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ON THE DETERMINATIONS OF THE CONSTANT OF ABERRATION MADE AT PULKOWA,

BY M. NYRÉN.

In the interesting remarks of Mr. GILL, upon certain astronomical constants, reproduced in the *Bulletin Astronomique* for September, some doubts are expressed on the certainty of the results obtained at Pulkova by observations in the prime-vertical. In part these same doubts may be read in Mr. NEWCOMB's *Astronomical Constants*, and more explicitly still in an article by the same author in the *Astronomical Journal*, no. 369. It was in reply to that article that I wrote for the *Journal*, more than six months ago, the remarks that I take the liberty of producing here with some slight changes. To prevent all misunderstanding I should say that my reply was not sent directly* to the eminent Editor of the *Astronomical Journal*.

The doubts raised by Mr. NEWCOMB, and supported by Mr. GILL, with regard to the results of my prime-vertical observations, rest on the supposition that the small modifications, dependent on brightness, noticed by some astronomers in the personal equation for meridian-transits, will affect also prime-vertical transits of zenithal stars; they suppose that certain traces of such differences that have been noted depend on a general law; they suppose further that the images of such stars, seen in the fully illuminated field of the telescope, are sensibly larger than those seen in twilight without illumination. If these three hypotheses are well based we must, without doubt, regard the results of my observations as subject to the error mentioned.

The determination of W. STRUVE, obtained by the same instrument in the same way, is in all probability below rather than above the true value. Hence it follows that this method of observation, in an authenticated case, does not influence the result in the manner indicated by Mr.

NEWCOMB. Nevertheless, this proof is not decisive for my observations. On the one hand, the equation for brightness might have been insensible in STRUVE's case without being so in mine; on the other hand, the mean brightness of STRUVE's stars is considerably greater than for those in my series, a fact which permitted his making a large part of the observations during daylight in both branches of the prime-vertical, while for fainter stars observation is necessarily limited to night and twilight. In my series we find, among stars much fainter, also those of STRUVE, observed now nearly in the same conditions as they were by him. Now, if the error in question is a function of brightness, it should, for this reason, appear in the differences of the corrections for stars of different brilliancy. Let us divide, then, the 24 stars in my series into three groups, according to magnitude, and take the means of the corrections given in my *Aberration des Étoiles Fixes*, p. 35-36, with the corresponding weights. We thus have

	Corrections	Stars	Weight
Stars brighter than 4 ^m .0,	+0.163	5	554
" between 4 ^m .0 and 5 ^m .0,	+0.030	6	289
" fainter than 5 ^m .0,	+0.080	13	516

These results are incompatible with such an error as has been supposed; the brightest stars, which were all observed also by STRUVE, give the largest correction for the aberration employed.

In reflecting on the method of observing prime-vertical transits of zenithal stars, it also appears to me improbable that an error of this sort can affect them. The personal error, aside from some exceptional cases, ought not to be interpreted as produced by defective estimation of the geo-

* From what the author here says, taken in connection with a letter, dated 1896 May 7, received from him by the Editor, it appears that this article was sent by him indirectly, but that by some mischance it has never been received. Thus, Dr. NYRÉN's letter communicated the fact that he had prepared such an article for this *Journal*, and would shortly forward it for printing, but that he desired preliminarily to submit it to Prof. NEWCOMB for perusal.

From further expressions of his letter it would appear that he intended that the manuscript should subsequently be forwarded to the *Journal*. If so, by some misunderstanding or miscarriage, it has never been received. Under these circumstances it seems eminently proper that the article should be here reproduced, by translation from the *Bulletin Astronomique*. — ED.

metrical bisection of the observed image; the error is committed in the expression, by one manner or another, of the phenomenon in a function of the time. It follows that, if the apparent velocity of the object bisected has diminished to a certain limit, the personal error will be imperceptible, or, at least, will not change with any small modification in brilliancy of the image. This limit is doubtless attained as well in prime-vertical transits of zenithal stars as in meridian-transits of polar stars.

The truth of this proposition may be demonstrated also in another way. Although the velocity of the motion at right angles to the vertical threads is very slow for all stars observed in the prime-vertical, there is a very considerable difference in velocity between the stars passing the meridian a few minutes from the zenith, and those most distant from it, comprised in my series. From this point of view we can also divide them into three groups, thus:

Zenith-distance		Corrections	Stars	Wt.
Greater than 50',	mean 64	+0.117	7	545
Between 50' and 25',	" 40	+0.031	9	357
Less than 25',	" 15	+0.123	8	457

The mean velocity in the given direction, for the first group, is twice as great as for the last; nevertheless, the corrections are nearly identical. From this agreement of the corrections found from stars of such different velocity, it appears to me proved that the bisection of the images, expressed in time, was sensibly the same for all. Besides, considering that the stars of the first group undergo many more variations of illumination, as between the two branches of the prime-vertical, than do those of the last—the interval between east and west being for the first 133^m, and for the last 65^m—we see in this agreement of the corrections a further proof that the observations of my series are free from this supposed error.

