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VARIATION OF (3416)* — *VELORUM* AND (5949) — *ARAE*,

By A. W. ROBERTS.

During the last two years two *Algol*-variables have been discovered in the Southern hemisphere, one at Lovedale in 1892, and the other at the Cape Royal Observatory in February of the present year. The first star is Lacaille 6887 [No. (5949) in CHANDLER's Catalogue.] Its period is $4^d\ 10^h\ 12^m\ 42^s$, the duration of variation being about $10^h\ 20^m$.

Most of the observations have already been reduced, but the star being still well suited for prolonged observation, it has been thought best to delay publication for a little.

Concerning the other star, Cordoba General Catalogue 13052, $\alpha = 9^h\ 28^m\ 30^s.6$, $\delta = -44°\ 39'\ 19''$ (1875), [No. (3416) of CHANDLER's Catalogue], the same reason for delay does not exist. It is now so low down in the west that, for the next three or four months, observations will of necessity be few; apart therefore from the advisableness of confirming variation as soon as possible, the present time is not unsuitable for discussing the observations made here from April to July.

Although Dr. GILL most kindly communicated to me its variation early in February, a combination of circumstances — cloudy weather chiefly — hindered my obtaining good observations for some time; yet the observations made during February and March were sufficient to certify the nature of the star's variation. After March the weather became more settled, and observations were made more regularly.

It would burden the present paper unduly to give all the observations made here, and so only those are given in detail which are of importance in determining the form of the light-curve, that is, those made during a varying phase.

All the other observations indicate that for $5^d\ 7^h$ the star's light remains constantly at $7^M.85$. Its type is therefore unquestionable.

Several of the minima took place at full moon, 5 light-periods being performed in almost exactly a synodical month, and although a large number of observations were made at these times they are not included in the discussion, as the effect of moonlight upon magnitude is still very uncertain.

Method of Observation. Two instruments are used for the observation of variable stars, a good 1-inch theodolite, and a 2½-inch telescope. Two eyepieces are always used, the one a direct, and the other a reversing eyepiece. The mean of both is the observation recorded. The two standard magnitudes used are 6.8 and 9.3. The former magnitude is considered to be that of a star just on the threshold of visibility on a clear evening; the latter magnitude is that just seen, and no more, in the 1-inch theodolite. The same comparison-stars are always used, and their magnitudes are estimated by a method of sequences *inter se*, each step being, as nearly as possible, made equal to $0^M.1$. In the present case the sequences were made upwards from $9^M.3$, and consequently the values given represent actual magnitudes, and not steps merely.

It may not be out of place to enter more fully into the necessity for, and the importance of, the method I have adopted of observing first direct, and then reverse.

The disturbing influence of position upon magnitude is well known among variable-star observers. Dr. GOULD has on several occasions directed the attention of observers to this subjective source of error. Prof. PICKERING has discussed the matter in his "Harvard Photometry." Its existence is therefore real and active; its effect may be traced in every catalogue of "suspected" variables; it is to light-measurement what instrumental flexure, eccentric movement, is to meridian-observation.

To eliminate this source of error is therefore a necessity, and I think there is no method more simple or handy than taking two observations, one of them being in a reverse position from the other.

*This confirmation by Prof. ROBERTS permits the definitive notation 3416 *S Velorum*; and the star may be removed from the "Unconfirmed List," Table III, of the Supplement to Second Catalogue (*A.J.* 319). This letter is chosen to avoid confusion; although the variation of (3614) (*R*) *Velorum*, of the "Unconfirmed List" of the Second Catalogue (*A.J.* 300), still awaits independent confirmation. — ED.

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Before adopting this method, I had thought of having a telescope constructed with a prism in the focus, so that the field could be turned round in any direction. With this instrument four observations would be taken, one in each quadrant.

In taking observations, the position of the head had to be carefully noticed. Thus, for example, the direct-vision eyepiece is very much longer than the reversing one, and the tendency was slightly to twist the head in looking through it, so that the position of the eye with regard to the two eyepieces was not similar. This apparently trifling matter caused a considerable amount of trouble for a time.

The method of reduction from the observed measures may be illustrated by the following tables. In table I, we have ten measures of the variable made on different evenings with the reversing eyepiece. It may be stated that in the reversing eyepiece A.Z.C. IX 2429 was the lowest star in the field, while in the direct-vision eyepiece its position was highest. A glance at direct and reverse measures of this star will abundantly testify to the influence of position; at least in my case.

