above described, however, the plane of their rotation will gradually shift, so that from being at first nearly parallel to the plane of their orbits, it becomes later perpendicular to them, and finally again parallel, but this time with the rotation direct. Successive satellites formed by the contracting mass would thus originally revolve in different planes, but would all finally approach the plane of rotation of their primary through the attraction of their equatorial regions.

Such a progressive change of plane is found in the orbits of the satellites of the four major planets. Thus, for *Neptune* the approximate angle is 145°, for *Uranus* 98°, for *Saturn* (inner satellites) 27°, and for *Jupiter* 2°. It is also found in the case of the four inner planets, as far as is known, as determined by the inclination of their equators to the plane of their orbits. Thus, for *Mars* the angle is 25°, for the *Earth* 23°, for *Venus* the angle is unknown, and for *Mercury*, while undetermined, it is certainly very small, as is indicated by the drawings of surface detail made at Milan, Arequipa and Flagstaff. While the force producing this change must at the present time be almost infinitesimal, yet such would not have been the case in the past, when the planets were perhaps one hundred or more times their present dimensions.

If we take the great nebula in *Andromeda* as a type of our earlier existence, the planets being merely condensed masses revolving within and with the solar atmosphere, this atmosphere itslf would excite a frictional force which would tend always to keep the same side of the planet towards its primary, while gravitation acting on the mass before it had separated itself from the spiral would tend to cause it to revolve in a retrograde direction. Thus in the earlier times it is very certain that these forces would be much more active than we find them to be at the present day.

Harvard College Observatory, 1901 *Nov.* 7.

THE GREENWICH REFLEX ZENITH-TUBE,

By S. C. CHANDLER.

Nothing in modern astronomy is so melancholy a record of futile result from a promising project, pursued with admirable perseverance under disheartening circumstances, as the history of the Greenwich Reflex Zenith-Tube. All investigations of the observations made with it have been absolutely nugatory, and the memoirs communicating them have candidly confessed failure in arriving at any acceptable astronomical conclusions or any determinable reason therefor. The persistently anomalous results, apparently pointing to undiscoverable instrumental sources of error, finally discouraged further employment of the instrument, and the apparently hopeless undertaking was abandoned in 1882 after thirty years' continuous trial.

But, although the immediate objects for which this series of observations was instituted have been frustrated, it is proposed in this article to show that it has accomplished, unwittingly, an even higher service to astronomy than that for which it was intended, and that, in place of a fallacious aberration-constant and an impossible stellar-parallax, it in reality contains a body of evidence of the highest value in relation to the constants of the latitude-variation during the period which the observations cover. Immediately upon the discovery of the approximate laws of the polar motion about ten years ago the writer was forcibly impressed with the importance of this series as a contribution to their further development, and through a provisional investigation it was drafted into that service. This use of it was criticized at the time by reputable authority, but I never thought it worth while to notice this or other like strictures, since they were of the kind that time could be relied upon to answer. They are only mentioned now as curious illustrations of the tenacity of prejudice, once respectable, but no longer so when the cause for it has disappeared. It is now manifest that astronomers up to the last decade had incurred a habit of resorting to the hypothesis of subjective error whenever they met unexplained residuals in series of zenith-distance measurements, and that the inertia of this habit led to a certain want of alertness to perceive that the verdict of discredit that had fallen on many of these series required reconsideration, in view of a *vera causa* suddenly thrust upon their attention. In the case of the series now under discussion, for example, however and by whomever treated the outcome had always been a large negative parallax of γ *Draconis*, and an aberration-constant impossible to accept. It is indeed true that the palpably large accidental error of the individual measures intensified the impression as to the untrustworthiness of the series as a whole, and it is to be regretted that a higher degree of refinement in this regard was not striven for, since there is no discernible reason why it could not have been reached. The theory of the instrument is perfect, its construction is of the last simplicity, and the quantity measured is obtained with a degree of directness and thorough elimination of instrumental error as high as it is easy to conceive.

