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COMMUNICATION FROM THE OBSERVATORY AT LEIDEN.

The longitudes of Jupiter's Satellites derived from photographic plates taken at the Observatory at Pulkovo in the years 1904 to 1910, by *W. de Sitter* and *G. Pels.*

In the years 1904 to 1910 plates were taken of Jupiter and its satellites at Pulkovo by Prof. KOSTINSKY with the Carte du Ciel telescope, of which the aperture was screened down to 210 mm. The times of exposure were communicated to me by the late director BACKLUND in December 1913, and tabular places were computed at Leiden in the course of 1914. The war intervened, and the measures of the plates, which were executed, partly at Pulkovo and partly at Nicolaiev, by Mr. I. BALANOVSKY, only became available a few months ago. *) The comparison was then immediately taken in hand, and the results are published below. There are six series in all, but those taken in 1907 and 1909 consist of only 6 and 5 plates respectively, and were rejected. On the plates the differences in right ascension and declination of the satellites and Jupiter were measured. From these measured differences $\Delta\alpha \cos\delta$ and $\Delta\delta$ the coordinates x were derived by the formula

$$x = \Delta\alpha \cos\delta \cos P - \Delta\delta \sin P,$$

P being the position angle of the projection on the celestial sphere of the perpendicular through the centre of Jupiter to the adopted fundamental plane of the theory. The orientation of the plates had been derived at Pulkovo from exposures of the Pleiades, Praesepe or Coma Berenices, using the positions of these stars referred to the equinox of 1907·0. For P therefore must be used the position angle of the said projection at the date of observation, referred to the fixed equator of 1907·0, i.e.:

$$P = P_1 - 20''{\cdot}05 \sin\alpha \sec\delta\,(t - 1907{\cdot}0),$$

P_1 being the position angle computed by the usual formulas, and the time t being counted in years.

The same stars were also used to derive the scale value. As in the series of plates from the Cape and Greenwich, an unknown μ was introduced representing a constant correction to the adopted scale value for each series. The resulting values of μ were

Series	*Stars*	μ	p. e.
1904-5	Pleiades	— ·000138	± ·000034
1905-6	Pleiades	— ·000062	± 31
1908	Praesepe	+ ·000297	± 30
1910	Coma	— ·000256	± 31

The difference between the values of μ found for the first and the second series, in both of which the Pleiades were used as standard stars, is probably not real. The probable errors as stated above are those derived from the solutions. Individual corrections to the scale value were also derived for every separate plate, and from these individual corrections we find for the whole series the same value of μ as from the solution, with probable errors of ± ·000026 and ± ·000028 respectively for the two series. In the first series one half of these individual values of μ were between — ·00007 and — ·00023, in the second series one half were between + ·00009 and — ·00021. On the other hand the differences found here between the scale values as derived from the Pleiades, Praesepe and Coma Berenices are almost certainly real.

From his measures Mr. BALANOVSKY derived for the probable error of one difference $x_i - x_j$ the value ± 0″·036, or for one x_i ± 0″·026 = ± 0′·00043. On the plates taken at Helsingfors and Pulkovo in 1892 to 1898, and measured by Mr. RENZ, the same probable error was ± 0″·024 for the Pulkovo plates and ± 0″·030 for those from Helsingfors. The probable error of unit weight was also derived from the residuals. By comparing the values thus derived with the value $\rho = \pm\,'{\cdot}00043$ from the measures, we find the following values for the plate errors in the different series:

Series	ρ *from resid.*	*plate error*
1904—05	± 0′·00097	± 0′·00087
1905—06	± 89	± 78
1908	± 104	± 93
1910	± 92	± 81

*) *Publications de l'Observatoire Central Nicolas*, Série II, Vol XXXI, dated 1916, but received at Leiden in January 1926.

The plate errors are of the same order of magnitude as those found on the older series 1892—98, which were discussed by me in *Groningen Publications* **17** (see p. 53). The probable errors derived from the residuals are on the average very nearly twice those found in the series from the Cape and Greenwich, i. e. exactly in the ratio of the focal distances of the telescopes.

The observations were compared with my theory of 1908, from which the coordinates of the satellites at the times of the observations were computed by the usual formulas. As unknowns we introduced the corrections $\lambda_i = \Delta l_i / k_i$, the scale value μ, and four constants c_i subject to the condition $c_1 + c_2 + c_3 + c_4 = 0$. As in the other series, only the relative coordinates of the satellites, referred to the mean of the four as origin, were used, so as to eliminate the large systematic error of the pointing on the planet. The equations of condition and the normal equations were formed in the same way as for the other series, as explained e. g. in *B. A. N.* **50**. For all series individual corrections for scale value were derived for every plate, but these were small and not systematic, and were not used.

In the course of the work the following mistakes were detected in the printed Pulkovo volume:

page 90, plate *A* 810, sat. I, $\Delta\delta$: for $-0''.5311$ read $-0''.5371$
» III, $\Delta\alpha\cos\delta$: » $+5''.4192$ » $+5''.4162$
» *A* 825, » IV, $\Delta\alpha\cos\delta$: » $-8''.1597$ » $+8''.1597$
» 94, » *B* 223, » IV, $\Delta\delta$: » $+1''.3995$ » $-1''.3995$
» 95, » *B* 234, » IV, $\Delta\alpha\cos\delta$: » $-8''.3197$ » $+8''.3197$

page 89, plate *A* 802, time	: for	11	27	21	read	11	27	31
» 90, » *A* 825, »	: »	9	53	12	»	9	53	19
» 92, » *B* 42, »	: »	9	37	6	»	9	37	36

All these are misprints in the table of final results, the correct numbers and signs being given on the pages of the separate plates. There are two or three other differences of one or two seconds in the time, which have been neglected.

The following cases of misidentification of satellites occur:

Change IV into I on plates *B* 26, *B* 46, *B* 59.
» II » I » » *A* 776, *B* 60, *B* 72, *B* 80, *B* 223, *B* 228.
» I » II » » *A* 776, *B* 223.
» I » IV » » *B* 72.
» III » II » » *A* 832.

In addition to these, on plate *A* 803 $\Delta\alpha\cos\delta$ of satellite II has been altered a whole revolution of the screw, giving a correction of $-0'.4964$ to $\Delta\alpha\cos\delta$.

