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COMMUNICATION FROM THE OBSERVATORY AT LEIDEN.

The longitudes of Jupiter's Satellites derived from plates taken with the 26-inch refractor of the Yale Observatory Southern Station in 1928,

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The series of plates discussed in the present article were treated in exactly the same way as those of 1927, the results of which were published in *B.A.N.* 170. The plates were all taken by the first of the three authors. As soon as the observations were completed, the times were sent to Leiden and tabular coordinates of the satellites and the standard stars were computed for these times and sent to Johannesburg, where the plates were then measured and reduced by the first author. The discussion of the measures took place in Leiden, as in the former case.

From August 17 to October 5, 1928, twenty plates of the satellites of Jupiter were obtained with the Yale photographic refractor. The unfavourable conditions prevailing in 1928 are shown by comparison with the 1927 series when eighteen plates were secured in a period of twenty-one days. These unfavourable conditions combined with the northern declination of Jupiter have affected the quality of the plates to some extent.

The procedure at the telescope was the same as in 1927, several exposures averaging between one and two seconds being made on each plate. The six best images were later selected for measurement. Several exposures to a pair of standard stars were made on each plate prior to the exposures on the satellites. As the star pair preceded Jupiter a few minutes in right ascension, the resulting hour angles were very nearly the same for stars and satellites. The standards were:

Star	D.M. No.	α_{1900}	δ_{1900}	Mag.	Sp.
	°	h m	° ′		
a	+ 13 395	2 23·1	+ 13 26	8·5	F 5
b	+ 13 402	2 25·4	+ 13 31	8·6	F 8

By means of these stars all plates have been reduced to the same scale. The scale value derived from the previous series has been adopted, namely 1 mm = 0′·313575 = 18″·8145.

As before, the measures refer to axes parallel and perpendicular to the fundamental plane of the system. The computed apparent y-coordinates of the satellites were used for the orientation of the plates with a few exceptions. As the measuring engine is provided with a screw in but one direction, the plate was first placed in the machine in such a position as to give the required difference between the y-coordinates of the extreme satellites. By means of dust specks or ink spots appropriately placed 150 millimeters apart, the plate was then turned accurately through an angle of 90°. This involves a knowledge of the angle between the vertical and the microscope ways. This angle was found to differ from 90° by 1′·68 ± 0′·04 and was duly taken into account in the placing of the spots, or selection of the dust specks. This deviation from perpendicularity is 0′·85 less than a former determination made in the latter part of 1927 and used in the previous measures.

The data are given in the table at the end of this paper in the same form as the corresponding table for the 1927 measures. The number of exposures measured is omitted, as six exposures were measured on all these plates.

The computed coordinates correspond to the final elements of *B.A.N.* 102 and *Leiden Annals* XVI, **2**, as has been explained for the plates of 1927 in *B.A.N.* 170. A slight mistake was afterwards detected in the corrections applied to the M.S. tables based on the theory of 1908 to reduce them to that of *Annals* XVI, **2**. A correction must on this account be applied to the final result, which is

$$(1)\qquad \begin{array}{ll} \Delta l_1 = +\,0^\circ\!\cdot\!0011 & \Delta c_1 = -\cdot 00012 \\ \Delta l_2 = +\quad 42 & \Delta c_2 = +\quad 12 \\ \Delta l_3 = -\quad 13 & \Delta c_3 = +\quad 20 \\ \Delta l_4 = \quad 00 & \Delta c_4 = -\quad 20 \end{array}$$

Two solutions were made. In solution I the values of λ_i, μ and c_i were determined from the original right hand members n_i and residuals were formed,

which are given in the table under the heading "Resid. I". In solution II a correction for scale value was derived for each plate separately from these residuals and applied, and corrections to the values of λ_i and c_i were then determined from the corrected residuals. The residuals remaining after the substitution of these values of λ_i and c_i are given in the table under the heading "Resid. II". The average residuals of unit weight were:

right hand members	± ′·00104
Solution I	± 60
after application of individual scale corrections	± 35
Solution II	± 33

The following table gives for every plate the scale value α as derived from the standard stars, and the corrections μ derived from the satellites. It will be seen that these corrections are of the same order of magnitude as those from the stars, though on the average somewhat larger.

