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ELEMENTS AND EPHEMERIS OF JUPITER'S SEVENTH SATELLITE*

The observations available for the present determination of the elements of the orbit of the Seventh Satellite of Jupiter were those secured by Dr. Perrine with the Crossley Reflector of the Lick Observatory on January 3, 28, February 3, 8, 22, 28, March 2, and 6. The method of arbitrary variations of the position of the plane of the orbit was used; and, applied to the observations of January 3, February 8, and March 6, it led to the following system of elements:

ECLIPTIC ELEMENTS.

Mean Jovicentric Longitude at Epoch	333°55	1905 Jan. 0.0 G. M. T.
Longitude of Perijove	336.65	
Longitude of Node	237.23	
Inclination to Ecliptic	31.0	
Inclination to Jupiter's Orbit	32.0	
Longitude of Node on Jupiter's Orbit	238.6	
ELEMENTS REFERRED TO EARTH'S EQUATOR.		
Mean Jovicentric Right Ascension	328°18	
Right Ascension of Perijove	331.28	
Right Ascension of Node	281.13	
Inclination to Equator	26.2	

Mean Daily Motion = $1^{\circ}358$
 $\log a = 8.9004$
 $a = 52.54$ (for $\log \Delta = 0.71624$)
 $e = 0.0246$
 Period = 265.0 days
 Distance at maximum elongation = $70'$

As a test of the correctness of the work, the positions of the Satellite were computed for the dates of the observations used in deriving the elements. The residuals are as follows:

Date	Δs	$s \Delta p$
January 3	+ 0.01	0.00
February 8	- 0.06	- 0.03
March 6	- 0.02	0.00

*Computed, at my request, by Dr. Ross, formerly Fellow in the Lick Observatory, University of California.—W. W. C.

The result is, therefore, highly satisfactory.

On account of the great distance of the Satellite from its primary, computations based upon position-angle and distance, following Marth's formulæ, are not entirely accurate. In order therefore to obtain a precise comparison with observations, the geocentric positions of the Satellite for all eight dates for which observations are available were computed according to the rigid formulæ given by the writer in "Investigations on the Orbit of Phoebe," Annals of Harvard College Observatory, Vol. LIII, No. 6, p. 104. The resulting residuals are shown in the following table:

Date	$\Delta \alpha$	$\Delta \delta$
January 3	+ 0".2	+ 3".2
January 28	- 0.8	- 28.0
February 3	- 5.5	- 19.3
February 8	- 1.5	- 2.2
February 22	+ 6.9	+ 4.5
February 28	+ 7.4	+ 8.5
March 2	+ 11.0	+ 11.7
March 6	- 2.6	- 4.7

The smallness of the residuals for January 3, February 8, and March 6, furnish another important check upon the correctness of the elements. The residuals for the intermediate observations are, however, larger than one would expect. A least-square adjustment of the residuals in declination was made, which had the effect of reducing the largest from $-28''.0$ to $-18''.6$. The residual for the first observation was, however, increased to $+18''.6$. Since no considerable improvement in the representation of the observations resulted therefore by such solution, the elements and residuals were allowed to stand as they are. Previous experience has shown that it is useless to attempt by least-square adjustment to reduce the residuals in the cases of these distant satellites to normal values. The difficulty lies partly in the indeterminateness of the elements based upon such a short arc, but principally in the large periodic per-

turbations suffered by the Satellite. (See below.) The indeterminateness of the elements was well illustrated in the course of the computation.

According to the elements just obtained, the Satellite moves in a *direct* orbit. The possibility of its motion being in reality *retrograde* was considered. I found a retrograde orbit which exactly satisfied the observations of January 3, February 8, and March 6. If no further observations of the Satellite were available, this orbit could be considered as another solution. The intermediate observations, however, showed that the retrograde orbit was not the true one. The residuals for the intermediate dates, computed from the retrograde orbit, were quite large, having an average value of almost a minute of arc. The direct-motion orbit should therefore be considered as the correct one.

The magnitude of some of the residuals in the tabular exhibit above, and their systematic character, show that either the elements need considerable correction or that large perturbing forces are active. I was unable to fix upon any conceivable change in the elements which would eliminate the large residual in declination for January 28. On the other hand it is known that the periodic perturbations of this Satellite, due to the action of the Sun, are large, and on account of their great number, complicated in their effects. They will, it is believed, sufficiently account for most of the outstanding residuals. In the present preliminary determination it is not considered to be worth while to take them into account.

I have computed some of the larger periodic solar perturbations in longitude, as well as the secular motions of Node and Perijove. Being based upon preliminary elements, they cannot be considered definitive.

Annual Motion of Node on Ecliptic	$-1^{\circ}15$
Annual Motion of Perijove	$+1.45$

Periodic Perturbations in Longitude:

Annual Equation	$-0^{\circ}.42 \sin l'$
Evection	$+0.38 \sin (2D-l')$
Variation	$+0.12 \sin 2D$

These values are considerably smaller than in the case of the Sixth Satellite, due to the smaller value of the eccentricity. Besides these, there will probably be about forty other sensible inequalities in longitude, and an equal number in the radius vector.

Owing to the large inclination of the plane of motion of the Satellite to Jupiter's orbit, the inequalities in latitude also are large and numerous. The largest of these is found to be

$$+0^{\circ}.90 \sin (2D-F).$$

This is the most important single periodic pertur-

bation in any of the three coordinates. Acting alone it may displace the Satellite in latitude by more than one minute of arc, and undoubtedly therefore has had considerable to do with the large residuals which were obtained in declination.

The disturbing action of Saturn is small, but not insensible.

On comparing the orbits of the Sixth and Seventh Satellites, it is noticed that their periods and therefore their distances from Jupiter differ very little. On account of the considerable eccentricities of the two ellipses, it is seen that their orbits mutually interlock. The similarity of the orbits does not extend any further. The mutual inclination of the two orbits is about 27° .

These two Satellites taken together will prove useful in redetermining the mass of Jupiter, and should lead to results comparable in accuracy with the best determinations so far made. The large perturbations of the radius vector will complicate the problem somewhat but should not prove a serious obstacle.

In order to enable the Satellite to be more easily found during the present opposition, the following ephemeris, based upon the elements given in the present paper, has been computed.

EPHEMERIS.

Greenwich Mean Noon		p	s
1905 July	1	111°	$16'$
	6	110	12
	11	109	7
	16	96	2
	21	300	4
	26	295	10
August	31	294	15
	5	294	21
	10	294	26
	15	294	31
	20	293	36
	25	293	41
September	30	293	45
	4	292	49
	9	292	53
	14	292	56
	19	291	58
	24	291	59
October	29	290	59
	4	290	59
	9	289	58
	14	289	55
	19	288	51
	24	287	46
November	29	287	40
	3	285	33
	8	284	26
	13	283	18

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