We now give the results of the separate series.

1904—05.

This series consists of 15 plates taken on 15 nights from 1904 October 3 to 1905 January 21. There are many large gaps, e. g. of 19 days each between Oct. 11 and Oct. 30 and between Oct. 30 and Nov. 18, several others of from 8 to 12 days. The only compact series that could be formed out of it would be one of 6 plates from Dec. 28 tot Jan. 11, which is too small a number to derive reliable results. A solution was first made from all plates. The residuals were satisfactory, with the exception of plate *A* 776 on January 11. The recorded times of plate *A* 759 taken on October 30, as printed on p. IV of the Pulkovo volume, evidently contain some mistakes. Also their mean does not agree with the mean time as given on p. 759 and the time communicated in advance in 1913 differed from both. It was not possible to reconstruct the correct time, and the plate must be rejected. This leaves a gap of 38 days between the first three plates and the rest of the series. A second solution was therefore made, based on the ten remaining plates taken from Nov. 18 to Jan. 21, rejecting also *A* 776 on Jan. 11. The weights in the second solution, of course, are much smaller than in the first, owing to the reduced number of plates, but the probable error of unit weight came out much smaller also, and the resulting probable errors of the unknowns are the same in both solutions. The determination is rather weak, depending on a small number of plates not distributed very evenly over the interval covered by the observations, which interval moreover is rather long. The uncertainty of the resulting corrections to the longitudes must be considerably larger than would be inferred from the probable errors.

The results from the two solutions are:

	Sol. I	Sol. II
λ_1	+ ·00009	— ·00011
λ_2	+ 20	— 13
λ_3	+ 37	+ 27
λ_4	— 32	— 40
μ	— ·00017	— ·00014
c_1	— ·0011	— ·0012
c_2	+ 36	+ 44
c_3	— 7	— 10
c_4	— 18	— 22
aver. resid.	± ·0013	± ·0010

It is proposed to adopt the second solution. This gives

$$\Delta l_1 = -0''.016 \pm 0''.013$$
$$\Delta l_2 = - \cdot 013 \pm 10$$
$$\Delta l_3 = + \cdot 018 \pm 6$$
$$\Delta l_4 = - \cdot 013 \pm 3$$

The mean epoch is 1904·981.

1905—06.

This series consists of 19 plates taken on 18 nights from 1905 October 17 to 1906 March 3. The first plate is isolated, the next one being on November 17. There are other large gaps between Nov. 19 and Nov. 30, between Dec. 6 and Dec. 20; Jan. 4 and Jan. 20; Feb. 8 and Feb. 21. Two solutions were made, one including all dates, and one including only the 13 plates from November 30 to February 8. The results were

	Sol. I	Sol. II
λ_1	−0·00009	−0·00002
λ_2	− 30	− 26
λ_3	+ 9	+ 17
λ_4	+ 8	+ 6
μ	− ·00006	− ·00006
c_1	+ ·0008	+ ·0007
c_2	+ 21	+ 21
c_3	− 7	− 8
c_4	− 22	− 20
aver. resid.	± ·0012	± ·0010

The two solutions give practically the same values for the unknowns. The second solution was adopted, which gives

$$\Delta l_1 = -0^\circ\!\cdot\!003 \pm 0^\circ\!\cdot\!011$$
$$\Delta l_2 = - \cdot 026 \pm 6$$
$$\Delta l_3 = + \cdot 011 \pm 4$$
$$\Delta l_4 = + \cdot 002 \pm 2$$

The mean epoch is 1906·003.

1908.

There is one plate on 1907 December 17, and then 26 plates on as many nights from 1908 January 25 to April 21. In the beginning of the series there are large gaps, but a very strong and compact series can be made out of the 21 plates taken from March 18 to April 21. Two solutions were made, the first based on all plates, the other on the last 21 plates. The results are given above.

	Sol. I	Sol. II
λ_1	+0·00034	+0·00042
λ_2	+ 22	+ 24
λ_3	+ 15	+ 27
λ_4	− 9	+ 4
μ	+ ·00028	+ ·00030
c_1	+ ·0004	+ ·0005
c_2	− 20	− 16
c_3	+ 8	+ 8
c_4	+ 8	+ 3
aver. resid.	± ·0012	± ·0012

The two solutions do not differ much, and give nearly the same residuals. The second solution was adopted. This gives

$$\Delta l_1 = +0^\circ\!\cdot\!063 \pm 0^\circ\!\cdot\!010$$
$$\Delta l_2 = + \cdot 024 \pm 7$$
$$\Delta l_3 = + \cdot 018 \pm 4$$
$$\Delta l_4 = + \cdot 001 \pm 2$$

The mean epoch is 1908·250.

1910.

This series, consisting of 12 plates taken on as many nights from 1910 April 1 to April 20, is very satisfactory as it is. No plates were rejected, and only one solution was made, giving

$$\lambda_1 = +0^\circ\!\cdot\!00003 \qquad c_1 = + \cdot 0006$$
$$\lambda_2 = + 47 \qquad c_2 = - 19$$
$$\lambda_3 = + 20 \qquad c_3 = + 9$$
$$\lambda_4 = - 7 \qquad c_4 = + 4$$
$$\mu = - \cdot 00026 \quad \text{aver. resid.} \pm \cdot 0010$$

The corrections to the longitudes and their probable errors are

$$\Delta l_1 = +0^\circ\!\cdot\!004 \pm 0^\circ\!\cdot\!011$$
$$\Delta l_2 = + \cdot 047 \pm 7$$
$$\Delta l_3 = + \cdot 013 \pm 4$$
$$\Delta l_4 = - \cdot 002 \pm 2$$

The mean epoch is 1910·273.

The following tables contain in the first column the plate number and the date, the second column gives the Greenwich mean time, uncorrected for aberration, and the position angle P which has been used to derive the x from $\Delta\alpha \cos\delta$ and $\Delta\delta$. The values of $x_i = x_i - x_o$, x_o being the mean of the satellites occuring on the plate, are given under x_{obs}. The fourth to seventh columns give the computed values of the jovicentric longitude in the orbit, the radius vector, the coordinate x_i, and the coefficients $a_i = dx_i/d\lambda_i$. The last two columns contain the right hand members of the equations of condition $n = x_{obs} - x_{comp}$, and the residuals of the finally adopted solution. The remarks have been translated from the Pulkovo volume, with the exception of the one printed in italics, which was added here. All plates were taken by S. KOSTINSKY and measured by I. BALANOVSKY.