The objection made to the determination of the aberration by the transits of polar stars by WAGNER does not appear to me to be better founded. It must not be here forgotten that the transits are observed as often below as above the pole. Consequently the conditions of observation, so far as the difference between night and day only is

concerned, are the same for the maxima as for the minima of the aberration. As to the faint polar stars, we observe in our transit-instrument either amplitude of the aberration only near midnight. So long as we do not consider an origin of personal error other than the one above assumed, it appears to me beyond debate that the transits of polar stars observed by my late colleague provide very precious materials for the determination of the aberration.

The other objection, raised by Mr. GILL, to my series of observations, relating to the influence of variation of latitude, has certainly a better foundation, at least so far as isolated observations are concerned. The considerable difference of the corrections found from stars in different right-ascensions is the proof of this; and unfortunately the elements of this variation are yet too little known to permit its elimination by subsequent corrections. But it should here be remarked that the certainty of the mean result is much greater than the separate corrections would imply. By the method—later developed more in detail by Mr. KÜSTNER, but the advantages of which, in case of a variable latitude, I had already indicated in my memoir, p. 39—of observing, evening and morning at the same time of the year, stars about 12^h apart in right-ascension, we may reduce nearly to nothing the influence of variation of latitude on the mean correction of the whole series, separated into groups according to right-ascension.

For a future determination of the constant of aberration it appears to me beyond doubt that we should choose, either STRUVE's method of observing in the prime-vertical, or that of HORREBOW. The latter has the advantage that more stars can be found suitable for observation, while in the prime-vertical the individual observations are more exact. Before making use of other proposed methods, we should examine whether the risk is not incurred of introducing systematic errors graver than those which it is sought to avoid. And the occasions of obtaining series of observations of polar stars so homogeneous as those of WAGNER are too rare for them to be included in the program.

NOTE ON THE FOREGOING ARTICLE,

BY SIMON NEWCOMB.

The preceding paper reached me in May last while I was travelling abroad. I greatly regret that, owing to the circumstance of my being away from home, I overlooked or forgot Dr. NYRÉN's intimation that he would like to have it published in the *Astronomical Journal*. Only now am I reminded of this wish. It may be remarked that the comparison of results obtained from stars of different magnitudes does not disprove the existence of the source of systematic error which I pointed out. This source is to be found in the systematic difference between the apparent

brilliancy of a star during its transit over the east and west verticals in the morning or evening twilight, owing to the increasing brightness of the sky in the one case and the diminishing brightness in the other. This cause would affect stars of all magnitudes in the same direction. Yet I quite agree with Dr. NYRÉN that there is no certainty that this equation exists in the case of his prime vertical observations. It was suggested by me simply as a more or less probable conclusion, not as an established one.

OBSERVATIONS OF COMETS,

MADE AT THE LICK OBSERVATORY,
By C. D. PERRINE.

1896 Mt. Hamilton M.T.	*	No. Comp.	δ —*	δ	α	δ	$\log p\Delta$ for α	for δ
COMET <i>d</i> 1896 (GIACOBINI).								
Nov. 28 6 ^h 14 ^m 50 ^s	1	<i>d</i> 10, 8	+0 ^m 12.49	—1 ['] 30.1	21 ^h 16 ^m 32.62	—12 [°] 17 ['] 50.8	9.274	0.583
COMET <i>f</i> 1896 (PERRINE).								
Nov. 28 7 28 22	3	<i>d</i> 10, 10	—0 38.99	+7 26.0	19 54 27.88	+ 7 36 10.2	9.621	0.687
29 7 14 56	4	10, 7	—1 11.52	+4 52.9	19 53 59.85	+ 7 5 15.7	9.612	0.684
Dec. 1 7 38 36	5	<i>d</i> 7, 3	—0 12.46	—0 19.3	19 53 8.69	+ 6 4 4.8	9.641	0.702
1 8 33 16	6	<i>d</i> 10, 8	—0 5.10	+6 27.8	19 53 7.79	+ 6 3 1.9	9.669	0.716
2 7 17 44	8	<i>d</i> 10, 8	—0 17.24	+3 55.9	19 52 45.76	+ 5 35 1.3	9.626	0.700
4 7 17 48	9	14, 8	—0 51.34	—1 54.4	19 52 4.18	+ 4 37 35.3	9.633	0.707
9 6 47 40	10	4	. . .	—3 25.8	. . .	+ 2 23 14.0	. . .	0.716
9 6 54 4	10	<i>d</i> 7	—0 14.62	. . .	19 50 42.11	. . .	9.630	. . .
COMET <i>g</i> 1896 (PERRINE).								
Dec. 15 8 57 10	11	<i>d</i> 10, 8	+0 4.08	—0 10.7	1 40 40.97	+ 3 40 7.8	9.064	0.689
17 9 53 5	12	<i>d</i> 10, 8	+0 21.06	+7 10.3	1 54 25.92	+ 2 57 19.4	9.328	0.700
20 7 13 25	13	<i>d</i> 10, 9	—0 15.13	—5 6.2	2 13 15.23	+ 2 3 3.5	<i>n</i> 9.079	0.707
Jan. 4 ¹⁸⁹⁷ 8 49 7	15	14, 8	—0 57.85	—2 29.6	3 35 13.39	— 0 35 29.8	8.462	0.732
5 7 19 19	16	<i>d</i> 10, 8	—0 15.08	—1 51.0	3 39 26.98	— 0 39 0.0	<i>n</i> 9.185	0.734
11 9 50 39	17	<i>d</i> 10, 8	+0 5.33	—3 54.0	4 4 49.34	— 0 48 53.2	9.173	0.736
20 6 44 28	19	<i>d</i> 10, 8	+0 5.31	+4 17.8	4 36 12.36	— 0 31 16.2	<i>n</i> 9.332	0.732
21 7 12 48	20	<i>d</i> 10, 8	+0 18.11	—6 27.4	4 39 27.60	— 0 27 32.9	<i>n</i> 9.201	0.732
22 7 51 34	22	<i>d</i> 10, 8	+0 14.68	—7 3.7	4 42 41.68	— 0 23 20.2	<i>n</i> 8.914	0.732

