

On the Rotation-period of Jupiter.

By H. Pratt, Esq.

On the 24th July 1879, between 11^h 30^m and 12^h G.M.T., on turning my telescope on *Jupiter* for the first time this season, I saw, near the middle of the great white belt on the south of the equatoreal zone, a finely developed reddish spot, or short belt. At that time its apparent centre was about half-way from the central meridian to the preceding limb. From its definiteness of outline and vividness of colour, I concluded it would prove useful as a means of obtaining a new determination of the rotation-period; and accordingly made observations for this purpose on every available occasion, and from them have derived the results which are detailed below.

The only previous determinations of *Jupiter's* rotation-period with which I am acquainted, are as follows:—

Author.	Date.	Rotation-period.			Authority.
		h	m	s	
Cassini	1665	9	55	49.5	Dick, <i>Celestial Scenery</i> .
"	"	9	56		Grant, <i>Hist. of Astron.</i>
"	1672	9	55	50	" "
"	1692	9	50		" "
Maraldi	1708	9	56	48	" "
"	1713	9	56		" "
Sylvabelle	1773	9	56		Arago, <i>Pop. Astron.</i>
Herschel, W.	1779	9	55	40	Grant, <i>Hist. of Astron.</i>
"	"	9	55	48	" "
Schroeter	1786	9	55	33.6	" "
"	"	9	56	56	Arago, <i>Pop. Astron.</i>
"	"	9	55	18	" "
Schmidt	No date	9	55	28.7	Chambers, <i>Astron.</i>
Mädler	1835	9	55	29.9	Hind, <i>Solar System</i> .
Airy	"	9	55	21.3	<i>Mem. R.A.S.</i> , vol. ix.
Schmidt	1866	9	55	46.3	Webb, <i>Celes. Objects</i> .

Considering the three most recent determinations, when the observers, the instruments, and the methods were all of the best, it may seem folly even to attempt the work again. Indeed it may prove impossible ever to arrive at a nearer knowledge of the true rotation-period of the planet. Yet, as the harmony between those three results is not perfect, and in view of the suggested cause of discrepancy being a proper motion of the spots made use of, I beg to submit (with what value may be attached to them) the following observations and inferences therefrom.

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The observations themselves consisted of the Greenwich Mean Times of the transits of the middle of the spot across Jupiter's central meridian. These were obtained by means of micrometer measures of the distances of the ends of the spot from the E. and W. limbs of the planet. When these distances were equal it was concluded that the middle of the spot was on the central meridian. My clock's rate had been kept corrected by the frequent use of my transit-instrument.

The times of transit of the spot, found in this manner, were:—

			h	m	s
1	1879	July 26	12	25	0
2	"	Sept. 3	9	19	
3	"	" 10	10	1	30
4	"	" 27	8	59	
5	"	Oct. 1	12	15	30
6	"	" 6	11	22	15
7	"	" 26	7	50	
8	"	Nov. 2	8	35	20
9	"	" 5	6	4	20
10	"	" 12	6	50	
11	"	" 19	7	35	30
12	"	Dec. 6	6	36	

Arranging these observations in two series; taking them consecutively in pairs; and designating the intervals in the first series, between 1 and 2 (*a*), 2 and 3 (*b*), 3 and 4 (*c*); and in the second series between 1 and 2 (*a*), 1 and 3 (*β*), 1 and 4 (*γ*), and so on, we have:—

Intervals.	No. of Rotations.	Time elapsed in Mean Solar Seconds.
(<i>a</i>)	94	3,358,440
(<i>b</i>)	17	607,350
(<i>c</i>)	41	1,465,050
(<i>d</i>)	10	357,390
(<i>e</i>)	12	428,805
(<i>f</i>)	48	1,715,265
(<i>g</i>)	17	607,520
(<i>h</i>)	7	250,140
(<i>i</i>)	17	607,540
(<i>j</i>)	17	607,530
(<i>k</i>)	41	1,465,230
(<i>α</i>)	94	3,358,440
(<i>β</i>)	111	3,965,790
(<i>γ</i>)	152	5,430,840

Intervals.	No. of Rotations.	Time elapsed in Mean Solar Seconds.
(δ)	162	5,788,230
(ε)	174	6,217,035
(ζ)	222	7,932,300
(η)	239	8,539,820
(θ)	246	8,789,960
(ι)	263	9,397,500
(κ)	280	10,005,030
(λ)	321	11,470,260

The method by which I have arrived at the final result has been to take, as an assumed period of rotation, 35,726 seconds, multiply it by the number of rotations, and, after having corrected it for the difference of the Jovi-centric longitudes of the Earth at the two stations, to subtract the total from the time elapsed. Then, if the assumed rotation-period is in accord with the observed times when the middle of the spot was found to be on the planet's central meridian (allowing for the equation of light), there will be no remainder. If it is not so, then the remainder divided by the number of rotations will give a result which, after it is corrected for the differences of the equation of light due to the varying distances between the Earth and *Jupiter* at the times of the two observations under discussion, will give the final correction to the assumed rotation-period which the case requires.