Plate N°. Date 1904	P G. M. T.	Satellite	v	ρ	x	a	x_{obs}	n	Resid.	Remarks
A 748	337° 35′·8	I	162°·5729	0·997621	+ 1′·6989	− 4·53	+ 1′·8554	− 0′·0012	[+ 0′·0004]	
		II	187·7876	1·008025	+ 1·2875	− 6·42	+ 1·4470	+ 18	[− 25]	Good images.
Oct. 3	9h 58m 41s	III	109·5850	1·001369	+ 6·1177	+ 0·93	+ 6·2744	− 10	[+ 14]	
		IV	271·6634	0·992866	− 9·7347	− 2·69	− 9·5767	+ 3	[+ 8]	
A 749	337° 26′·4	I	313·7092	1·001007	− 2·3307	+ 1·91	− 4·0368	+ 0·0022	[+ 0·0027]	
		II	81·1544	0·994817	+ 3·1569	+ 3·88	+ 1·4487	+ 1	[− 39]	Images diffused.
Oct. 9	11h 5m 32s	III	53·9275	1·000110	+ 2·8685	+ 6·38	+ 1·1605	+ 3	[− 6]	
		IV	43·0316	1·003548	+ 3·1387	+ 6·07	+ 1·4277	− 27	[+ 18]	
A 753	337° 23′·3	I	354·9625	1·003146	− 1·2642	+ 5·49	− 3·6072	+ 0·0018	[+ 0·0023]	
		II	279·3754	1·002386	− 3·7344	− 1·95	− 6·0753	+ 39	[− 23]	Images of Pleiades
Oct. 11	10h 26m 21s	III	152·9606	1·001668	+ 4·9707	− 4·35	+ 2·6240	− 19	[− 2]	elongated.
		IV	85·1289	1·006944	+ 9.4069	+ 3·28	+ 7·0585	− 36	[+ 1]	
A 759	336° 54′·5	I	252·3731	0·998170	− 1·8281	− 4·18	− 5·0641	− 0·0032	[− 0·0026]	
		II	42·4568	0·992474	+ 1·2450	+ 6·33	− 1·9823	+ 55	[+ 22]	*Time uncertain.*
Oct. 30	9h 22m 37s	IV	133·3374	1·006447	+ 10·2816	− 2·16	+ 7·0464	− 24	[+ 4]	
A 762	336° 32′·4	I	145·7751	0·996861	+ 1·9388	− 3·47	+ 1·2265	− 0·0009	+ 0·0007	
		II	162·2290	1·008357	+ 2·3892	− 5·12	+ 1·6818	+ 40	− 3	
Nov. 18	7h 56m 40s	III	259·6661	0·999527	− 5·0854	− 3·66	− 5·7990	− 22	− 4	
		IV	181·4634	1·001738	+ 3·6031	− 5·78	+ 2·8907	− 10	− 1	
A 764	336° 23′·9	I	74·8462	1·000202	+ 1·8542	+ 3·49	− 1·1712	− 0·0015	− 0·0007	
		II	301·3688	0·994147	− 3·5483	+ 1·18	− 6·5659	+ 63	+ 6	Images very dif-
Nov. 30	8h 50m 8s	III	145·4672	1·001473	+ 4·7658	− 3·87	+ 1·7423	+ 4	+ 20	fused.
		IV	82·2462	1·006819	+ 9·0240	+ 2·83	+ 5·9949	− 52	− 17	
A 765	336° 20′·8	I	243·6928	0·999426	− 1·5339	− 4·24	+ 1·0073	+ 0·0018	+ 0·0013	
		III	182·9871	1·001255	+ 1·6867	− 6·31	+ 4·2277	− 25	− 7	
Dec. 8	6h 30m 7s	IV	251·9248	0·993924	− 7·7792	− 3·58	− 5·2349	+ 8	− 6	
A 768	336° 20′·2	I	335·7962	1·003712	− 1·5122	+ 4·04	− 4·8554	− 0·0015	− 0·0003	
		II	66·3267	1·000162	+ 2·4688	+ 4·14	− 0·8681	+ 48	+ 11	Images irregular.
Dec. 19	8h 11m 32s	IV	130·7958	1·006598	+ 9·0687	− 1·98	+ 5·7236	− 34	− 9	
A 770	336° 22′·5	I	348·8436	1·003446	− 1·0996	+ 4·67	+ 0·3905	− 0·0008	+ 0·0007	Wind.
		II	247·6469	0·998559	− 2·4382	− 3·94	− 0·9429	+ 44	− 10	
Dec. 28	6h 3m 51s	III	108·5321	1·000828	+ 5·3075	+ 0·20	+ 6·7965	− 19	− 3	
		IV	323·8933	0·994253	− 7·7332	+ 2·97	− 6·2440	− 17	+ 5	
A 771	336° 23′.4	II	92·5932	1·004872	+ 3·1574	+ 1·79	+ 3·0721	+ 0·0046	− 0·0001	Wind.
		III	209·1494	1·000698	− 0·7885	− 6·07	− 0·8807	− 21	− 5	Images diffused.
Dec. 30	6h 9m 37s	IV	7·4278	0·998927	− 2·0991	+ 5·23	− 2·1914	− 24	+ 7	
1905										
A 772	336° 26′·2	I	339·0910	1·003550	− 1·3646	+ 4·00	− 4·0838	− 0·0025	− 0·0013	
		II	240·1431	0·998892	− 2.0563	− 4·39	− 4·7661	+ 69	+ 15	
Jan. 4	6h 45m 47s	III	102·2145	1·000644	+ 5·1257	+ 0·91	+ 2·4076	− 14	− 1	
		IV	114·8430	1·007395	+ 9·1620	− 0·37	+ 6·4422	− 31	+ 1	
A 773	336° 27′·6	II	82·8884	1·004288	+ 2·8575	+ 2·67	− 1·7317	+ 0·0018	− 0·0008	Images of Pleiades
Jan. 6	6h 19m 37s	IV	157·0620	1·004617	+ 6·3244	− 3·82	+ 1·7317	− 17	+ 8	elongated, Satel- lites diffused.
A 774	336° 29′·1	I	69·1674	0·998698	+ 1·4952	+ 3·52	+ 3·7188	− 0·0018	+ 0·0011	Wind.
		II	284·2464	0·993079	− 3·1612	− 0·67	− 0·9325	+ 33	− 6	Images elongated
Jan. 8	6h 20m 50s	III	302·3724	0·999067	− 5·0102	+ 1·16	− 2·7864	− 16	− 5	and diffused.
A 776	336° 31′·6	I	313·1561	1·003711	− 1·8598	+ 1·94	− 0·3008	− 0·0003	[+ 0·0014]	
		II	224·5135	1·000457	− 1·2475	− 5·10	+ 0·3079	− 39	[− 85]	Images of Pleiades
Jan. 11	5h 32m 20s	III	91·8674	1·000365	+ 4·7716	+ 1·97	+ 6·3321	+ 12	[+ 30]	misformed.
		IV	264·5728	0·993121	− 7·9016	− 2·33	− 6·3394	+ 29	[+ 39]	
A 777	336° 41′·8	I	174·9733	0·997389	+ 0·8892	− 4·47	− 1·4934	− 0·0023	− 0·0019	
		II	152·2552	1·008101	+ 2·3816	− 3·46	+ 0·0066	+ 53	+ 5	
Jan. 21	3h 59m 12s	III	231·4350	1·000585	− 2·3815	− 5·00	− 4·7629	− 11	+ 5	
		IV	118·9592	1·007127	+ 8·6320	− 0·57	+ 6·2497	− 20	+ 9	