Mean Places for 1896.0 and 1897.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
1	21 ^h 16 ^m 16.89 ^s	+3.24	—12 [°] 16 ['] 32.3 ["]	+11.6	Micrometer comparison with *2
2	21 14 21.84	+3.23	—12 15 25.6	+11.4	$\frac{1}{2}$ (Santini 2391 + Munich 28009)
3	19 55 4.52	+2.35	+ 7 28 34.2	+10.0	$\frac{1}{3}$ (Munich (2) 9591 + Munich (1) 22563)
4	19 55 9.02	+2.35	+ 7 0 13.0	+ 9.8	$\frac{1}{3}$ (Mu. (1) 22566 + Bonn VI, 6°4395 + Sant. 1384)
5	19 53 18.80	+2.35	+ 6 4 14.9	+ 9.2	Schjellerup 7715, 7716
6	19 53 10.54	+2.35	+ 5 56 25.0	+ 9.1	Micrometer comparison with *7
7	19 53 2.81	+2.35	+ 5 47 15.7	+ 9.1	Schjellerup 7714
8	19 53 0.64	+2.36	+ 5 30 56.4	+ 9.0	$\frac{1}{3}$ (2 Schj. 7712 + Munich (1) 22437)
9	19 52 53.14	+2.38	+ 4 39 21.1	+ 8.6	Boss, Albany A.G. 6924
10	19 50 54.30	+2.43	+ 2 26 32.5	+ 7.3	" " " 6911
11	1 40 32.58	+4.31	+ 3 39 52.6	+25.9	" " " 502
12	1 54 0.49	+4.37	+ 2 49 44.0	+25.1	" " " 556
13	2 13 25.90	+4.46	+ 2 7 45.6	+24.1	Micrometer comparison with *14
14	2 13 56.43	+4.46	+ 2 11 12.1	+24.1	Boss, Albany A.G. 653
15	3 36 9.56	+1.68	— 0 33 6.0	+ 5.8	$\frac{1}{3}$ (Göttingen 949, 50 + Schj. 1112 + Mu. (2) 715)
16	3 39 40.37	+1.69	— 0 37 14.8	+ 5.8	$\frac{1}{2}$ (Göttingen 961 + Rad. (3) 878)
17	4 4 42.28	+1.73	— 0 45 4.1	+ 4.9	Micrometer comparison with *18
18	4 6 16.34	+1.74	— 0 41 23.4	+ 4.9	$\frac{1}{2}$ (Paris 4858 + Göttingen 1089)
19	4 36 5.23	+1.82	— 0 35 37.9	+ 3.9	Göttingen 1282
20	4 39 7.66	+1.83	— 0 21 9.3	+ 3.8	Micrometer comparison with *21
21	4 39 5.00	+1.83	— 0 13 51.0	+ 3.8	Göttingen 1308
22	4 42 25.17	+1.83	— 0 16 20.2	+ 3.7	$\frac{1}{2}$ (Göttingen 1314 + Paris 5490)

Dec. 1. First observation made through haze and clouds.
 " 4. Telescope swayed by the wind.
 " 9. Haze prevents completion of measures.
 " 17. Windy. Comet faint in the moonlight.
 " 20. Comet faint in the moonlight.

Jan. 20. Comet much fainter. Seeing poor.
 " 22. Hazy. South wind sways telescope.

Comet Giacobini observed with 36-inch telescope.
 Comets *f* and *g* observed with 12-inch telescope.

Lick Observatory, University of California, 1897 Jan. 23.

OBSERVATIONS OF COMET *g* 1896,MADE AT THE VASSAR COLLEGE OBSERVATORY,
By MARY W. WHITNEY.