As this last correction is in every case *plus*, it remains merely to add it to the assumed period in order to obtain that value of the time of *Jupiter's* rotation which is indicated by that pair of observations.

Treating the whole of the two series, in pairs of observations, by this method, I obtain the following corrections :—

	secs.		secs.
(a)	7.06	(α)	7.06
(b)	4.86	(β)	6.71
(c)	9.73	(γ)	7.47
(d)	15.23	(δ)	7.99
(e)	8.13	(ε)	7.96
(f)	7.86	(ζ)	7.90
(g)	7.57	(η)	7.97
(h)	6.95	(θ)	7.92
(i)	7.70	(ι)	7.78
(j)	7.68	(κ)	7.72
(k)	7.60	(λ)	7.43
Mean	8.21	Mean	7.62

and

$$\frac{8.21 + 7.62}{2} = 7.91 \text{ secs.} = \text{the final correction.}$$

With regard to the relative value of the two series, undoubtedly that of the second is the greatest, for including as it does a much larger number of rotations of the planet between each pair of observations, its results must therefore be the more accurate of the two.

From the fairly close accord between the means of the two sets of double observations, we may assume with great probability that the spot was without variable proper motion; for what differences there are arise more probably from the unavoidable errors of observation. But I have thought it best to exhibit them thus plainly in order that a proper estimate may be formed of the whole matter; for, after all, the difference of the means does not exceed one second of time.

Therefore, if the mean of those two means, = $7^s.91$, is added to the assumed period, giving $9^h\ 55^m\ 33^s.91$ of Mean Solar Time, that may perhaps be accepted as the nearest approximation which I am able to derive from the whole of my observations, which include 321 rotations of *Jupiter*.

By substituting for the assumed period this now corrected value of it, and by calculating what should have been, according to it, the times of transit of the spot across *Jupiter's* central meridian on the dates of observation, we arrive at the following discrepancies between prediction and observation:—

	In Time. secs.		In Jovi-centric longitude. °
(a)	+ 79	or	0.7
(β)	+ 132	„	1.3
(γ)	+ 65	„	0.6
(δ)	— 14	„	0.01
(ε)	— 20	„	0.2
(ζ)	— 9	„	0.09
(η)	— 15	„	0.01
(θ)	— 5	„	0.05
(ι)	+ 33	„	0.3
(κ)	+ 54	„	0.5
(λ)	+ 154	„	1.5

from which it is apparent that the greatest of these discrepancies is 154^s in time of observation, equal to $1^{\circ}.5$ of longitude on *Jupiter*, which is well within the limits of possibility.

From the experience gained in making the original observations, I have concluded that it would have been impossible for me to have made an error exceeding two minutes, or two minutes and a half, in determining the times of central transit across *Jupiter's* disk. This amount doubled, as a possible excess and defect at the times of the first and last observations, amounts to

but $\frac{1}{38,000}$ th of the whole. From which it follows that the probable error in my determination is less than one second of time.

The rotation-period which is perhaps most frequently quoted in astronomical books is $9^h 55^m 26^s$. During the 321 rotations which I have observed during this series, that period would produce a discordance equal to $42^m 19^s$; and by that time, not only the middle, but the following end of the spot would have considerably passed the central meridian on the date of the last observation. It is therefore plainly evident that the most generally quoted value of the rotation-period is completely out of harmony with the present series of observations.

I gladly acknowledge the assistance derived from the perusal of the valuable paper, "On the Determination of the Rotation-period of Jupiter in 1835," to be found in vol. ix. of the *Memoirs*, by the Astronomer Royal, whose method to some extent I have followed.

18 Preston Street, Brighton,
1880, January 8.

Estimated Times of Transit of the Red Mark on Jupiter across the Central Meridian. By T. W. Backhouse, Esq.

1879.		G.M.T.			Long.			Length.
Mo.	Day.	Pr. End. h m	Middle. h m	Foll. End. h m	Pr. End. °	Middle. °	Foll. End. °	
8	29		10 14			255		
9	22	9 29	9 33	10 23	245	261	278	33
	29		10 43			264		
10	6	10 59*	11 23		248	263		
	28			9 56			283	
11	7			8 17†			288	
	10			5 44			287	
	17	5 35‡			260			
	29		5 53§	6 21§		271	287	
12	6	6 14§	6 40§	7 10§	256	272	290	34
	13		7 35‡			278		
	23	5 18§	5 48§	6 15§	259	277	293	34
	25	7 1	7 27	7 56‡	262	278	295	33

* Main part. A slender point extends a little further pr.
† Thickish cloud.
‡ Definition bad.
§ Definition not good.

Estimations made with a $4\frac{1}{4}$ -in. Refractor.
Sunderland.