Plate N°. Date 1905	P G. M. T.	Satellite	v	ρ	x	a	x_{obs}	n	Resid.	Remarks
			°		′		′	′	′	
A 795	349° 55′.0	I	259.8923	0.996802	— 0.5605	— 5.79	— 4.2670	+ 0.0029	[+ 0.0017]	
		II	95.5510	0.991711	+ 1.7970	+ 5.46	— 1.9120	+ 4	[— 5]	Good images.
Oct. 17	11h 46m 11s	III	103.7342	1.001819	+ 3.5826	+ 5.32	— 0.1269	— 1	[— 3]	
		IV	168.1229	1.003424	+ 10.0185	— 1.29	+ 6.3058	— 33	[— 9]	
A 796	348° 30′.9	I	75.1100	1.003605	+ 0.5331	+ 6.14	— 1.4422	+ 0.0011	[+ 0.0001]	
		II	350.8603	1.001010	— 3.6137	+ 2.13	— 5.5896	+ 5	[— 18]	
Nov. 17	10h 10m 42s	III	219.8672	1.000553	+ 2.3226	— 6.55	+ 0.3459	— 3	[+ 11]	
		IV	116.0134	1.007250	+ 8.6636	+ 3.71	+ 6.6860	— 11	[+ 7]	
A 799	348° 24′.2	I	127.6271	1.002826	+ 2.1878	+ 2.60	— 0.1862	+ 0.0015	[+ 0.0010]	Through clouds.
		II	198.4767	1.003005	+ 2.6356	— 4.84	+ 0.2605	+ 4	[— 25]	Images diffused.
Nov. 19	10h 52m 31s	III	322.2088	0.997822	— 5.9807	— 1.20	— 8.3553	+ 9	[+ 16]	
		IV	159.2540	1.004306	+ 10.6595	— 0.79	+ 8.2812	— 27	[— 1]	
A 801	347° 48′.2	I	196.7645	0.998286	+ 1.6514	— 4.52	+ 0.5858	+ 0.0006	+ 0.0002	
		II	228.6138	1.007512	+ 0.7914	— 6.55	— 0.2734	+ 14	— 17	
Nov. 30	9h 47m 57s	III	153.3838	1.002075	+ 6.0732	— 0.35	+ 5.0054	— 15	0	
		IV	37.0369	1.002623	— 4.2512	+ 5.69	— 5.3177	— 3	+ 14	
A 802	347° 45′.0	I	37.8360	1.002820	— 0.9204	+ 5.79	— 0.5576	+ 0.0035	+ 0.0027	
		II	327.0327	1.002103	— 3.8033	— 0.39	— 3.4441	— 1	— 25	Images very diffused.
Dec. 1	9h 26m 12s	III	202.7841	1.000950	+ 3.7088	— 5.60	+ 4.0655	— 28	— 11	
		IV	58.1205	1.004920	— 0.4225	+ 6.21	— 0.0637	— 4	+ 10	
A 803	347° 30′.0	I	298.1601	0.997267	— 2.0216	— 3.26	— 5.3571	— 0.0001	— 0.0012	Through cirrus.
		II	96.7103	0.991989	+ 2.2554	+ 5.23	— 1.0791	+ 8	0	Images a little elongated.
Dec. 6	5h 3m 34s	III	85.6014	1.001324	+ 2.6315	+ 6.32	— 0.7026	+ 13	+ 10	
		IV	160.7215	1.004238	+ 10.4765	— 1.18	+ 7.1390	— 21	+ 4	
A 804	347° 29′.5	I	333.7778	0.999273	— 2.3710	+ 0.44	— 5.9828	+ 0.0009	— 0.0001	Through cirrus.
		II	114.6556	0.993391	+ 3.0747	+ 3.77	— 0.5376	+ 4	— 8	
Dec. 6	9h 14m 42s	III	94.3511	1.001558	+ 3.4299	+ 5.78	— 0.1826	+ 2	0	
		IV	164.4536	1.003845	+ 10.3172	— 1.58	+ 6.7029	— 16	+ 9	
A 807	346° 51′.5	I	293.5678	0.997547	— 1.9131	— 3.45	— 4.3159	+ 0.0049	+ 0.0038	Foggy.
		II	89.2235	0.992156	+ 1.8963	+ 5.49	— 0.5117	— 3	— 11	
Dec. 20	8h 12m 3s	III	76.6068	1.000862	+ 1.8717	+ 6.51	— 0.5387	— 27	— 31	
		IV	106.2178	1.007527	+ 7.7757	+ 4.06	+ 5.3663	— 17	+ 3	
A 810	346° 33′.0	I	306.5823	0.998666	— 2.1310	— 2.11	— 0.2510	+ 0.0002	— 0.0004	
		II	271.4147	1.007154	— 2.0506	— 5.29	— 0.1678	+ 30	— 3	
Dec. 29	6h 2m 10s	III	164.6369	1.001658	+ 5.5395	— 2.01	+ 7.4196	+ 3	+ 21	
		IV	298.5957	0.992809	— 8.8772	— 2.83	— 7.0009	— 35	— 16	
A 811	346° 29′.6	I	5.2232	1.002342	— 1.7907	+ 3.67	+ 1.0065	+ 0.0009	— 0.0001	
		II	121.4727	0.996264	+ 3.2397	+ 2.72	+ 6.0368	+ 8	— 7	
Dec. 31	7h 25m 18s	III	268.0813	0.998965	— 2.9591	— 5.75	— 0.1644	— 16	— 1	
		IV	343.5080	0.996113	— 9.6753	+ 1.65	— 6.8791	— 1	+ 10	
1906										
A 814	346° 23′.6	I	112.0400	1.001924	+ 1.8443	+ 3.37	— 1.2107	+ 0.0008	+ 0.0005	
		II	173.6726	1.004421	+ 3.2049	— 2.82	+ 0.1527	+ 36	+ 12	Images diffused.
Jan. 4	9h 1m 37s	III	112.9748	1.001670	+ 4.7296	+ 3.70	+ 1.6747	+ 9	+ 16	
		IV	70.9931	1.006164	+ 2.4444	+ 5.67	— 0.6165	— 51	— 31	
A 818	346° 12′.3	I	118.9827	1.000761	+ 1.8993	+ 2.58	+ 1.3579	+ 0.0004	— 0.0004	
		II	349.6425	0.994598	— 3.1110	+ 2.33	— 3.6491	+ 37	+ 18	IV touches planet.
Jan. 20	8h 0m 56s	III	195.5927	1.000899	+ 3.5594	— 4.79	+ 3.0150	— 26	— 10	
		IV	55.3657	1.004643	— 0.1803	+ 5.57	— 0.7238	— 17	— 3	
A 822	346° 12′.3	I	295.0863	0.998999	— 1.8207	— 2.90	— 2.5802	— 0.0004	— 0.0013	
		II	78.3403	0.993090	+ 1.2559	+ 5.45	+ 0.4986	+ 18	+ 11	
Jan. 21	4h 41m 24s	IV	73.7439	1.006205	+ 2.8421	+ 5.31	+ 2.0815	— 15	+ 3	
A 825	346° 12′.4	I	8.7675	1.003235	— 1.5714	+ 3.74	— 1.3271	— 0.0004	— 0.0009	
		II	292.9421	1.002479	— 2.8196	— 3.26	— 2.5684	+ 45	+ 17	Images diffused.
Jan. 23	7h 52m 0s	III	346.5098	0.998513	— 5.0414	+ 2.14	— 4.7959	— 2	+ 2	
		IV	119.0910	1.007145	+ 8.4496	+ 2.54	+ 8.6914	— 39	— 12	