It is needless here to devote any space to description of the instrument or the method of observation. It suffices to refer to Airy's account in the first appendix to the Greenwich volume for 1854, to Main's paper in the *R.A.S. Memoirs*, Vol. XXIX, and to Poor's discussion of the theory and errors of the instrument in *Astr. Journ.*, Vol. IX, p. 153 ff. The results of the observations from 1852–59 will be found in Main's paper above referred to; from 1857–75 in Downing's paper in the *Monthly Notices, R.A.S.*, Vol. XLII.

Date	No.	n
1852		
Aug. 27	12	+0.30
Sept. 20	4	− .22
Oct. 14	2	− .82
1853		
Apr. 19	2	− .24
May 27	4	− .18
June 17	6	− .47
July 14	4	− .97
Aug. 9	4	− .93
22	2	+ .13
Sept. 15	2	− .54
1854		
Jan. 25	1	−0.77
Mar. 15	1	(−3.23)
Apr. 22	2	−1.09
May 15	3	−0.36
30	5	− .53
June 15	4	+ .65
29	2	− .98
July 24	9	− .32
Aug. 16	5	− .37
Sept. 5	11	−0.92
27	2	−1.44
1855		
Mar. 27	1	−0.07
Apr. 21	4	− .16
May 9	1	+ .52
June 5	4	− .90
25	6	− .61
July 10	5	+ .23
24	3	− .81
Aug. 15	5	− .52
31	8	+ .04
Sept. 21	3	− .69
1856		
May 23	2	+ .31
June 6	5	+1.01
16	3	+0.43
July 1	5	+ .27
22	8	+ .03
31	6	− .06
Aug. 9	8	− .27
Sept. 2	7	− .13
26	4	− .82
Oct. 24	5	+ .14
Nov. 5	2	− .20
24	1	− .42
Dec. 17	4	− .31
1857		
Jan. 1	1	+ .03
Feb. 13	5	− .36
Mar. 15	4	− .08
Apr. 17	6	+ .15
May 7	7	+ .13
31	6	+ .11
June 14	7	+ .04
26	6	+ .66
July 12	9	+ .17
27	8	+ .12
Aug. 21	8	− .02
Sept. 6	5	+ .31
23	8	− .32
Oct. 8	3	− .11
28	3	− .71
Nov. 11	1	−0.36

Date	No.	n
1857		
Nov. 29	3	−0.17
Dec. 10	2	−0.30
31	1	−1.11
1858		
Jan. 10	3	−0.64
28	4	− .82
Feb. 22	6	− .27
Mar. 9	3	− .46
23	4	− .79
Apr. 18	4	+ .41
May 8	7	− .12
22	5	+ .36
June 13	11	+ .74
29	6	+ .28
July 16	7	+ .25
Aug. 1	9	+ .45
13	5	+ .55
31	5	+ .26
Sept. 17	8	+ .17
Oct. 7	3	− .11
Nov. 4	3	− .03
18	1	− .04
Dec. 2	2	− .79
21	2	+ .20
1859		
Jan. 31	3	− .56
Feb. 23	5	− .01
Mar. 11	5	− .81
Apr. 5	4	− .96
22	1	− .19
May 10	5	− .82
29	3	−0.89
June 25	6	−1.08
July 11	12	−0.14
Aug. 2	4	− .08
21	7	+ .63
Sept. 2	4	− .07
21	3	− .17
Oct. 7	3	+ .42
27	3	+ .51
Nov. 16	4	− .07
Dec. 1	5	− .05
26	1	− .32
1860		
Jan. 7	1½	− .25
23	2	− .75
Feb. 25	6	− .28
Mar. 5	2	− .88
17	4	− .84
Apr. 1	1	− .09
May 19	6	− .92
June 5	3	− .20
16	4	+ .29
July 10	3	+ .13
20	2	+ .51
Aug. 7	5	+ .48
Sept. 10	5	+0.34
29	3	+1.28
Oct. 16	4	+0.32
Nov. 3	4	+ .25
21	2	+ .14
Dec. 24	3	+0.04