I. Measures made with Reversing Eyepiece.

Date	A.Z.C. 2147	A.Z.C. 2157	A.Z.C. 2301	A.Z.C. 2429	Var.
	M	M	M	M	M
1894 May 25	8.0	8.2	8.4	8.2	7.8
25	8.0	8.1	8.4	8.0	7.8
31	8.2	8.1	8.1	7.8	7.7
June 1	8.1	8.1	8.0	7.9	7.6
2	8.0	8.3	8.2	8.0	7.8
8	8.0	8.2	8.0	7.8	7.7
July 4	8.1	8.2	8.0	7.9	7.7
6	8.1	8.1	8.0	7.9	7.7
8	8.1	8.3	8.1	8.0	7.8
27	8.0	8.2	8.1	7.9	7.7

These measures are not in any way reduced, but are simply put down from the observing sheet.

Table II gives the measures made at the same time with the direct-vision eyepiece. As in Table I the results are unreduced.

II. Measures made with Direct-Vision Eyepiece.

Date	A.Z.C. 2147	A.Z.C. 2157	A.Z.C. 2301	A.Z.C. 2429	Var.
	M	M	M	M	M
1894 May 25	7.8	8.0	8.2	8.5	8.0
25	8.0	8.2	8.4	8.6	7.8
31	7.8	8.0	8.4	8.6	8.1
June 1	7.6	7.9	8.3	8.6	8.0
2	7.8	8.0	8.3	8.6	7.9
8	7.8	8.0	8.3	8.6	7.9
July 4	7.8	8.0	8.5	8.7	7.8
6	7.6	7.8	8.4	8.7	8.0
8	7.8	8.0	8.4	8.7	7.9
27	7.8	8.0	8.4	8.7	8.0

If we now take the mean of these apparently contradictory measures we have Table III.

III. Mean of Reverse and Direct-Vision Measures.

Date	A.Z.C. 2147	A.Z.C. 2157	A.Z.C. 2301	A.Z.C. 2429	Var.	Total
	M	M	M	M	M	M
1894 May 25	7.90	8.10	8.30	8.35	7.90	40.55
25	8.00	8.15	8.40	8.30	7.80	40.65
31	8.00	8.05	8.25	8.20	7.90	40.40
June 1	7.85	8.00	8.15	8.25	7.80	40.05
2	7.90	8.15	8.25	8.30	7.85	40.45
8	7.90	8.10	8.15	8.20	7.80	40.15
July 4	7.95	8.10	8.25	8.30	7.75	40.35
6	7.95	7.95	8.20	8.30	7.85	40.15
8	7.95	8.15	8.25	8.35	7.85	40.50
27	7.90	8.10	8.25	8.30	7.85	40.40

The next step is to reduce the measures to the same standard, that is, to make all their totals equal to the mean total of Table III.

Table IV. Reduced Results.

Date	A.Z.C. 2147	A.Z.C. 2157	A.Z.C. 2301	A.Z.C. 2429	Var.	Total
	M	M	M	M	M	M
1894 May 25	7.86	8.06	8.26	8.31	7.86	40.35
25	7.94	8.09	8.34	8.24	7.74	40.35
31	7.99	8.04	8.24	8.19	7.89	40.35
June 1	7.91	8.06	8.21	8.31	7.86	40.35
2	7.88	8.13	8.23	8.28	7.83	40.35
8	7.94	8.14	8.19	8.24	7.84	40.35
July 4	7.95	8.10	8.25	8.30	7.75	40.35
6	7.89	7.99	8.24	8.38	7.89	40.35
8	7.87	8.12	8.22	8.32	7.82	40.35
27	7.89	8.09	8.24	8.29	7.84	40.35

The average error of an observation is $\pm 0^{M}.038$, an amount which is almost identical with that found from an examination of several other variables.

I have dwelt more fully upon this portion of my paper than I had at first intended; but an exposition of the method rigorously adopted in reducing the observations of this star, as well as of all the other variables observed here, is of as much importance as the results obtained from the observations, inasmuch as the results depend to some extent on the method of reduction adopted.

It may be remarked in passing, that if m be the average magnitude of any star in a field of say five or six stars, and m_0 its magnitude at any date obtained by sequences from the other stars, using only a reversing eyepiece, then

$$m - m_0 = x \sin(h+M) + y \sin(2h+N)$$

where h is the hour-angle of the star, and x, y, M, N, values constant for the same star.