Plate N°. Date 1906	P G. M. T.	Satellite	v	ρ	x	a	x_{obs}	n	Resid.	Remarks
			°		′		′	′	′	
A 828	346° 15′·5	I	349·2877	1·002679	— 1·9152	+ 2·10	+ 1·6781	— 0·0012	— 0·0015	
		II	280·6191	1·003506	— 2·2996	— 4·15	+ 1·2984	+ 35	+ 7	
Jan. 30	7h 24m 42s	III	337·7071	0·998576	— 5·1482	+ 1·18	— 1·5543	— 6	+ 1	
		IV	269·6282	0·992975	— 5·0150	— 4·49	— 1·4224	— 19	+ 5	
A 832	346° 24′·8	I	15·4404	1·003661	— 1·3379	+ 3·95	— 3·9490	+ 0·0003	— 0·0005	
		II	112·3609	0·999242	+ 2·6273	+ 3·17	+ 0·0173	+ 14	+ 2	
Feb. 8	6h 50m 11s	IV	103·5049	1·007525	+ 6·5446	+ 3·61	+ 3·9316	— 16	+ 4	
A 834	346° 48′·5	I	132·6811	0·998369	+ 1·8541	+ 1·34	+ 4·3397	0·0000	[— 0·0004]	
		II	344·8967	0·992767	— 2·9114	+ 1·54	— 0·4231	+ 27	[+ 9]	
Feb. 21	5h 57m 54s	III	1·6006	0·998803	— 4·0658	+ 3·14	— 1·5811	— 9	[— 7]	
		IV	23·9220	1·001167	— 4·8195	+ 4·14	— 2·3355	— 16	[+ 2]	
A 837	346° 55′·7	I	26·6906	1·003652	— 1·0049	+ 4·26	— 2·4367	— 0·0006	[— 0·0010]	
		II	290·1764	0·999187	— 2·3855	— 3·28	— 3·8116	+ 51	[+ 22]	Plate entirely fogged. Images very diffused, especially IV.
Feb. 24	6h 21m 14s	III	153·2271	1·001556	+ 4·8326	— 0·48	+ 3·4006	— 8	[+ 5]	
		IV	88·3910	1·007112	+ 4·2829	+ 4·31	+ 2·8479	— 38	[— 16]	
A 840	347° 14′·6	I	2·5981	1·003702	— 1·5636	+ 2·69	— 1·9705	— 0·0004	[— 0·0011]	Through cloud.
		II	275·4767	1·000619	— 1·7611	— 4·16	— 2·1617	+ 59	[+ 28]	
March 3	5h 20m 54s	III	146·3448	1·001566	+ 4·7208	+ 0·56	+ 4·3125	— 18	[— 7]	
		IV	237·5919	0·995053	+ 0·2299	— 4·81	— 0·1802	— 36	[— 12]	
1907										
B 26	18° 35′·8	I	287·5703	1·002795	+ 0·9157	— 5·01	+ 1·0505	+ 0·0007	[+ 0·0003]	
		II	358·0080	1·003446	— 2·3841	— 4·18	— 2·2535	— 35	[— 20]	
Dec. 17	10h 23m 44s	III	301·6801	0·998765	+ 1·0661	— 6·12	+ 1·2030	+ 28	[+ 16]	
1908										
B 31	17° 19′·9	I	282·9393	1·001513	+ 0·9925	— 5·28	+ 4·0878	0·0000	[0·0000]	
		II	341·3162	1·004658	— 1·9121	— 5·30	+ 1·1813	— 19	[+ 2]	
Jan. 25	7h 55m 49s	III	99·4100	1·000584	— 2·8209	+ 5·75	+ 0·2751	+ 7	[— 23]	
		IV	69·9429	1·006018	— 8·6406	+ 3·00	— 5·5441	+ 12	[+ 20]	
B 33	16° 47′·8	I	216·8131	1·003677	+ 2·2467	+ 0·07	+ 3·9457	+ 0·0009	[— 0·0008]	
		III	345·8432	0·997693	— 3·5187	— 5·18	— 1·8212	— 6	[+ 4]	
Feb. 6	9h 18m 35s	IV	330·0859	0·994622	— 3·8223	— 5·36	— 2·1243	— 1	[+ 3]	
B 39	16° 29′·5	I	203·0544	1·003727	+ 2·1704	+ 1·37	+ 2·8583	+ 0·0013	[— 0·0004]	
		II	112·3132	1·000095	— 0·8754	+ 5·98	— 0·1896	— 8	[— 3]	
Feb. 13	9h 31m 13s	III	338·4779	0·997739	— 2·9759	— 5·58	— 2·2896	— 3	[+ 13]	
		IV	120·5105	1·007208	— 1·0654	+ 5·77	— 0·3790	— 2	[— 5]	
B 40	16° 3′·6	I	276·8064	1·000491	+ 1·0491	— 5.04	+ 1·4425	— 0·0009	[+ 0·0003]	
		II	145·5929	0·994495	+ 1.1943	+ 5·67	+ 1·5867	— 19	[— 21]	Images elongated.
Feb. 24	9h 2m 6s	III	170·9538	1·002181	+ 3·9705	+ 4·53	+ 4·3668	+ 20	[— 12]	
		IV	358·3397	0·997445	— 7·7911	— 3·42	— 7·3959	+ 9	[+ 29]	
B 42	15° 40′·3	I	30·5078	0·996620	— 2·1178	— 0·37	— 1·3681	— 0·0023	[— 0·0020]	
		II	17·9516	1·008501	— 3·2798	— 1·68	— 2·5318	— 40	[— 4]	Images a little diffused.
March 8	7h 36m 17s	III	102·3030	1·000880	— 2·0231	+ 5·83	— 1·2718	— 7	[— 12]	
		IV	276·4931	0·992679	+ 4·4127	— 4·87	+ 5·1719	+ 72	[+ 36]	
B 46	15° 28′·4	I	276·1966	0·999456	+ 0·9601	— 4·81	— 0·5398	+ 0·0004	+ 0·0006	
		II	318·2010	1·006562	— 0·8285	— 5·62	— 2·3317	— 29	— 8	Images very diffused.
March 18	8h 58m 2s	III	247·7694	1·000351	+ 4·3693	— 3·43	+ 2·8715	+ 25	+ 3	
B 49	15° 27′·7	II	56·2393	1·004438	— 3·0527	+ 2·22	— 3·7941	+ 0·0008	+ 0·0026	
		III	297·2371	0·998332	+ 0·5941	— 6·07	— 0·1513	— 32	— 28	
March 19	8h 31m 47s	IV	154·1396	1·005058	+ 4·6853	+ 4·64	+ 3·9453	+ 22	+ 2	
B 51	15° 27′·0	II	148·4698	0·992468	+ 1·3634	+ 5·16	— 0·3364	— 0·0017	— 0·0013	
		III	343·0288	0·997542	— 3·3136	— 4·71	— 5·0113	+ 4	+ 23	
March 20	6h 16m 41s	IV	173·5265	1·002978	+ 7·0447	+ 3·46	+ 5·3477	+ 11	— 10	