1897 Greenwich M.T.	*	No. Comp.	$\Delta\alpha$	$\Delta\delta$	α	δ	log $p\Delta$	
							for α	for δ
Jan. 7 ^h 16 ^m 14 ^s 43	1	9	+0 ^m 19.66	+2 ['] 19.2	3 ^h 48 ^m 23.13	-0 [°] 44 ['] 48.8	9.525	0.772
25 14 38 27	2	6	-1 44.41	-8 47.7	4 51 37.30	-0 10 19.8	9.145	0.769
26 13 7 21	2	11	+1 1.12	-4 22.8	4 54 22.83	-0 5 55.0	nS.496	0.768

Mean Places for 1897.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
1	3 ^h 48 ^m 1.76	+1.71	-0 [°] 47 ['] 13.5	+5.5	Micr. comp. with $\frac{1}{2}$ (Glas.(1) 906 + Rad.(90) 902) Copeland and Börgen 1401; 2
2	4 53 19.87	+1.84	-0 1 35.3	+3.2	

On Jan. 25 and 26, comet very faint and difficult.

ELEMENTS AND EPHEMERIS OF COMET *g* 1896,

By F. RISTENPART.

The following elements are based on three normal places, 1896 Dec. 10.5 (7 obs.), 1896 Dec. 28.5 (6 obs.), 1897 Jan. 5.5 (14 obs.). They also represent an observation of Jan. 12 (Nice) within $+0^{\circ}.18$ in α , and $-0^{\circ}.3$ in δ , and two further observations, of Jan. 26 and 27, agree exactly with an ephemeris computed with five-place logarithms. The elements are

$$\begin{aligned} T &= 1896 \text{ November } 24.65674 \text{ Mean Berlin Time} \\ \omega &= 163^{\circ} 53' 30''.0 \\ \Omega &= 246 \ 34 \ 35.9 \\ i &= 13 \ 40 \ 25.9 \end{aligned} \left. \vphantom{\begin{aligned} T \\ \omega \\ \Omega \\ i \end{aligned}} \right\} 1897.0$$

$$\begin{aligned} \log q &= 0.045405 \\ \log e &= 9.832054 \quad q = 42^{\circ} 47' 17''.0 \\ a &= 3.4617 \quad \mu = 550''.901 \\ U &= 2352.5 \text{ days} = 6.441 \text{ years} \end{aligned}$$

The comet, which can approach to *Jupiter's* orbit within 0.053 in longitude 247° , thus almost exactly in his ascending node, was in the neighborhood of that planet in the year 1888. But, while the comet was passing through this point on April 27, the heliocentric longitude of *Jupiter* was only 239° ; therefore the perturbations of the comet were great, but not enough to change the orbit entirely. It will be necessary to compute these perturbations and then carry the comet's path backward, in order to judge whether the comet is identical with *BIELA's*, or is only a body which formerly moved in *BIELA's* orbit. The two orbits, whose major axes now include an angle of 60° , intersect one another 161° from the common ascending node, at $v = 297^{\circ}$ for *BIELA*, and $v = 357^{\circ}$ for *PERRINE*. Only refined elements of *PERRINE's* comet, based on a sufficient heliocentric

are in the present apparition, and the retrospective computation of the perturbations, can enable us to settle the question whether at any previous time the two comets have simultaneously occupied this point of intersection. Since I wish to undertake the definite determination of the comet's orbit and its relations to *BIELA's*, I hope that observers with the great American telescopes will follow it as long as possible. The following ephemeris will represent the comet's path satisfactorily. It will be continued, if necessary.

EPHEMERIS OF COMET *g* 1896 FOR BERLIN MIDNIGHT.

Date	App. α	App. δ	log Δ	Br.
1897 Feb. 22.5	6 ^h 1 ^m 18 ^s	+2 35.2		
24.5	5 39	47.1	9.97214	0.05
26.5	9 56	2 58.6		
28.5	14 11	3 9.8	9.99787	
Mar. 2.5	18 23	20.6		
4.5	22 33	31.0	0.02293	0.04
6.5	26 41	41.0		
8.5	30 46	50.6	0.04723	
10.5	34 49	3 59.8		
12.5	38 50	4 8.6	0.07082	0.03
14.5	42 49	16.9		
16.5	46 47	24.8	0.09374	
18.5	50 43	32.1		
20.5	54 38	39.0	0.11599	0.02
22.5	6 58 31	45.4		
24.5	7 2 23	51.3	0.13760	
26.5	6 13	4 56.8		
28.5	7 10 1	+5 1.9	0.15857	0.01

Brightness on Dec. 10 taken as unity.

Heidelberg, 1897 Jan. 27.

ELLIPTIC ELEMENTS AND EPHEMERIS OF COMET *g* 1896,

By C. D. PERRINE AND R. G. AITKEN.

