\Delta) - s(P_1 - 2\Delta)$, etc. to be formed and let the sum of their squares be denoted by $S(P_1)$. Likewise other sums of n squares $S(P_2)$, $S(P_3)$ are defined. The value of n will be an integer in the vicinity of $\frac{1}{2}(N-2)$. Then the curve $S(P)$ will, by the abscissa P_0 of its minimum, define the line of symmetry, $P = P_0$, of the light curve and, by its height and its width, the mean error of P_0, in the way described by PANNEKOEK (*Untersuchungen über den Lichtwechsel Algols*, p. 215, Diss. Leiden, 1902, see also *B.A.N.* No. 297, 142, 1937). The equations of condition, which have the form $s(P + \Delta) - s(P - \Delta) = 0$, etc., are n in number, the process described above being an equivalent to the standard process of forming normal equations by differentiation of the squared and summed equations of condition. As the number of unknowns is one, the factor $S(P_0 + \text{m.e.}) / S(P_0)$ is in this case $n / (n-1)$. If $S(P)$ can be approximated to by the parabola $S = a + b\,P/\Delta + c\,P^2/\Delta^2$, the mean error can be written in the form $\Delta\sqrt{(a/c - b^2/4c^2) / (n-1)}$, which will be near $\Delta\sqrt{2\,(a/c - b^2/4c^2) / (N-4)}$, cf. HERTZSPRUNG, *B.A.N.* No. 340, 209 (1941). The expression proposed by HALL (*Ap. J.* **90**, 462, 1939) will be too large, as, in his method, it applies to the mean error corresponding to unit weight. This is, however, without taking into account the uncertainty of his drawn curve. With the present method $^{P}{\cdot}99995 \pm {}^{P}{\cdot}00102$ (m.e.) is the middle of the visual eclipse and $^{P}{\cdot}99986 \pm {}^{P}{\cdot}00087$ (m.e.) the middle of the infrared eclipse. The probable errors are thus about 2·5 minutes, whereas HALL finds 6 minutes.

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