Date	No.	n
1861		
Jan. 9	2	+0.01
Feb. 20	3	+ .03
Mar. 21	2	+ .06
Apr. 19	5	− .88
June 14	7	− .17
25	4	+ .43
July 11	5	+ .96
29	4	+ .17
Aug. 12	4	+ .46
25	10	− .09
Sept. 6	3	+ .30
Oct. 4	2	− .89
27	6	+ .17
Dec. 7	3	+ .45
1862		
Jan. 9	1	+ .77
Mar. 18	1	−0.69
Apr. 20	2	+1.71
May 20	1	−0.41
June 3	1	+ .29
28	2	+ .13
July 12	1	− .20
23	5	− .58
Aug. 6	5	+ .37
26	5	−0.73
Sept. 15	4	−1.35
Oct. 8	5	+0.02
1863		
Jan. 6	1	− .86
Feb. 1	2	−0.21
14	3	−1.01
Mar. 2	1	−0.44
13	1	+ .31
May 13	1	− .19
26	2	+ .02
June 3	4	− .59
23	7	− .04
July 11	11	+ .01
28	6	+0.66
Aug. 12	5	+1.03
20	4	+0.04
Sept. 23	7	− .46
Oct. 16	3	− .08
Nov. 29	4	− .30
1864		
Jan. 29	3	− .13
Feb. 9	0	(−3.48)
Mar. 19	3	−1.05
May 18	4	−0.88
June 4	4	− .29
13	3	− .04
July 2	4	− .83
18	5	− .03
Aug. 4	4	− .27
13	6	+ .11
Sept. 4	3	+ .76
25	6	.00
Oct. 4	2	− .11
26	3	− .18
Dec. 2	5	−0.06
1865		
Jan. 12	½	+1.12
Feb. 19	1	−0.85
Mar. 19	1	−0.55

Date	No.	n
1865		
May 12	1	+0.01
27	3	−1.32
June 10	4	−0.84
22	5	− .27
July 9	6	− .26
24	5	− .09
Aug. 5	4	+0.26
25	3	−1.20
Sept. 5	6	+0.02
22	9	− .56
Oct. 5	7	− .19
1866		
Jan. 16	2	−0.64
Feb. 21	2	−1.20
Mar. 6	4	−0.58
May 4	2	−1.68
21	8	−1.35
June 8	1	−1.11
24	5	−0.73
July 10	5	−0.25
19	2	−1.28
Aug. 5	3	−0.43
19	5	−0.26
Sept. 10	1	+0.30
27	½	+1.94
Oct. 12	3	+0.26
28	2	−0.88
Nov. 30	1	−1.22
1867		
Feb. 6	1	−0.34
Mar. 15	1	− .40
May 30	2	+ .17
June 13	5	− .01
26	5	− .85
July 10	6	− .23
29	3	− .60
Aug. 13	7	− .46
30	5	− .25
Sept. 23	6	−0.97
Oct. 17	½	−1.80
Nov. 6	1	−1.84
1868		
Feb. 5	1	+0.55
27	1	−1.71
Mar. 11	4	−0.53
May 18	4	− .40
26	5	+ .86
June 6	6	+0.70
17	5	+1.40
25	7	+0.52
July 9	4	− .31
15	5	+ .39
23	5	− .03
Aug. 4	6	+ .08
Sept. 5	8	− .21
22	3	+ .29
Oct. 9	4	+ .15
29	1	+ .10
1869		
Jan. 23	2	+ .68
Feb. 12	2	+ .01
Mar. 12	1	+0.51
Apr. 1	1	+1.09
May 5	2	+0.42