The following system of elements is based upon normal places from observations on December 8, 9, 10 (Mt. Hamilton), Dec. 10 (Munich, Bamberg, Strassburg, Nice), Dec. 11 (Vassar, Edinburgh), Jan. 2 (Bamberg, Strassburg), Jan. 4, 5, 6, 8 (Mt. Hamilton), Jan. 20, 21, 22, 23, 24, 25 (Mt. Hamilton).

Epoch 1896 Dec. 10.0 Greenw. M.T.

$$M = 2^{\circ} 22' 49''.6$$

$$\left. \begin{array}{l} \omega = 163 \ 52 \ 8.7 \\ \Omega = 246 \ 36 \ 4.4 \\ i = 13 \ 39 \ 24.5 \end{array} \right\} 1897.0$$

$$\log a = 0.536366$$

$$\log e = 9.830734$$

$$\log \mu = 2.745458$$

$$q = 21^{\circ} 18' 49''.0$$

$$\text{Period } 6^{\text{y}}.376$$

CONSTANTS FOR THE EQUATOR AND MEAN EQUINOX OF 1897.0.

$$x = r[9.989557] \sin(139^{\circ} 51' 56''.0 + v)$$

$$y = r[9.979418] \sin(45 \ 51 \ 7.9 + v)$$

$$z = r[9.568973] \sin(83 \ 39 \ 27.5 + v)$$

Lick Observatory, University of California, 1897 Feb. 7.

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT.

1897	a $^{\text{h}} \ ^{\text{m}} \ ^{\text{s}}$	δ $^{\circ} \ ' \ ''$	$\log \Delta$	Br.
Feb. 20.5	5 56 59.0	+2 23 55	9.9451	0.046
22.5	6 1 23.8	2 35 51		
24.5	6 5 45.0	2 47 34	9.9716	0.039
26.5	6 10 3.0	2 59 0		
28.5	6 14 18.0	3 10 8	9.9973	0.033
Mar. 2.5	6 18 30.4	3 20 56		
4.5	6 22 40.3	3 31 21	0.0224	0.028
6.5	6 26 47.9	3 41 23		
8.5	6 30 53.4	3 51 0	0.0467	0.024
10.5	6 34 57.0	4 0 11		
12.5	6 38 58.6	4 8 56	0.0703	0.021
14.5	6 42 58.2	4 17 14		
16.5	6 46 56.0	4 25 4	0.0932	0.018
18.5	6 50 52.2	4 32 26		
20.5	6 54 46.7	4 39 20	0.1154	0.016
22.5	6 58 39.7	4 45 46		
24.5	7 2 31.2	4 51 44	0.1370	0.014
26.5	7 6 21.3	4 57 12		
28.5	7 10 10.1	5 2 11	0.1580	0.012
30.5	7 13 57.6	5 6 42		
Apr. 1.5	7 17 44.0	5 10 44	0.1784	0.011
3.5	7 21 29.2	5 14 16		
5.5	7 25 13.3	5 17 19	0.1981	0.009
7.5	7 28 56.2	5 19 53		
9.5	7 32 38.1	+5 21 57	0.2173	0.008

Brightness on December 8 unity.

DISCOVERY OF THREE BRILLIANT STELLAR SYSTEMS IN THE SOUTHERN HEMISPHERE,

MADE WITH THE 24-INCH REFRACTOR OF THE LOWELL OBSERVATORY,

By T. J. J. SEE.

Since the establishment of the observatory in Mexico, we have resumed our sweeps for southern double stars, with the result of finding a number of objects of great interest. As the latter part of the night has been devoted to the double star work, our sweeps have been confined chiefly to the constellations *Puppis*, *Carina*, *Vela*, *Cruz* and *Centaurus*. On a few evenings some time has been available for hurried sweeps over the bright stars in *Phoenix*, *Eridanus* and *Dorado*. Three of the objects recently discovered are of particular interest, and may properly be regarded as among the most splendid systems in the heavens. These systems are:

(1). *a Phoenix*, discovered 1897 Jan. 10.

The position of this star is:

$$\alpha = 0^{\text{h}} 21^{\text{m}} 19^{\text{s}}.5 ; \delta = -42^{\circ} 50' 48''.1 \text{ (1900).}$$

The companion is of the 13th magnitude, and purplish in color. According to the *Uranometria Argentina*, *a Phoenix* is of the 2.4 magnitude; so great an inequality in

brightness combined with the well known deep orange or reddish color of *a Phoenix*, renders the system both very striking and very difficult. Though our measures have been made when the star was several hours west of the meridian, and therefore under some difficulty, owing to the low altitude, there is reason to think that the mean position is essentially correct. We find by the settings of the micrometer:

t	θ_0 $^{\circ}$	ρ_0 $''$	Mags.	Remarks
1897.028	287.8*	9.68	2:13.5	certainly real
1897.030	275.5	9.57	2:13	clear at moments
1897.036	269.8	10.57	2.5:13	
1897.039	266.0	10.64	2.5:13	
1897.046	269.3	9.60	2:13	
1897.071	268.±	9.40	2:13	difficult
1897.041	272.7	9.73	2.2:13.1	

* This angle is so inconsistent with the estimate of 265° , and with subsequent measures, that I suspect a mistake in reading the circle.