The same formula, adding 12 hours to h, will be applicable to magnitudes estimated with a direct-vision eyepiece only. The magnitude of x and y depends on the distance of the star from the center of the field.

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Detailed Observations. In determining the magnitudes of the variable the following comparison-stars have been used. The places are for 1875.

A.Z.C. IX Hours	α	δ	Mag.	A.Z.C. IX Hours	α	δ	Mag.
	h m s	° ′ ″			h m s	° ′ ″	
2034	9 25 11	−44 21 37	7.80	2175	9 26 49	−44 56 24	9.15
2126	26 16	44 41 59	8.85	2204	27 17	44 53 1	9.70
2137	26 23	44 54 46	8.95	2207	27 18	45 14 36	8.80
2147	26 34	45 27 24	7.95	–	28 8	44 37 57	9.40
2153	26 36	44 40 57	8.90	2301	28 31	44 57 41	8.25
2157	26 38	45 3 53	8.10	–	29 18	44 42 36	9.15
2174	9 26 49	−44 34 48	9.20	2429	9 30 11	−44 40 29	8.33

The magnitudes of these comparison-stars have been obtained by the method already described. All the times of observation have been reduced to Greenwich mean heliocentric time.

1894 *April* 1.

G.M.T.	Observed	O—C
h m	M	M
5 35	7.83	−0.02
6 35	7.90	+0.05
7 0	7.85	0.00
7 35	7.80	−0.05
8 5	7.86	+0.01
8 35	7.81	−0.04
9 10	7.90	0.00
9 50	7.93	−0.08
10 5	8.03	−0.01
10 35	8.19	+0.06
11 5	8.25	+0.02
11 35	8.45	+0.07
12 5	8.50	−0.08
12 35	8.90	+0.05
13 5	9.10	−0.10

Average error = ±0ᴹ.042.

1894 *April* 13.

G.M.T.	Observed	O—C
5 4	7.83	−0.02
5 34	7.85	0.00
6 4	7.92	0.00
6 34	8.10	+0.10
6 51	8.05	+0.01
7 26	8.20	+0.06
7 44	8.25	+0.05
8 4	8.30	+0.01
8 11	8.30	−0.01
8 32	8.40	−0.04
8 39	8.40	−0.09
9 2	8.70	+0.04
9 9	8.65	−0.07
9 34	9.10	+0.14
10 4	9.30	+0.05

1894 *April* 13.—Cont.

G.M.T.	Observed	O—C
h m	M	M
10 34	9.20	−0.05
11 26	9.25	0.00
11 34	9.27	+0.02
12 4	9.20	−0.05
12 24	9.25	0.00
12 34	9.20	−0.05
12 49	9.25	0.00
13 19	9.25	0.00

Average error = ±0ᴹ.036.

1894 *May* 1.

G.M.T.	Observed	O—C
5 3	9.20	−0.03
5 8	9.20	−0.05
5 31	9.25	0.00
5 51	9.30	+0.05
6 36	9.30	+0.05
6 43	9.30	+0.05
6 58	9.30	+0.05
7 3	9.25	0.00
8 3	9.20	−0.05
8 8	9.25	0.00
9 3	9.30	+0.05
10 3	9.25	0.00
10 13	9.20	−0.05
10 48	9.20	−0.05
10 53	9.25	0.00

Average error = ±0ᴹ.032.

1894 *May* 7.

G.M.T.	Observed	O—C
4 22	9.20	−0.05
5 32	9.20	−0.05
5 52	9.20	−0.05
6 32	9.25	0.00

1894 *May* 7.—Cont.

G.M.T.	Observed	O—C
h m	M	M
7 2	9.20	−0.05
7 32	9.20	−0.05
8 2	9.20	−0.05
8 47	9.20	−0.05

Average error = ±0ᴹ.044.

1894 *May* 25.

G.M.T.	Observed	O—C
4 23	9.25	0.00
4 53	9.30	+0.05
5 48	8.75	−0.08
5 57	8.73	−0.01
6 17	8.60	+0.03
6 38	8.40	−0.03
6 54	8.40	+0.07
7 14	8.35	+0.11
7 31	8.15	−0.03
7 49	8.15	+0.03
8 15	8.10	+0.06
8 40	8.00	+0.02
9 6	7.90	−0.01
9 45	7.90	+0.05
9 58	7.80	−0.05

Average error = ±0ᴹ.042.