Date	No.	n
1869		
May 27	3	−0.79
June 11	7	+0.30
26	3	−1.35
July 18	7	+0.36
Aug. 3	4	+ .11
17	7	− .21
29	4	− .99
Oct. 9	2	− .29
Nov. 16	2	+0.60
Dec. 1	0	(−2.67)
1870		
Jan. 20	2	−0.30
Feb. 24	1	− .25
Mar. 13	1	− .84
May 21	8	−0.09
June 7	4	−1.03
19	8	+0.09
July 2	4	− .33
20	13	− .26
Aug. 13	9	− .32
Sept. 1	5	− .14
26	10	− .30
Oct. 10	2	− .28
Nov. 1	2	− .57
12	1	−0.63
1871		
Feb. 16	½	−1.54
May 24	2	−0.91
June 5	1	− .03
July 6	4	− .31
17	3	− .80
31	4	− .35
Aug. 11	8	+ .01
1872		
Jan. 18	2	−0.68
Feb. 12	1	−1.13
Aug. 15	1	−0.78
Dec. 6	1	− .84
27	3	+0.40
1873		
Jan. 27	2	−1.05
May 17	3	−0.61
June 20	3	−0.32
July 1	1	−1.83
23	8	−0.56
Aug. 5	8	−1.34
18	8	−0.09
Sept. 5	3	+ .72
24	5	− .18
Oct. 17	1	+ .23
Nov. 15	1	−0.16
25	1	−2.23
1874		
May 22	5	+0.60
June 8	9	+1.02
23	2	+1.47
July 4	6	+0.56
17	8	+ .70
29	3	+ .20
Aug. 9	4	+ .79
19	4	+ .13
31	4	+ .10
Sept. 13	3	+ .80
25	2	−0.33
Oct. 10	2	−1.03

Date	No.	n
1874		
Oct. 24	1½	+0.58
Nov. 20	1	− .50
1875		
May 22	3	− .30
June 1	2	+ .27
14	5	+ .79
24	3	−0.97
July 7	5	−1.62
30	5	−1.39
Aug. 20	5	−1.80
Sept. 3	6	−0.81
17	5	−1.23
1876		
May 27	4	+0.42
June 23	4	− .60
July 17	6	−0.48
Aug. 6	6	−1.04
14	5	−0.14
Sept. 17	4	−1.12
1877		
Feb. 2	1	−1.35
May 28	3	−0.86
June 21	4	−1.24
July 9	5	−0.97
28	5	−0.02
Aug. 16	5	−0.62
29	4	−1.51
Sept. 30	3	−2.18
1878		
June 15	4	+1.34
24	4	−0.04
July 1	5	+1.00
19	5	+0.45
31	4	+ .61
Sept. 8	5	− .36
26	5	− .42
1879		
May 17	3	− .54
June 2	3	− .02
24	4	− .21
July 6	3	− .50
26	4	+ .05
Aug. 28	6	+ .22
Sept. 22	3	− .24
1880		
May 23	4	−0.85
June 6	3	−2.70
29	5	−1.42
July 10	5	−1.07
26	5	−1.34
Aug. 10	5	+0.50
28	6	−0.27
1881		
May 13	3	−0.59
June 1	7	−1.29
22	4	−0.47
July 9	4	−0.56
27	4	−1.36
Aug. 17	5	−1.14
Sept. 23	2	−1.80
1882		
May 18	5	−0.60
June 5	6	+ .30
25	5	− .46
July 15	6	+0.27
Aug. 3	6	−1.21
14	5	−1.13

Those from 1875 to 1882, when the series was abandoned, I have collected from the Greenwich annual volumes.

In the preceding table the results for the whole series from 1852 to 1882 are given, homogeneously reduced. Each line contains the result of a group of observations, the mean date and number of observations being given in the first and second columns. The third column, n, contains the mean value of the residual of the zenith-distance of γ *Draconis*, expressed in the sense Δq (O−C) $= q - q_0$. These have been referred to the value of the aberration-constant 20″.505, which seemed to me to be the best at the time these computations were made, although evidence has been since accumulating that would seem to make a somewhat larger value more probable. Besides this correction for aberration it was necessary to refer the portion before 1857 to the same zero as for the subsequent series, on account of the change of location of the instrument in 1856 to a point 53 feet south of its previous position, and to correct for the difference of annual proper motion in declination assumed by MAIN (−0″.04), and that used by DOWNING and myself (−0″.028). Thus, MAIN's residuals, after change of sign, required the correction, +0″.16 +0″.012 $(t-1852)$; and both MAIN's and DOWNING's the reduction from the aberration-constant assumed by them (20″.400).

An inspection of the table of observations will show at once that the unequal distribution as regards time of year makes it impossible to get an adequately independent determination of the constants of the latitude-variation except for the interval from 1857 to 1870. Before and after this the measurements are practically confined to five months of the year, from May to September, which makes futile the attempt at an independent elimination of the fourteen-months' and annual terms. The following condensed count of the observations makes this clear.