(2). μ *Velorum*, discovered 1897 Jan. 10.

This star has a magnitude of 2.9; its companion about 11, purplish, and very close to the large star. The position of μ *Velorum* is

$$\alpha = 10^{\text{h}} 42^{\text{m}} 27^{\text{s}}.9 ; \delta = -48^{\circ} 53' 31''.1 \text{ (1900).}$$

Though the object is easy with the large telescope, the great inequality in brightness would render it difficult for an inferior glass, especially if the atmospheric conditions were not of the very best. The system is one of the most extraordinary in the heavens, and is almost certain to have rapid orbital motion. Our measures of the companion are as follows:

t	θ_0	ρ_0	Mags.	Remarks
1897.025	65.8	2.59	2.5:11	good measures
1897.041	59.6	2.91	2.5:11	blurred
1897.085	62.6	2.18	2.5:10	good images
1897.086	63.0	2.38	3:10.5	good measures
1897.059	62.7	2.54	2.6:10.6	

Mr. COGSHALL:

$$1897.085 \quad 63.0 \quad 2.24 \quad 3:9$$

(3). η *Centauri*, discovered 1897 Jan. 11.

$$\alpha = 14^{\text{h}} 29^{\text{m}} 10^{\text{s}}.3 ; \delta = -41^{\circ} 42' 59''.6 \text{ (1900).}$$

Magnitudes, 2.5; 13.5; colors, yellow, purplish.

This object is extremely difficult, and can be seen only with a powerful telescope; it is certainly a physical system, and will possess the highest interest.

t	θ_0	ρ_0	Mags.	Remarks
1897.028	270 $\pm$	6.0 $\pm$	2.5:13.5	very difficult
1897.041	264.4	5.57	2.5:13.5	
1897.085	276.0	5.38	2.9:13.5	
1897.051	270.1	5.65	2.6:13.5	

Lowell Observatory, City of Mexico, Mexico, 1897 Feb. 2.

REVISED ELEMENTS OF 320 U CEPHEI,

By S. C. CHANDLER.

The elements of this star given in the Second and Third Catalogues have been recently revised by means of the minima observed by YENDELL and J. A. PARKHURST during the past four years. The revised elements are:

$$1880 \text{ June } 23^{\text{d}} 9^{\text{h}} 39^{\text{m}}.6 \text{ (Gr. M.T.) } + 2^{\text{d}} 11^{\text{h}} 49^{\text{m}} 37^{\text{s}}.85 \text{ E} \\ + 130^{\text{m}} \sin(0^{\circ}.06 \text{ E} + 300^{\circ})$$

They indicate a larger amplitude and a longer cycle for the periodical term than the former elements gave, and satisfy all the data since 1828 entirely within the uncertainty of the observations.

For the purpose of accurate comparison of observation with the above elements the following ephemeris of minima for 1897 is given, containing the heliocentric Greenwich mean time of every tenth minimum. The intermediate ones may be interpolated directly with precision, or with sufficient approximation by means of the adjoined table of multiples of the period. The length of the period, from the above elements, for any value of E, is $2^{\text{d}} 11^{\text{h}} 49^{\text{m}} 37^{\text{s}}.85 + 8^{\text{s}}.168 \cos(0^{\circ}.06 \text{ E} + 300^{\circ})$.

$$\text{Hence for } \begin{array}{l} \text{E 2420, } P = 2^{\text{d}} 11^{\text{h}} 49^{\text{m}}.644 \\ \text{E 2560, } \quad \quad = \quad \quad 49.622 \end{array}$$

A mean value of P for the year is used for the table of multiples.

E	Heliocentric Greenwich M.T.	Multiples of Period
2420	1896 Dec. 29 ^d 1 ^h 35.76	1 Per. = 2 ^d 11 ^h 49.63
30	1897 Jan. 22 23 52.18	2 " 4 23 39.27
40	Feb. 16 22 8.57	3 " 7 11 28.90
50	Mar. 13 20 24.96	4 " 9 23 18.53
60	Apr. 7 18 41.34	5 " 12 11 8.17
70	May 2 16 57.70	6 " 14 22 57.80
80	27 15 14.04	7 " 17 10 47.43
2490	June 21 13 30.37	8 " 19 22 37.06
2500	July 16 11 46.68	9 " 22 10 26.70
10	Aug. 10 10 2.98	10 " 24 22 16.33
20	Sept. 4 8 19.27	
30	29 6 35.55	
40	Oct. 24 4 51.81	
50	Nov. 18 3 8.05	
60	Dec. 13 1 24.27	
2570	37 23 40.49	

OBSERVATIONS OF VARIABLE STARS IN 1896,

By WALTER J. GILL, JR.