Plate	α	μ
12825	+ 0·000120	+ 0·000107
12835	+ 25	+ 116
12889	+ 76	+ 19
12899	+ 120	— 50
12909	— 30	+ 472
12951	— 51	+ 217
13025	— 46	— 157
13038	— 35	— 61
13073	— 87	+ 97
13120	— 8	+ 10
13160	+ 47	+ 90
13184	— 4	— 50
13212	— 48	— 6
13246	— 50	+ 50
13283	— 73	— 401
13380	+ 54	— 61
13406	— 11	+ 271
13449	+ 34	— 85
13487	+ 15	— 203
13519	— 44	+ 96

The improvement by the introduction of the individual scale corrections is very great, in the ratio of 0·55, the theoretical ratio if the corrections were purely accidental being about 0·80. The values of the unknowns λ_i and c_i in the two solutions are very nearly the same. We have finally adopted solution II. The probable error of unit weight corresponding to the average residuals ± ′·00033 for 77 equations and 27 unknowns (4 λ_i, 3 c_i, there being one rigorous condition, and 20 individual μ) would be ± ′·00035. I have, however, used the value ± ′·00038.

The two solutions are

1928	I	II	p. e.
λ_1	— ·000139	— ·000131	± ·00023
λ_2	— 276	— 258	± 23
λ_3	— 76	— 43	± 19
λ_4	+ 1	— 11	± 18
μ	— ·000194	individual	
c_1	— ·00031	— ·00047	± ·00008
c_2	+ 5	— 3	
c_3	+ 31	+ 47	
c_4	— 5	+ 3	

Returning to the original unknowns, and adding at the same time the corrections given above under (1), we have thus:

1928·69
$\Delta l_1 = -0^\circ 0185 \pm ^\circ 0034$
$\Delta l_2 = - 216 \pm 23$
$\Delta l_3 = - 42 \pm 13$
$\Delta l_4 = - 4 \pm 6$

These are corrections to the longitudes according to the final solution of *LeidenAnnals* XVI, **2**.

The following table is entirely similar to that of *B. A. N.* 170.

Plate No. D, S, T Qual.	Date 1928 G. M. astr. T	Satellite	v	ρ	x	y	a	$x_{obs.}$	n	Residuals I	Residuals II	Remarks
12825	Aug. 16	I	143°·7829	1·000772	+ 2′·04040	— 0′·0284	— 1·30	+ 1′·93632	— 0′·00044	+ 0′·00048	+ 0′·00040	
4—3—9	15h 16m 31s	II	195·4229	1·006017	+ 1·40307	— 0·2010	— 5·33	+ 1·30066	+ 123	+ 37	+ 37	
p		III	309·6186	0·999685	— 5·32303	+ 0·0116	— 0·05	— 5·42634	+ 33	— 62	— 24	
		IV	54·2717	1·002804	+ 2·29413	+ 0·4875	+ 5·29	+ 2·18938	— 111	— 24	— 53	
12835	Aug. 18	I	189·3430	0·997594	+ 1·08016	— 0·1039	— 4·74	— 2·22229	+ 0·00030	— 0·00043	+ 0·00009	Sat. II
5—5—9	15h 5m 42s	III	50·0004	0·999458	+ 0·91262	+ 0·3015	+ 6·13	— 2·38999	+ 14	— 11	— 13	occulted.
fg		IV	96·8296	1·006843	+ 7·91547	+ 0·2981	+ 3·03	+ 4·61227	— 45	+ 54	+ 3	