	Jan.–Apr.	May–Oct.	Nov.& Dec.
1852–56	10	200	7
1857–63	98	345	41
1864–70	34	340	12
1871–77	6	213	7
1878–82	0	153	0

Pertinent results for both terms can therefore be expected only for the two seven-year cycles 1857–63 and 1864–70.

The process of finding the constants was that of successive approximation, by alternate elimination of each term. Thus, the circumference of the fourteen-months' term was divided into sixteen parts; the data of the table, for each of the intervals 1857–63 and 1864–70, were classified accordingly; and the mean values of n thus found furnished a first approximation to the 428-day term. The original values of n were then corrected for this and the residuals were classified by calendar months, giving a first approximation to the annual term. Correcting the original n's for this, a second approximation to the 428-day term was found. A repetition of the process for the annual term gave values differing so little from the previous approximation that it did not seem necessary to carry the process further.

In this manner we have the values of $q - q_0$.

1857–63; $-0''.246\cos(t-240\,0541)0^\circ.84 - 0''.166\cos(\odot-323^\circ)$

1864–70; $-0.222\cos(t-240\,3238)0.84 - 0.134\cos(\odot-313)$

which have been used in the investigations in *A.J.* 489, p. 71 (note), and in *A.J.* 494, p. 109, as there stated. The following tables give the comparison of the computed and observed values, the latter having been corrected by the constants +0″.09 and +0″.34, which are the reductions to arbitrary zero given by the computations for the series 1857–63 and 1864–70, respectively.

428d-TERM.

1857–63			1864–70		
t	O	C	t	O	C
	″	″		″	″
240 0413	+0.06	+0.07	240 3013	−0.08	+0.22
0440	+ .03	− .03	3040	+ .26	+ .21
0467	− .11	− .12	3067	+ .47	+ .18
0494	− .29	− .19	3094	+ .07	+ .11
0521	− .13	− .24	3121	+ .32	+ .03
0548	− .31	− .24	3148	− .17	− .06
0575	− .03	− .22	3175	− .34	− .13
0602	− .05	− .15	3202	− .17	− .19
0629	− .34	− .07	3229	− .37	− .22
0656	− .14	+ .02	3256	− .38	− .21
0683	+ .21	+ .12	3283	+ .04	− .18
0710	+ .45	+ .19	3310	+ .17	− .11
0737	+ .16	+ .24	3337	+ .07	− .03
0764	+ .27	+ .24	3364	− .11	+ .06
0791	+ .14	+ .22	3391	+ .03	+ .13
240 0818	+0.16	+0.15	240 3418	+0.20	+0.19

ANNUAL TERM.

1857–63			1864–70		
	O	C		O	C
	″	″		″	″
Jan.	−0.25	−0.15	Jan.	+0.20	−0.13
Feb.	− .15	− .17	Feb.	− .27	− .13
Mar.	− .29	− .14	Mar.	− .16	− .10
Apr.	+ .29	− .08	Apr.	−	− .04
May	− .25	+ .01	May	− .15	+ .03
June	+ .12	+ .09	June	+ .24	+ .09
July	+ .18	+ .15	July	+ .13	+ .13
Aug.	+ .31	+ .17	Aug.	+ .06	+ .13
Sept.	+ .01	+ .14	Sept.	+ .09	+ .10
Oct.	+ .10	+ .08	Oct.	+ .11	+ .04
Nov.	− .01	− .01	Nov.	−0.16	− .03
Dec.	−0.06	−0.09	Dec.	−	−0.09

I do not think the above results could be essentially varied by different method of reduction, and see no reason to doubt that they are real, and afford a tolerably correct

idea of the elements of the latitude-variation during the period embraced by the series. The outcome of the discussion ought to dissipate the prejudice that has so long prevailed against these observations, since the anomalies are now traced to the intervention of a phenomenon not suspected at the time they were made. In the installation and persistent use of this instrument AIRY was building better than he knew, and in an unforeseen way conferred on astronomy a higher benefit than his actual aim would have been had it been attained.