4521. *R Virginis*.

Twelve observations of this star, made between May 13 and Aug. 11, inclusive, indicate a minimum June 4. As I have no reliable magnitudes of the comparison-stars, the light is not given.

4557. *S Ursae Majoris*.

From Mar. 31 to Aug. 12, I have twenty-four observations, indicating a maximum of 8^m.6, June 16. Its light at the first observation was 9^m.8, at the last about 10^m.0.

4816. *V Virginis*.

Six observations, from June 4 to July 18, yield a maximum June 23. The observations being few the curve is somewhat uncertain.

4847. *S Virginis*.

A maximum of 6^m.7 is indicated on June 6, by twenty-one observations from April 15 to Aug. 11. Its light at the first observation was 9^m.2, at the last 8^m.5. The increase was more rapid than the decrease.

5194. *V Bootis*.

Sixteen observations of the above star, beginning June 3 with the variable about 8^m.2, and ending Oct. 27, when it was 8^m.7, indicate a maximum of 7^m.5 July 23.

5501. *S Serpentis*.

Seventeen observations, from May 12 to Aug. 19, indicate a maximum of 7^m.6 on June 19. Its light at the first observation was about 9^m.7, at the last about 9^m.6.

5675. *V Coronae*.

Observations of this star began April 15, when it was about 9^m.0. It rose to a maximum of 8^m.5 May 23, and then fell till it was about 9^m.5 July 16, after which it remained nearly stationary during the rest of the time it was under observation. The nineteenth and last observation was on Aug. 29.

5955. *R Draconis*.

I have fifteen observations, from Aug. 11 to Dec. 5. Its light was about 9^m.5 on both of the above dates. A maximum of 6^m.8 is indicated on Sept. 24. The increase was much more rapid than the decrease.

6512. *T Herculis*.

Observed this star eleven times. On June 27 it was about 9^m.6, increasing gradually till on July 16 it was about 9^m.5. It then rose rapidly to a maximum of 8^m.1, Aug. 10, after which it decreased slowly until the last observation Oct. 7, when it was 9^m.5.

6636. *U Sagittarii*.

Twenty-four observations of this short-period variable,

Roxbury, Mass., 1897 Feb. 1.

from July 11 to Oct. 7, give the following maxima and minima:

MAXIMA		MINIMA	
July 13.57	Aug. 29.33	July 17.84	Aug. 22.02
Aug. 9.39	Sept. 11.42	26.03	Sept. 4.10
17.35	20.29	Aug. 7.81	10.13
24.60	26.83	14.17	24.09
			Oct. 7.35

6733. *R Scuti*.

I made twenty-six observations of this star. At the first, on June 19, it was 5^m.7. It then decreased to a minimum of 7^m.5, July 22, after which it rose steadily to a maximum of 5^m.2, Sept. 4.

After passing the maximum the light-curve shows a bright minimum of about 6^m.0, Oct. 5, and a faint maximum of 5^m.6, Oct. 25. After this, twilight and low altitude made the observations somewhat uncertain; but they seem to indicate a slow decrease.

7085. *RT Cygni*.

A maximum of 7^m.3 is indicated on July 12, by twenty observations, from May 19 to Sept. 20. Its light on the first named date was about 10^m.3; on the last about the same.

7560. *R Vulpeculae*.

I have ten observations, from Oct. 3 to Dec. 5. A maximum of 8^m.2 is indicated on Nov. 6. Its light at both first and last observations was about 9^m.7. The light-curve is very regular, with about equal times of increase and decrease.

REQUEST FOR MERIDIAN-OBSERVATIONS.

Prof. C. L. DOOLITTLE of the University of Pennsylvania, Philadelphia, desires meridian-observations of the following stars from his latitude list; and requests that observers may obligingly favor him with preliminary or other results in advance of publication.

	Mag.	α 1897	δ 1897
DM. 61°1381	7.5	13 46 43 ^s	+61° 1.9
37 2545	6.8	14 29 8	+37 24.9
41 2539	6.8	14 52 7	+41 33.1
49 2583	5.8	17 2 6	+43 56.8
43 2711	neb.	17 13 58	+43 14.9
39 3147	6.5	17 27 14	+38 57.6
51 3324	7.5	22 14 39	+52 8.4

OBSERVATIONS AND PERIOD OF 3495 *i CARINAE*,

By R. T. A. INNES.

[Communicated by Dr. GILL, H. M. Astronomer.]

This star has been continuously observed during 1896, and some interesting features of its variation brought to light.

In the annexed table the dates of maximum and minimum which I have access to are given, including my recent observations. The first three are to be found in the

"*Uranometria Argentina*," the following fifteen (to February 1896) in the publications of the British Astronomical Association, the remainder are now published for the first time. The column headed O—C is the difference between observation and maxima calculated from the elements, 1871 July 24.9+35^d.5236 E.