1894 *May* 31.

G.M.T.	Observed	O—C
6 7	8.05	−0.09
6 25	8.00	−0.08
6 47	7.95	−0.07
6 7	7.95	−0.02
6 27	7.90	−0.02

Average error = ±0ᴹ.056.

NOTE. Night hazy, and observations difficult.

1894 *July* 23.

G.M.T.	Observed	O—C
h m	M	M
4 36	8.25	0.00
4 39	8.30	+0.03
4 43	8.25	−0.04
5 7	8.45	+0.03
5 15	8.50	+0.02
5 22	8.55	+0.02
5 32	8.65	+0.05
5 42	8.70	+0.02
5 46	8.70	−0.01
5 56	8.75	−0.06
6 1	8.75	−0.11
6 6	8.86	−0.05
6 16	9.00	−0.01
6 26	9.10	−0.05
6 36	9.20	−0.05

Average error = ±0ᴹ.037.

1894 *July* 29.

G.M.T.	Observed	O—C
4 37	8.95	−0.04
4 40	9.05	+0.02
4 41	9.05	+0.01
4 43	9.10	+0.03
4 47	9.15	+0.03
4 49	9.15	0.00
4 50	9.20	+0.04
4 52	9.25	+0.06
4 57	9.25	0.00
5 7	9.25	0.00
5 27	9.25	0.00
5 33	9.25	0.00
5 41	9.25	0.00
5 49	9.25	0.00
5 57	9.25	0.00

Average error = ±0ᴹ.015.

It has already been stated that only those observations are given which were taken during a minimum-phase.

Measures were made regularly, night after night, but there is no necessity for giving them.

Reduction of Observations. If we regard the variation of this star as due to an eclipse of one star by another, then we may represent the amount of variation as a function of the time.

Thus, let M be the magnitude at a maximum; M_0 the magnitude at any time, t, during the decreasing phase; D the date when the two discs just touch; then

$$M-M_0 = x(D-t)+y(D-t)^2+z(D-t)^3+w(D-t)^4 \dots \quad (1)$$

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As D may be known with fair exactness by a graphical solution, let

$$D = D_1 + \Delta\delta$$

and as $D_1 - t$ will then be known, we may write equation (1) in the form

$$(2) \qquad M - M_0 = x(t_1 + \Delta\delta) + y(t_1 + \Delta\delta)^2 + z(t_1 + \Delta\delta)^3 + w(t_1 + \Delta\delta)^4$$

where $\qquad t_1 = D_1 - t$

Expanding this equation and making

$$\alpha = x\Delta\delta + y\Delta\delta^2 + z\Delta\delta^3 + w\Delta\delta^4 \ldots.$$
$$\beta = x + 2y\Delta\delta + 3z\Delta\delta^2 + 4w\Delta\delta^3 \ldots.$$
$$\gamma = y + 3z\Delta\delta + 6w\Delta\delta^2 \ldots.$$
$$\delta = z + 4w\Delta\delta \ldots.$$
$$\varepsilon = w + \ldots.$$

equation (2) becomes

$$(3) \qquad M - M_0 = \alpha + \beta t_1 + \gamma t_1^2 + \delta t_1^3 + \varepsilon t_1^4 \ldots.$$

For the ascending period an equation of a similar type may be formed, equation (2) being of course

$$M - M_0 = x(t_1 - \Delta\delta) + y(t_1 - \Delta\delta)^2 + z(t_1 - \Delta\delta)^3 + w(t_1 - \Delta\delta)^4$$

The observations themselves give as the limits of variation, $7^{M}.85$ and $9^{M}.25$. We may therefore determine for each evening the values of x, y, z, w; the time D of beginning or end of eclipse; the time of minimum phase, and also the weights of these values. To obtain the most probable period, and the mean probable values of x, y, z, w, is but a step more.