THE OBSERVATIONS OF *ALGOL* BY ARGELANDER, SCHMIDT AND SCHÖNFELD,

BY S. C. CHANDLER.

The long series of minima of *Algol* observed by ARGELANDER, SCHMIDT and SCHÖNFELD supply means that are too important to be overlooked, for examining the question of the existence of minor irregularities in its period. SCHMIDT's series overlaps ARGELANDER's at one end and SCHÖNFELD's at the other, and all three are long enough to give series of observed values of the period that are independent of each other and entirely free from the effects of personal differences between the three observers in the determination of the time of minimum.

On p. 171 of Vol. VII, *A.J.*, I have given a table of yearly mean epochs deduced separately for the different observers. By combining these into normals, each embracing one or two years' observations, and taking differences for epochs separated by several hundred periods, independently for ARGELANDER, SCHMIDT and SCHÖNFELD, we have the appended table. The column *O* contains the observed periods, and column *C* the periods computed from the elements in *A.J.* 509.

The differences $O-C$ display very clearly a systematic deviation from the elements that must be entirely independent of systematic personal differences in deducing the times of minima, as has been stated above. The accordance of the three sets of observations in this regard enables us to conclude with reasonable certainty that there was an actual irregularity, consisting of a rather sudden diminution of the period, with respect to the elements, between 1854 and 1857 of about $1''.5$, and a subsequent increase, gradual from 1863 to 1872, of the same amount.

Thus we have additional evidence, of a cumulative character, of the reality of such minor irregularities, similar to that adduced in *A.J.* 509 from a comparison of MÜLLER's results with those of other observers for the interval 1875 to 1878.

		Period $2^d\ 20^h\ 48^m+$				
Date	Epoch	*O*	*C*	*O*—*C*	Wt.	Observer
		s	s	s		
1844.4	5661	53.9	53.9	+0.0	3	Argelander
1847.4	6042	53.2	53.0	+0.2	2½	"
1850.1	6380	53.3	52.8	+0.5	1½	"
1851.4	6548	53.2	52.7	+0.5	3	"
1851.7	6583	53.3	52.6	+0.5	1½	Schmidt
1854.0	6880	53.2	52.8	+0.4	1	Argelander
1854.1	6894	53.0	52.8	+0.2	3½	Schmidt
1856.0	7135	54.1	53.1	+1.0	2	Argelander
1856.6	7212	52.6	53.1	−0.5	2	Schönfeld
1856.8	7233	53.3	53.2	+0.1	3½	Schmidt
1857.4	7299	52.2	53.3	−1.1	1	Argelander
1859.2	7534	52.6	53.5	−0.9	2	Schönfeld
1859.4	7556	52.5	53.6	−1.1	1	Argelander
1859.5	7586	53.0	53.6	−0.6	1½	Schmidt
1862.1	7913	52.8	53.9	−1.1	1	Argelander
1862.3	7933	53.6	53.9	−0.3	4½	Schmidt
1862.9	8023	54.2	53.9	+0.3	3½	Schönfeld
1864.5	8218	54.1	54.0	+0.1	2½	"
1864.6	8229	53.8	54.0	−0.2	6	Schmidt
1867.4	8580	53.9	53.8	+0.1	4	"
1867.8	8635	54.0	53.6	+0.4	4	Schönfeld
1869.4	8836	53.9	54.0	−0.1	2½	"
1869.9	8902	53.6	53.3	+0.3	4	Schmidt
1871.4	9081	53.8	53.0	+0.8	2½	Schönfeld
1872.6	9243	52.9	52.6	+0.3	5	Schmidt
1872.8	9278	53.4	52.6	+0.8	2½	Schönfeld

CHANGE IN NEBULA SURROUNDING *NOVA PERSEI*,

The following telegraphic dispatches have been received *via* Harvard College Observatory:

Nov. 10. From Crossley-photograph PERRINE finds that four principal condensations faint nebula surrounding *Nova Persei* moved southeast one minute of arc in six weeks.

Nov. 11. RITCHEY states photograph Yerkes November ninth confirms large motion nebula near *Nova.*

Nov. 12. From photographs *Nova Persei* November RITCHIE finds Nebula probably expanding in all directions. This certainly true of southern half.

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