Date	Observer	Phase and Mag.	O—C
1871 July 31	Cordoba	<i>M</i>	+4.3 ^d
Aug. 31	"	<i>M</i>	—0.2
1872 May 7	"	<i>M</i>	+1.1
1891 Apr. 23	Roberts	<i>M</i> 3.30	+2.5
July 28	"	<i>m</i> 5.30	
1892 May 18	"	<i>M</i> 3.30	+2.3
July 18	"	<i>m</i> 5.50	
1895 Jan. 27	Innes	<i>m</i> 4.80	
Feb. 10	"	<i>M</i> 3.68	+1.6
Mar. 2	"	<i>m</i> 4.53	
14	"	<i>M</i> 3.50	—1.9
31	"	<i>m</i> 4.50	
Apr. 21	"	<i>M</i> 3.55	+1.5
Dec. 12	"	<i>m</i> 4.72	
25	"	<i>M</i> 3.56	+0.9
1896 Jan. 17	"	<i>m</i> 4.36	
28	"	<i>M</i> 3.50	—0.6
Feb. 19	"	<i>m</i> 4.58	
Apr. 8	"	<i>M</i> 3.38	—0.7
May 5	"	<i>m</i> 4.40	
14	"	<i>M</i> 3.40	—0.2
June 7	"	<i>m</i> 4.70	
19	"	<i>M</i> 3.64	+0.3
July 13	"	<i>m</i> 4.70	
25	"	<i>M</i> 3.48	+0.7
Oct. 31	"	<i>m</i> 4.90	
Nov. 6	"	<i>M</i> 3.48	—1.8
Dec. 3	"	<i>m</i> 4.80	
12	"	<i>M</i> 3.63	—1.4

The observations made in 1895 and 1896 were plotted and the data in the above table taken from the best curve

Royal Observatory, Cape of Good Hope, 1896 December.

drawn through the observations. Details of these observations will be published in due course.

In the above table the dates of the chief maximum and minimum only are recorded; there is a secondary maximum which is well shown in the observations from 1896 April 10 to May 16, as follows:

Apr. 10	^M 3.35	Apr. 21	^M 4.3	May 6	^M 4.4
11	3.7	22	4.2	7	4.1
13	3.8	25	4.2	9	4.0
14	3.8	26	4.2	10	3.9
15	4.0	27	4.1	12	3.7
16	4.0	28	4.0	13	3.6
18	4.2	29	4.1	14	3.4
19	4.3	30	4.3	16	3.6
20	4.3	May 4	4.4		

On other occasions the secondary maximum has not been so marked in character, sometimes degenerating to a halt in the passage to the chief minimum. From the chief minimum to the chief maximum the interval varies from 6 to 21 days, the average being 13^d.4. The range of magnitude is from 3^m.30 to 5^m.50, according to Mr. A. W. ROBERTS's observations, whilst I find 3^m.38 to 4^m.90.

The residuals in the column O—C show a variation in the period amounting to about 2 days above and below the mean period. It will be also noticed that the brightness at maximum and minimum varies in a series.

The elements given by Dr. CHANDLER in his Third Catalogue are at present about a fortnight in error.

NEW ASTRONOMICAL WORK.

Veröffentlichungen der Grossherzoglichen Sternwarte zu Karlsruhe; Fünftes Heft. Dr. W. VALENTINER.

With this volume closes the published series of observations undertaken at the Grand-Ducal Observatory of Baden for the determination of the positions of all stars to the eighth magnitude which are included between the parallels of 0° and —8° of declination. The instrument with which these observations were made was originally a Reichenbach "Multiplicationskreis," first set up in 1811 at Mannheim. It had long figured as a museum-exhibit of historic interest, when Dr. VALENTINER, under conditions of strictest economy, conceived the idea of converting it into a meridian circle. The objective of the telescope is of 84 mm. aperture, and the circle is a little more than 0.9 m. in diameter.

In the introduction of this fifth number of the publications of the Karlsruhe Observatory are exhibited the results of an extended examination of the error of graduation, for every degree throughout the circle, and for each graduation mark within the limits employed in observation. From the latter section of the investigation it is shown

that there is a well marked systematic error in the subdivisions of a degree amounting to 0".5 or more in three instances out of nineteen, and to 0".26 in the mean.

The present volume contains about 8300 observations reduced to 1885, of which about one in four are of the stars considered as standard. The final catalogue will contain about 16,200 observations of 2700 stars, — three in each position of the circle for each star.

Dr. VALENTINER notes that, besides these meridian observations, during the period from 1892 to 1896 July 1, a continuous series of latitude-determinations by the Talcott method has been kept up at Karlsruhe, and that observations of 5949 pairs of stars on 639 evenings are contained in the records of this undertaking.

This volume marks the close of the establishment at Karlsruhe, transferred from Mannheim sixteen years ago, and now transferred to Heidelberg. In the new location this observatory is to be associated with a separate astro-physical establishment; and its means for observation will be greatly enlarged, to include, among other new instruments, a meridian-circle by REPSOLD.

L. B.

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