In this way the following elements of this variable were rigorously computed.

	d	h	m
Period of variation,	5	22	23.4
Descending period,	0	4	18.0
Stationary period at minimum,	0	6	35.0
Ascending period,	0	4	18.0
Stationary period at maximum,	5	7	12.4

	G.M.T.	
Epoch of commencement of descending phase, 1894 May 1,	h 0	m 47
end of descending phase,	5	5
beginning of ascending phase,	11	40
end of ascending phase,	15	58

Law of variation:

$$M - M_0 = 0^{m}.1622\,t_1 - 0^{m}.0256\,t_1^2 + 0^{m}.0133\,t_1^3 + 0^{m}.0003\,t_1^4$$

t_1 being the time to, or after, minimum.

The form of the light-curve can best be seen by reducing all the observations given in this paper to the minimum of 1894 May 1. It may specially be noticed here that a secondary maximum does not appear, the fall and rise being quite regular. Indeed, I think the "secondary maximum" is often made a good excuse for poor observations. Frequently what has apparently seemed a decided wave in a curve has disappeared with more careful reduction.

Observations Reduced to 1894 May 1.

G.M.T.	M_0	$M_0 - M_c$	G.M.T.	M_0	$M_0 - M_c$	G.M.T.	M_0	$M_0 - M_c$	G.M.T.	M_0	$M_0 - M_c$
h m	M	M	h m	M	M	h m	M	M	h m	M	M
−2 28	7.83	−0.03	+3 54	8.55	+0.02	+5 16	9.25	0.00	+ 9 9	9.20	−0.05
1 28	7.90	+0.05	4 2	8.50	−0.08	31	9.25	0.00	9 39	9.20	−0.05
1 3	7.85	0.00	4	8.65	+0.05	36	9.25	0.00	10 3	9.25	0.00
−0 28	7.80	−0.05	12	8.70	+0.04	42	9.25	0.00	13	9.20	−0.05
+0 2	7.86	+0.01	14	8.70	+0.02	44	9.20	−0.05	24	9.20	−0.05
14	7.83	−0.02	18	8.70	−0.01	50	9.25	0.00	48	9.20	−0.05
32	7.81	−0.04	19	8.65	−0.07	51	9.30	+0.05	50	9.25	0.00
0 44	7.85	0.00	28	8.75	−0.06	58	9.25	0.00	10 53	9.25	0.00
1 7	7.90	0.00	32	8.90	+0.05	5 59	9.20	−0.05	11 20	9.30	+0.05
14	7.92	0.00	33	8.75	−0.11	6 6	9.25	0.00	12 15	8.75	−0.08
42	8.10	+0.10	38	8.86	−0.05	36	9.30	+0.05	24	8.73	−0.01
1 47	7.93	−0.08	44	9.10	+0.14	36	9.25	0.00	12 44	8.60	+0.03
2 1	8.05	+0.01	46	8.95	−0.04	43	9.30	+0.05	13 5	8.40	−0.03
2	8.03	−0.01	48	9.00	−0.01	44	9.27	+0.02	21	8.40	+0.07
32	8.19	+0.06	49	9.05	+0.02	6 58	9.30	+0.05	41	8.35	+0.11
36	8.20	+0.06	50	9.05	+0.01	7 3	9.25	0.00	13 58	8.15	−0.03
2 54	8.25	+0.05	52	9.10	+0.03	9	9.20	−0.05	14 10	8.05	−0.09
3 2	8.25	+0.02	56	9.15	+0.03	14	9.20	−0.05	16	8.15	+0.03
8	8.25	0.00	58	9.10	−0.05	29	9.20	−0.05	28	8.00	−0.08
11	8.30	+0.03	58	9.15	0.00	34	9.25	0.00	42	8.10	+0.06
14	8.30	+0.01	4 59	9.20	+0.04	44	9.20	−0.05	14 50	7.95	−0.07
15	8.25	−0.04	5 1	9.25	+0.06	7 59	9.25	0.00	15 7	8.00	+0.02
21	8.30	−0.01	2	9.10	−0.10	8 3	9.20	−0.05	10	7.95	−0.02
32	8.45	+0.07	3	9.20	−0.03	8	9.25	0.00	30	7.90	−0.02
39	8.45	+0.03	6	9.25	0.00	9	9.25	0.00	15 33	7.90	−0.01
42	8.40	−0.04	8	9.20	−0.05	29	9.25	0.00	16 12	7.90	+0.05
44	8.50	+0.02	8	9.20	−0.05	8 39	9.20	−0.05	+16 25	7.80	−0.05
+3 49	8.40	−0.09	+5 14	9.30	+0.05	+9 3	9.30	+0.05			

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Interpretation of Results. The natural explanation of the variation of this star is, that here we have the opposite of what we have in the case of *Algol*. *Algol* is a bright star with a dark companion. This variable is a dark central star, with a brighter, but much smaller companion, revolving round it. The magnitude of the primary is $9^{M}.25$, of the companion about $8^{M}.05$. When the star is at a minimum we have the light of the primary only, and the variable remains for over six hours at $9^{M}.25$. At a maximum we have the combined light of both stars, that is, $7^{M}.85$.