Plate N°. Date 1908	P G. M. T.	Satellite	v	ρ	x	a	x_{obs}	n	Resid.	Remarks
			°		′	′	′	′	′	
B 55	15° 26′.4	I	151.3792	1.003427	+ 0.9590	+ 4.78	− 0.7746	+ 0.0028	+ 0.0008	
		II	254.7288	0.998371	+ 2.4656	− 3.75	+ 0.7271	− 21	+ 5	
March 21	7^h 5^m 54^s	III	35.1912	0.998411	− 5.2102	+ 0.16	− 6.9483	− 17	− 1	
		IV	195.7600	1.000191	+ 8.7313	+ 1.64	+ 6.9959	+ 10	− 12	
B 56	15° 25′.8	I	13.5114	0.996444	− 1.9188	− 1.84	− 5.5040	− 0.0022	− 0.0003	I and II too near together, measures impossible.
March 22	9^h 18^m 14^s	IV	219.3714	0.997209	+ 9.0848	− 0.53	+ 5.5041	+ 23	+ 4	
B 57	15° 24′.9	I	50.3992	0.997922	− 1.9477	+ 1.54	− 4.9287	− 0.0008	− 0.0001	
		II	202.5550	0.992698	+ 3.1602	+ 1.08	+ 0.1798	− 2	+ 14	
March 24	8^h 5^m 27^s	III	187.9814	1.002303	+ 4.6736	+ 2.61	+ 1.6939	+ 5	− 11	
		IV	261.8384	0.993368	+ 6.0347	− 3.93	+ 3.0551	+ 6	− 1	
B 59	15° 24′.2	I	81.4398	0.999941	− 1.3596	+ 3.94	− 0.3832	+ 0.0030	+ 0.0009	
		II	36.1546	1.005882	− 3.2414	+ 0.26	− 2.2702	− 22	− 2	Images indifferent.
March 26	6^h 12^m 26^s	III	284.5327	0.999709	+ 1.6809	− 5.67	+ 2.6536	− 7	− 8	
B 60	15° 24′.0	I	284.0984	0.998511	+ 0.6731	− 4.99	+ 2.4710	− 0.0013	− 0.0012	
		III	335.0537	0.997577	− 2.6764	− 5.08	− 0.8774	− 2	− 1	
March 27	6^h 12^m 29^s	IV	325.7449	0.994255	− 3.3944	− 4.85	− 1.5935	+ 17	+ 13	
B 63	15° 24′.0	I	334.8551	0.996359	− 1.0405	− 4.48	+ 2.7075	+ 0.0017	+ 0.0018	
		II	342.8403	1.008405	− 2.0426	− 4.36	+ 1.7000	− 37	− 20	Images diffused.
March 29	6^h 37^m 30^s	III	76.8660	1.000219	− 3.7076	+ 4.07	+ 0.0412	+ 25	+ 1	
		IV	9.5782	0.998965	− 8.1946	− 2.12	− 4.4486	− 3	+ 3	
B 64	15° 23′.7	I	181.8410	1.003680	+ 1.7097	+ 2.77	+ 4.7892	+ 0.0028	+ 0.0016	
		II	84.8804	0.999058	− 1.9883	+ 4.34	+ 1.0869	− 15	− 6	
March 30	7^h 2^m 17^s	IV	31.5061	1.001740	− 8.9516	− 0.19	− 5.8760	− 11	− 9	
B 68	15° 23′.7	I	31.0248	0.997199	− 1.9894	− 0.23	− 1.1633	− 0.0009	− 0.0006	
		II	190.2235	0.992207	+ 2.8934	+ 2.18	+ 3.7203	− 1	+ 3	Images a little diffused.
March 31	7^h 40^m 15^s	III	179.3025	1.002308	+ 4.1949	+ 3.33	+ 5.0239	+ 20	− 8	
