

The inclinations γ and the ascending nodes Γ of the orbits of the satellites in reference to the plane of *Jupiter's* equator are the following, the nodes being reckoned from the point of the vernal equinox of the planet:—

1877.	Sat. I.		Sat. II.		Sat. III.		Sat. IV.	
	γ_1	Γ_1	γ_2	Γ_2	γ_3	Γ_3	γ_4	Γ_4
Mar. 1	0°0098	40°9	0°4510	49°52	0°1990	274°46	0°3298	330°54
Apr. 30	98	39°5	°4518	47°51	°1981	273°91	°3290	330°53
June 29	98	37°9	°4525	45°49	°1972	273°35	°3281	330°50
Aug. 28	98	36°2	°4532	43°47	°1964	272°80	°3274	330°45
Oct. 27	0°0098	34°5	0°4539	41°45	0°1956	272°24	0°3267	330°39

On Two Ancient Occultations of Planets by the Moon, observed by the Chinese. By J. R. Hind, F.R.S.

In the Appendix to the *Connaissance des Temps* for 1810 will be found a considerable number of observations taken from the Chinese astronomical records by the Jesuit missionary Gaubil, whose manuscript relative to the Chinese observations of comets was so much used by Pingré in the preparation of his *Cometographie*. Amongst the numerous occultations comprised in this list, there are two, and two only, in which the hour, or rather the particular two-hourly interval, at which the occultation took place is distinctly stated, and it is to these occultations that the present Note refers.

I have calculated the circumstances of these phenomena with the view to check a system of lunar motions previously applied in searching for the dates of several solar eclipses recorded on the Nineveh tablets, to which my attention had been directed by Mr. J. W. Bosanquet, and which, as compared with several historical total eclipses, of which the dates are well known, appeared to require but small modification. I have employed Damoiseau's Tables of 1824, adapting his main arguments to the results for secular motions &c. obtained by the Astronomer Royal from the discussion of the Greenwich lunar observations from 1750 to 1830, retaining the last values given by Hansen for terms depending on the square of centuries, which I had found to fit in best with the Greenwich motion proportional to time, at least as regards the secular acceleration. For the Sun and planets Le Verrier's Tables were adopted.

The earliest occultation recorded by Gaubil is one of the planet *Mars* by the Moon, and is thus translated:—

“Dynastie des Han occidentaux, la cour à Si-gan-fou du Chen-sy. An 69 (B.C) = 1^{re} année *Ti-tsie*, 1^{re} Lune, jour *vou-ou* (14 février) à la 2^e veille de 9 à 11 heures du soir, la Lune éclipse *Mars*, entre les constellations *Kio* et *Kang*.”

B.C. 69, February 14.

Paris M.T. h	Sun's True Longitude. ° ' "	Log. R.		h	h	m	s
2	322 52 19.9	9.9979038	Sideral time at 0	21	23	31	
6	323 2 16.9	9.9979208	Equation of time (Subtractive from Mean Time).		17	13	
h	Mars' Helioc. Longitude. ° ' "	Mars' Helioc. Latitude. ° ' "	Mars' log. Rad. Vect.				
2	166 58 50.5	+ 1 20 50.0	0.2062127				
6	167 2 44.4	+ 1 20 44.7	0.2061696				
h	Mars' Apparent R.A. ° ' "	Mars' Apparent Decl. ° ' "					
2	196 49 44	-4 20 44	Log. distance 9.90774.				
6	196 49 51	-4 20 38					
h	Moon's R.A. ° ' "	Moon's Decl. ° ' "					
5	196 49 27	-3 46 31	Hor. Parallax 60 8.5.				
6	197 23 58	-3 57 50	Semi-diameter 16 23.				

I take the position of Si-gan-fou from M. Biot's *Dictionnaire des Noms Anciens et Modernes des Villes et Arrondissements de l'Empire Chinois*—

Long. 106° 37' 45" E. of Paris; Lat. 34° 16' 45";

and from the above data find a visible occultation :—

Immersion February 14 at	h	m	} Apparent time at Si-gan-fou.
Emersion „ „	10	22	
	10	59	

The immersion is therefore made to occur well within the two-hourly interval named in the Chinese annals, and the Moon was in *Virgo*, between the constellations *Kio* and *Kang*.

The second occultation to which I have referred is one of the planet *Venus*, thus given by Gaubil :—

“Dynastie des Tsin orientaux, la cour à Nanking, appelé alors Kien-Kang. An 361=5^e année, 1^{re} Lune, jour *y-tcheou* (20 Mars) à l'heure *tchin* (temps de 7 à 9 heures du matin), la Lune éclipa *Vénus* dans la constellation *Goey*.”

Calculating in the same manner as before, I find the following figures :—

A.D. 361, March 19.

Paris M.T. h	Sun's True Longitude. ° ' "	Log. R.		h	h	m	s
12	359 47 39.6	0.0018164	Sideral time at 0	23	49	28	
13	359 50 6.2	0.0018113	Equation of Time (Subtractive from Mean Time).		7	49	

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	Venus' Helioc. Longitude.	Venus' Helioc. Latitude.	Venus' Log. Rad. Vect.
h			
12	239 0 56.6	+ 0 9 55.5	9.8614762
13	239 4 54.3	+ 0 9 41.0	9.8614777
	Venus' Apparent R.A.	Venus' Apparent Decl.	
h			
12	317 36 26	-16 18 37	} Log. distance 9.94883
13	317 39 14	-16 17 59	
	Moon's R.A.	Moon's Decl.	
h			
12	317 4 23	-15 45 55	Hor. Parallax 59 58
13	317 41 17	-15 38 21	Semi-diameter 16 20

Taking the position of Nanking from the *Connaissance des Temps*, a visible occultation again results:—

Immersion, March 19 at	h m 19 34	} Apparent time at Nanking.
Emersion, „ „	20 59	

Consequently the phenomenon occurred within “l’heure *tchin*,” as recorded by the Chinese, and the Moon was at the time in the constellation named.

Note by the Astronomer Royal on the Numerical Lunar Theory.

In the *Monthly Notices of the Royal Astronomical Society* for 1874, January, vol. xxxiv., No. 3, I gave as the three equations of motion in the Lunar Theory the three following: (1) The equation of areas described by the radius vector parallel to the plane of the ecliptic; (2) The equation of *vis viva* parallel to the plane of the ecliptic; (3) The equation of motion perpendicular to the plane of the ecliptic.

It now appears preferable to substitute for (2) the equation of radial forces parallel to the plane of the ecliptic, which may be called (2*), and which is easily found to be the following:—

$$\begin{aligned} \frac{1}{2} \cdot \frac{d^2}{dt^2} \left\{ \frac{a'}{a} \cdot \frac{r'}{a'} \cos l' \right\}^2 & - \left(\frac{d}{dt} \left(\frac{a'}{a} \cdot \frac{r'}{a'} \cos l' \right) \right)^2 - \left(\frac{a'}{a} \cdot \frac{r'}{a'} \cos l' \right)^2 \cdot \left(\frac{dl'}{dt} \right)^2 \\ & + \left(\frac{a'}{a} \right)^2 \cdot \frac{\epsilon' + \mu'}{a'^3} \cdot \frac{a'}{r'} \cos^2 l' \\ & = + \frac{P}{a} \cdot \frac{a'}{a} \cdot \frac{r'}{a'} \cdot \cos l'. \end{aligned}$$