Considering the eclipse as a central one the ratio of the two diameters will be as 43 : 109.

The assumption that the eclipse is a central one gives us also the relation between the diameters and the distance that separates the two stars, for it is evident that if the smaller star takes 10.9 hours to pass across the primary, and 142.4 hours to describe its orbit, then the diameter of the larger star cannot be less than one-half the distance between the two stars.

It is much to be regretted that the star cannot be passed under the scrutiny of the spectroscope. Such an examination would yield a most valuable train of facts, and would raise probable results into actual knowledge. It is to be hoped that ere long we will have in the southern hemisphere a spectroscope, so adapted, and so powerful, that in half a dozen nights we will have settled, without the prospect of a doubt, the motions of this peculiar binary system; and above all, the motions, relative masses, distances, and hence parallax of $\alpha_2\,\alpha_1$ *Centauri*.

When this explanation of the variation of this star occurred to me, I bethought me of seeing how far the theory of an eclipse, such as I have indicated, would be met by the law of variation resulting from a least-square solution of the different observations.

It was necessary for such an investigation that the light-ratio be known as accurately as possible. I am certain most observers will agree with me that the present accepted value 2.512 is too small.

It certainly takes a group of at least three ninth magnitude stars to give the same light as an eighth magnitude star.

With the very inadequate means at my disposal—a sextant on an altazimuth stand—I made some observations towards obtaining a ratio that would fit better in with facts. I brought two stars into the same field, and estimated their magnitudes; then by the movements of the sextant, superimposed them on one another, and again noted the resultant magnitude. This was done several times, and the results obtained gave as the light-ratio 3.3. At some more convenient time I hope to take up this question again, for it is one which will have more than a mere theoretical value in the discussion of short-period variation.

Taking 3.3 as a probable value of the light-ratio, we find that at a maximum the combined light of both stars ($7^{M}.85$) is 5.32 times the light of the central star alone ($9^{M}.25$); that is, the companion-star is 4.32 times brighter than the primary. As the smaller star moves behind the larger, it becomes an easy geometrical problem to ascertain the amount of eclipse at any time. And from the light-ratio, 3.3, it is a simple matter to convert the amount of light into magnitudes. The following table gives the amount of light given out by the two stars at intervals of 30^{m} after the end of full eclipse, and the corresponding value in magnitudes. Column 4 gives the magnitudes as obtained from the actual light-curve; and column 5 gives the correspondence between the two.

Time after min.	Amount of light emitt'd by both stars	Amount expressed in magnitudes	Observed magnitude	Residuals
h m 0 0	1.00	M 9.25	M 9.25	M +0.00
0 30	1.34	9.00	8.88	+0.12
1 0	1.89	8.72	8.60	+0.12
1 30	2.50	8.48	8.40	+0.08
2 0	3.14	8.29	8.24	+0.05
2 30	3.75	8.14	8.14	+0.00
3 0	4.32	8.02	8.05	−0.03
3 30	4.85	7.93	7.97	−0.04
4 0	5.22	7.88	7.89	−0.01

It is possible that, when the light-ratio is more accurately known, the residuals will be less persistent in sign; however, it seems to me that the correspondence between theory and observation is close enough to warrant our accepting the explanation offered as a true interpretation of the facts observed.

I would desire to acknowledge my indebtedness to Dr. Gill for early information concerning this star, and for the positions of two of the comparison-stars.

Lovedale, South Africa, 1894 *Aug.* 1.

NOTE ON ACCOUNTING FOR THE SECULAR VARIATIONS OF THE ORBITS OF *VENUS* AND *MERCURY*,

By SIMON NEWCOMB.

The study of the secular variations of the orbits of the four inner planets, as derived from observation, has led me to the conclusion that the perihelion of *Mercury* is not the only element the secular variation of which cannot be satisfactorily represented by existing theory. The motion of the node of *Venus* cannot be explained except by supposing

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