		IV	53.5068	1.004285	− 8.4067	+ 1.78	− 7.5809	− 12	+ 12	
B 71	15° 23′.8	I	226.4328	1.001955	+ 1.9450	− 1.16	+ 1.7223	+ 0.0028	+ 0.0017	
		II	288.3469	1.004467	+ 0.8359	− 5.36	+ 0.6059	− 45	− 24	
April 1	6^h 47^m 33^s	III	227.6195	1.000900	+ 4.9078	− 1.43	+ 4.6856	+ 33	+ 10	
		IV	74.0717	1.006124	− 6.7868	+ 3.37	− 7.0137	− 14	− 3	
B 72	15° 24′.3	I	272.4071	0.998912	+ 1.0238	− 4.43	+ 1.7428	− 0.0012	− 0.0008	
		III	328.2263	0.997651	− 2.0917	− 5.31	− 1.3707	+ 8	+ 13	
April 3	6^h 41^m 3^s	IV	116.5103	1.007303	− 1.0928	+ 5.12	− 0.3723	+ 3	− 6	
B 75	15° 24′.6	II	236.9573	0.996997	+ 2.8735	− 2.17	+ 2.7693	− 0.0010	0.0000	
		III	21.2149	0.998224	− 4.8817	− 1.25	− 4.9872	− 23	− 16	
April 4	7^h 50^m 3^s	IV	138.8047	1.006326	+ 2.3179	+ 4.96	+ 2.2179	+ 32	+ 17	
B 77	15° 25′.5	I	166.8047	1.003779	+ 1.3456	+ 3.76	− 0.7755	+ 0.0002	− 0.0010	
		II	74.7218	1.000103	− 2.3500	+ 3.58	− 4.4751	− 38	− 11	
April 6	7^h 6^m 27^s	IV	180.9160	1.002197	+ 7.3682	+ 2.75	+ 5.2504	+ 35	+ 21	
B 78	15° 26′.0	I	13.3138	0.996702	− 1.8266	− 1.77	− 5.0576	− 0.0031	− 0.0011	
		II	178.7000	0.991683	+ 2.5257	+ 3.08	− 0.7035	− 13	0	
April 7	7^h 26^m 14^s	III	171.0532	1.002332	+ 3.6552	+ 3.91	+ 0.4310	+ 37	+ 20	
		IV	202.7482	0.999466	+ 8.5571	+ 0.96	+ 5.3300	+ 8	− 8	
B 80	15° 28′.0	I	263.2545	0.999163	+ 1.2570	− 3.86	− 0.3248	− 0.0012	− 0.0006	
		III	322.0105	0.997849	− 1.5378	− 5.42	− 3.1178	+ 6	+ 16	
April 10	7^h 27^m 27^s	IV	268.0263	0.993097	+ 5.0226	− 4.06	+ 3.4428	+ 8	− 10	
B 81	15° 30′.6	I	154.5767	1.003781	+ 0.9825	+ 4.33	+ 2.6671	+ 0.0005	− 0.0016	
		II	65.9976	1.000642	− 2.5852	+ 2.83	− 0.9016	− 5	+ 17	Images very diffused.
April 13	7^h 30^m 41^s	III	113.3298	1.001585	− 0.8913	+ 5.57	+ 0.7938	+ 10	− 5	
		IV	333.6831	0.994757	− 4.2423	− 4.31	− 2.5593	− 11	+ 5	
B 84	15° 32′.7	I	202.3381	1.002678	+ 1.8718	+ 1.01	+ 1.8198	+ 0.0017	0.0000	
		II	271.1785	1.003330	+ 1.6494	− 4.47	+ 1.5955	− 2	+ 17	Images grey and very diffused.
April 15	7^h 38^m 50^s	III	213.8396	1.001295	+ 4.8440	+ 0.01	+ 4.7923	+ 20	− 4	
		IV	17.1870	0.999837	− 8.1504	− 1.43	− 8.2074	− 33	− 12	