Plate No. D, S, T Qual.	Date 1928 G. M. astr. T	Satellite	v	ρ	x	y	a	$x_{obs.}$	n	Residuals I	Residuals II	Remarks
12889	Aug. 22	I	280°9862	0.996902	−1.′85963	−0.′0602	−2.′73	−2.′75933	−0.′00013	−0.′00085	−0.′00064	
4—4—9	14h 44m 3s	II	80.9653	0.991159	+2.19623	+0.1687	+4.46	+1.29532	− 134	− 2	− 6	
fg		III	250.4154	1.000534	−2.72875	−0.2653	− 5.47	−3.62611	+ 221	+ 67	+ 74	
		IV	181.6982	1.003711	+5.99041	−0.3852	−4.37	+5.09011	− 73	+ 20	− 5	
12899	Aug. 23	I	122.6012	1.001836	+2.12954	+0.0166	+0.76	+1.69571	−0.′00071	+0.′00035	+0.′00057	
3—3—8	14h 35m 43s	II	182.3168	1.004942	+2.11350	−0.1797	−4.72	+1.68053	+ 15	− 56	− 33	
fp		III	300.4243	0.999866	−5.36420	−0.0399	− 1.09	−5.79582	+ 150	+ 29	− 13	
		IV	203.0463	1.001064	+2.85365	−0.4837	−5.34	+2.41960	− 93	− 9	− 12	
12909	Aug. 24	I	325.0817	0.999731	−2.08020	+0.0316	+1.44	+0.40730	−0.′00133	−0.′00067	−0.′00067	
4—3—9	14h 22m 18s	II	281.1085	1.007058	−3.01049	−0.1108	−2.94	−0.52173	− 7	− 96	− 54	
f		III	350.3213	0.999325	−4.17761	+0.2145	+4.08	−1.68851	+ 27	+ 1	+ 56	
		IV	224.4340	0.998291	−0.68702	−0.5158	−5.58	+1.80293	+ 112	+ 160	+ 64	
12951	Aug. 30	I	102.0361	1.002725	+1.93416	+0.0607	+2.73	+3.81547	−0.′00110	+0.′00055	−0.′00018	
4—4—8	13h 59m 7s	II	169.4822	1.003800	+2.71903	−0.1481	−3.86	+4.60265	+ 122	+ 121	+ 32	
fg		III	291.3996	1.000009	−5.26426	−0.0917	−2.11	−3.38138	+ 48	− 43	+ 17	
		IV	355.0250	0.995631	−6.91855	+0.3506	+3.98	−5.03676	− 61	− 132	− 30	
13025	Sept. 6	I	84.7759	1.003289	+1.57335	+0.0940	+4.19	−0.78104	−0.′00103	−0.′00017	−0.′00019	
5—5—8	13h 45m 56s	II	158.2665	1.002871	+3.15613	−0.1134	−2.93	+0.80350	+ 73	+ 15	+ 38	
f		III	283.1854	1.000016	−5.06187	−0.1389	−3.02	−7.41216	+ 307	+ 121	− 4	
		IV	144.8198	1.006775	+9.74582	−0.1114	−1.47	+7.38968	− 278	− 118	− 15	
13038	Sept. 7	I	286.8616	0.997879	−2.05674	−0.0523	−2.33	−1.74069	−0.′00027	−0.′00025	−0.′00018	
9—9—9	13h 31m 12s	II	257.0721	1.008377	−2.16029	−0.1930	−5.03	−1.84241	+ 156	+ 13	+ 19	
f		III	333.0237	0.999390	−5.24750	+0.1436	+2.56	−4.92992	+ 126	+ 55	+ 2	
		IV	165.9150	1.005222	+8.19923	−0.2982	−3.42	+8.51304	− 251	− 44	− 4	
13073	Sept. 8	I	130.6681	1.000481	+2.25270	−0.0008	−0.04	+1.31611	+0.′00023	+0.′00037	+0.′00049	
4—3—9	13h 39m 26s	II	358.7159	0.993841	−2.35789	+0.1796	+4.65	−3.29550	− 79	− 63	− 22	
fp		III	23.7095	0.999220	−1.62080	+0.3265	+6.36	−2.55687	+ 75	− 1	− 4	
		IV	187.4308	1.002923	+5.47328	−0.4480	−4.95	+4.53624	− 22	+ 28	− 21	
13120	Sept. 11	I	18.6610	1.003592	−0.83298	+0.1260	+5.55	+0.55950	−0.′00121	−0.′00006	+0.′00003	
5—5—9	13h 16m 53s	II	301.0324	1.002238	−3.57599	−0.0379	−1.00	−2.18190	+ 40	− 39	− 29	
fg		III	173.9075	1.000740	+4.16769	−0.2473	−4.65	+5.56116	− 22	+ 16	+ 7	
		IV	251.9471	0.995236	−5.33349	−0.4832	−5.00	−3.93875	+ 105	+ 30	+ 18	
13160	Sept. 13	I	64.0990	1.003794	+0.93427	+0.1230	+5.48	+3.44721	−0.′00122	+0.′00052	+0.′00029	Time uncertain by 15 seconds.
4—3—8	13h 8m 22s	II	145.3237	1.001616	+3.51034	−0.0658	−1.68	+6.02443	− 7	+ 59	+ 12	
f		III	274.1350	1.000125	−4.69934	−0.1885	−3.96	−2.18489	+ 29	− 74	− 59	
		IV	295.5145	0.992805	−9.80193	−0.1644	−1.48	−7.28676	+ 101	− 35	+ 17	
13184	Sept. 16	I	313.4819	1.000076	−2.29663	+0.0084	+0.38	−1.41015	+0.′00005	−0.′00028	−0.′00013	
4—3—9	12h 55m 59s	II	88.2940	0.993476	+2.71934	+0.1618	+4.21	+3.60367	− 210	− 71	− 47	
f		III	64.8001	0.999635	+2.45752	+0.3066	+6.15	+3.34410	+ 15	+ 54	+ 41	
		IV	0.8559	0.996246	−6.42595	+0.4174	+4.62	−5.53763	+ 189	+ 45	+ 21	
13212	Sept. 17	I	157.2003	0.998241	+2.04536	−0.0624	−2.78	+0.41198	−0.′00039	+0.′00006	+0.′00021	
5—5—9	13h 3m 46s	II	190.0034	1.008104	+1.84077	−0.2174	−5.61	+0.20905	+ 127	+ 16	+ 31	
fg		III	115.4074	1.000152	+5.66976	+0.0713	+1.69	+4.03557	− 120	− 15	− 38	
		VI	22.6557	0.998794	−3.02392	+0.5288	+5.71	−4.65658	+ 33	− 8	− 15	
13246	Sept. 18	I	1.1960	1.003121	−1.44496	+0.1070	+4.75	−1.60736	−0.′00015	+0.′00057	+0.′00072	
5—4—9	13h 2m 17s	II	289.7035	1.003218	−3.46961	−0.0846	−2.21	−3.63184	+ 2	− 128	− 103	
fp		III	165.6421	1.000543	+4.76212	−0.2171	−4.01	+4.59895	− 92	− 58	− 89	
		IV	44.1992	1.001524	+0.80146	+0.5653	+5.99	+0.64027	+ 106	+ 128	+ 119	
13283	Sept. 19	I	198.8663	0.996205	+0.82107	−0.1274	−5.66	−1.10898	+0.′00034	+0.′00006	−0.′00027	Sat. II eclipsed.
4—4—9	12h 24m 13s	III	214.5762	1.000596	+0.52428	−0.3501	−6.83	−1.40451	+ 160	+ 92	+ 33	
f		IV	65.0836	1.004007	+4.44581	+0.5244	+5.45	+2.51349	− 193	− 98	− 7	
13380	Sept. 25	I	343.4175	1.002484	−1.94852	+0.0782	+3.47	−3.12484	−0.′00032	+0.′00004	−0.′00004	
3—3—7	12h 45m 38s	II	278.2343	1.004182	−3.22214	−0.1302	−3.38	−4.39607	+ 207	+ 42	+ 27	
vp		III	157.3195	1.000381	+5.26947	−0.1812	−3.27	+4.09301	− 46	− 5	+ 13	
		IV	193.3294	1.002393	+4.60520	−0.5091	−5.52	+3.42789	− 131	− 40	− 36	