Plate N°. Date 1908	P G. M. T.	Satellite	v	ρ	x	a	x_{obs}	n	Resid.	Remarks
			°		′		′	′	′	
B 86	15° 33′·8	I	42·4895	0·998462	— 1·8766	+ 0·73	+ 0·6148	+ 0·0013	— 0·0002	
		II	9·1155	1·007268	— 2·7633	— 2·24	— 0·2737	— 5	+ 19	
April 16	7h 10m 24s	III	263·1348	0·999393	+ 3·1585	— 4·24	+ 5·6501	+ 15	— 4	
		IV	38·2787	1·002547	— 8·4791	+ 0·37	— 5·9911	— 21	— 11	
B 87	15° 40′·2	I	345·3027	0·996264	— 1·2228	— 3·69	— 2·7266	— 0·0006	+ 0·0015	
		II	159·4418	0·991473	+ 1·6965	+ 4·21	+ 0·1904	— 29	— 22	
April 21	7h 51m 11s	III	156·3793	1·002281	+ 2·5227	+ 4·69	+ 1·0226	+ 31	+ 9	
		IV	145·4162	1·006036	+ 3·0165	+ 4·56	+ 1·5137	+ 4	— 3	
1910										
B 223	24° 59′·4	I	121·7351	0·997486	— 2·0066	+ 2·16	— 3·0917	+ 0·0005	— 0·0003	
		II	145·5543	1·008077	— 2·4142	+ 4·39	— 3·4995	+ 3	0	Images diffused.
April 1	10h 4m 11s	III	246·6397	1·000286	+ 4·6430	+ 3·47	+ 3·5578	+ 4	+ 8	
		IV	344·2201	0·995771	+ 4·1202	— 5·11	+ 3·0334	— 12	— 3	
B 224	25° 0′·1	I	324·2161	1·003371	+ 1·5450	— 4·04	— 1·0195	+ 0·0011	+ 0·0005	
		II	244·8426	1·001749	+ 2·8599	+ 3·42	+ 0·2936	— 7	+ 1	Images of stars
April 2	9h 53m 48s	III	296·6177	0·999300	+ 5·2686	— 1·92	+ 2·7023	— 7	+ 0	double.
		IV	5·7662	0·998318	+ 0·5889	— 5·65	— 1·9764	+ 3	— 6	
B 226	25° 0′·7	I	164·4852	0·996307	— 0·9026	+ 5·16	— 0·8019	+ 0·0026	+ 0·0006	
		II	345·6691	0·991305	+ 1·3664	— 5·50	+ 1·4594	— 51	— 11	
April 3	9h 32m 16s	III	346·2815	0·998784	+ 2·1427	— 5·92	+ 2·2411	+ 3	+ 3	
		IV	27·0316	1·001094	— 2·9991	— 5·40	— 2·8986	+ 24	+ 1	
B 228	25° 2′·0	I	218·3647	0·997802	+ 1·0684	+ 4·94	+ 5·3921	— 0·0020	— 0·0007	
		III	88·6946	1·000176	— 5·4355	— 1·13	— 1·1099	— 1	— 3	
April 5	10h 18m 39s	IV	70·5579	1·005893	— 8·6098	— 2·70	— 4·2821	+ 20	+ 9	
B 230	25° 2′·6	I	58·1890	1·001004	— 1·6542	— 3·71	+ 1·4076	+ 0·0005	+ 0·0001	
		II	290·8100	0·994609	+ 3·3642	— 1·26	+ 6·4223	— 32	+ 9	Only four exposures
April 6	9h 57m 59s	III	138·2229	1·001154	— 4·2572	+ 4·09	— 1·1931	+ 28	+ 11	measured, 5th and
		IV	91·5452	1·007126	— 9·6980	— 0·71	— 6·6368	— 1	— 22	6th overlap.
B 231	25° 5′·6	II	72·6108	1·000489	— 3·1153	— 2·59	— 1·9912	— 0·0017	— 0·0002	
		III	26·4221	0·998914	— 1·7292	— 6·08	— 0·6022	+ 12	+ 2	Images diffused.
April 11	8h 20m 47s	IV	196·8517	1·000180	+ 1·4669	+ 5·55	+ 2·5933	+ 6	+ 2	
B 233	25° 6′·7	I	43·4898	1·001573	— 1·2634	— 4·62	— 2·5871	+ 0·0006	— 0·0007	
		II	280·8010	0·995202	+ 3·4223	— 0·31	+ 2·0975	— 5	+ 21	Images very dif-
April 13	10h 4m 12s	III	130·6829	1·001081	— 4·6162	+ 3·47	— 5·9379	+ 25	— 2	fused.
		IV	241·7687	0·995001	+ 7·7544	+ 3·29	+ 6·4275	— 26	— 11	
B 234	25° 7′·2	I	235·7765	0·999181	+ 1·6056	+ 3·78	— 0·7193	+ 0·0036	+ 0·0021	
		II	17·6776	0·993301	— 0·5900	— 5·88	— 2·9226	— 41	— 6	
April 14	8h 39m 19s	III	177·9134	1·001392	— 0·9364	+ 6·29	— 3·2630	+ 19	— 12	
		IV	262·3065	0·993479	+ 9·2348	+ 1·48	+ 6·9049	— 14	— 4	
B 235	25° 8·2	I	289·6020	1·002496	+ 2·1154	— 1·19	— 2·3601	+ 0.0002	— 0·0008	
		II	222·3421	1·003541	+ 1·9668	+ 4·93	— 2·5108	— 19	— 19	
April 16	9h 28m 37s	III	280·1453	0·999505	+ 5·4681	— 0·30	+ 0·9949	+ 25	+ 25	
		IV	306·8148	0·993150	+ 8·3522	— 2·73	+ 3·8759	— 6	+ 2	
B 237	25° 8′·7	I	133·3326	0·996590	— 1·7384	+ 3·30	— 4·1921	+ 0·0008	— 0·0018	
		II	324·7949	0·991412	+ 2·3027	— 4·37	— 0·1539	— 21	+ 12	
April 17	9h 33m 40s	III	330·7337	0·998725	+ 3·2654	— 5·11	+ 0·8117	+ 8	+ 5	
		IV	328·7393	0·994489	+ 5·9883	— 4·36	+ 3·5344	+ 6	+ 1	
B 238	25° 12′·0	I	122·4822	0·996740	— 1·9149	+ 2·43	— 0·7864	+ 0·0014	— 0·0003	
		II	316·7375	0·991476	+ 2·5780	— 3·79	+ 3·7006	— 45	— 6	Images very dif-
April 24	10h 7m 45s	III	324·1260	0·998811	+ 3·6610	— 4·65	+ 4·7852	— 29	— 23	fused.
		IV	119·5565	1·007188	— 8·8325	+ 2·17	— 7·6993	+ 61	+ 31	
B 239	25° 12′·8	I	159·1535	0·996395	— 0·9712	+ 4·93	+ 1·8633	— 0·0002	— 0·0002	
		II	154·3302	1·008751	— 1·8134	+ 5·05	+ 1·0223	+ 10	+ 12	
April 26	8h 53m 0s	III	62·3483	0·999666	— 4·4775	— 3·52	— 1·6429	— 1	— 2	
		IV	161·0687	1·004500	— 4·0764	+ 5·01	— 1·2426	— 9	— 9	