Plate No. D, S, T Qual.	Date 1928 G. M. astr. T	Satellite	v	ρ	x	y	a	$x_{obs.}$	n	Residuals I	Residuals II	Remarks
13406	Sept. 28	I	232°.2103	0.996188	−0'.54098	−0'.1360	−6'.01	+3'.85718	+0'.00056	+0'.00105	+0'.00024	Time may
5—6—8	12h 35m 1s	III	307.7984	0.999980	−6.00293	+0.0086	−0.14	−1.60548	− 15	− 51	− 20	be one min.
fp		IV	258.1073	0.994733	−6.64888	−0.4656	−4.75	−2.25170	− 42	− 54	− 4	too early. Sat. II in transit.
13449	Oct. 2	I	323.2170	1.001575	−2.30927	+0.0354	+1.58	−0.33983	−0.00071	+0.00005	+0.00012	
5—3—9	12h 12m 0s	II	265.5898	1.005258	−2.79181	−0.1756	−4.54	−0.82065	+ 101	− 15	− 11	
f		III	148.3981	1.000134	+5.69450	−0.1374	−2.39	+7.66277	− 188	− 58	− 6	
		IV	345.2111	0.994592	−8.47403	+0.3247	+3.67	−6.50230	+ 158	+ 67	+ 3	
13487	Oct. 3	I	161.0492	0.997289	+2.00693	−0.0758	−3.36	+2.88347	−0.00102	−0.00075	−0.00004	
5—4—8	11h 37m 21s	II	4.9816	0.991417	−2.07543	+0.2129	+5.48	−1.19780	+ 7	+ 117	+ 85	
f		III	197.4762	1.000515	+2.17425	−0.3435	−6.60	+3.05129	− 52	− 87	− 25	
		IV	6.4477	0.996782	−5.61601	+0.4794	+5.23	−4.73697	+ 148	+ 47	− 57	
13519	Oct. 4	I	8.7819	1.003793	−1.18391	+0.1234	+5.47	−0.56677	−0.00161	−0.00087	−0.00075	
4—3—8	12h 3m 46s	II	109.7362	0.998335	+3.59921	+0.0817	+2.12	+4.21744	− 52	+ 62	+ 20	
f		III	248.6657	1.000518	−3.07053	−0.3044	−6.11	−2.45003	+ 175	+ 28	+ 51	
		IV	28.4975	0.999508	−1.81977	+0.5708	+6.10	−1.20063	+ 39	− 2	+ 4	