NORTH TEMPERATE BELT$_S$ MARKINGS ON JUPITER IN 1940-41

By Hugh M. Johnson

General Description.—It is well known that various latitudes over the observed surface of Jupiter maintain unequal rotation periods, somewhat less than 10 hours and having a range of several minutes, and that customarily the equatorial regions to latitudes about ±10° exhibit the shorter periods. Accordingly, it has been found convenient to employ two rotational systems fixed by Marth in 1896,[1] System I for the equatorial regions and System II for the rest of the planet, their periods being:

I	9h.	50m.	30.003s.
II	9	55	40.632

But these adopted periods do not fit at times even approximately to the observed motions of markings in certain restricted latitudinal regions, the appearance of which interesting motions at present can be termed only "abnormal" for want of any knowledge as to their cause. One of these regions is at the south edge of the dark north temperate belt, latitude about +25°, known for its *very short* rotation periods near 9h. 49m., which have displayed at least five distinct manifestations since the first in 1880. Others followed in 1891, 1926 (one object), and 1929, as listed by B. M. Peek.[2] In September-October, 1939, Peek discovered a new series of small, dark projections from the south edge of the north temperate belt, which appeared similar to the spots in the 1929 "outbreak" and which were soon found to have the rapid rotational motion. He has given an account of them in the 1939-40 apparition (to February, 1940),[3] using visual observations by five B.A.A. workers. A mean rotation period of 9h. 48m. 56s. for the 11 best observed spots was found.

Early in the 1940-41 apparition it was evident that the N. Temp. B.$_S$ markings had continued into a second apparition (not

[1] *Monthly Notices of the R.A.S.*, v. 56, pp. 395 and 517, 1896.
[2] *The Observatory*, v. 59, p. 280, 1936, with bibliography.
[3] *Journal of the B.A.A.*, v. 50, p. 270, 1940.

a unique case) and in this paper we deal with the 1940-41 observations of them made by five American amateurs while in the process of a general programme on Jupiter. Chiefly we were interested in deriving rotation periods, on a basis of visual transit observations for the determination of longitudes of individual marks, in the manner so successfully employed by the Jupiter Section of the B.A.A. and well explained by Peek.[4] In short, this method involves merely a record of the time at which any point of interest on the planet is estimated to be at the central meridian; a series of which records when reduced to longitudes System I or II may be translated into the rotation period of the mark concerned. Our group of observers, each of whom with his principal telescope and location is listed in Table I, together with his number of transits for the whole planet and transits of dark N. Temp. $B._s$ marks.

TABLE I

Observer, Telescope and Location	*Transits for Whole Planet*	*N. Temp. $B._s$ Transits*
T. R. Cave, Jr., 6-in. refl., Long Beach, Cal........	21	1
C. Cyrus, 10-in. refl., Lynchburg, Va.............	34	2
W. H. Haas, 6-in. refl., New Waterford, O.........	618	40
H. M. Johnson, 8-in. refl., Des Moines, Ia.........	1181	104
F. R. Vaughn, Jr., 8-in. refl., Des Moines, Ia.......	179	16
	2033	163

One other member of the group, D. P. Barcroft, with 6-in. refl. at Madera, Cal., obtained 37 transits, none of which pertained to N. Temp. $B._s$ marks, however. In the following sections we consider these collected observations in detail, U.T. dates and times being used.

Rotation Periods.—On the chart, Fig. 1, dates 1940-41 against longitudes System I,[5] are plotted the 163 transits of N. Temp. $B._s$ dark spots, with graphs joining those transits which seem likely to belong to one series on a spot. Only five transits were without one of the 16 graphs or "drifts" thereby found. In Table II data

[4]*Journal of the B.A.A.*, v. 47, p. 153, 1937.

[5]Because of the rapid rotation of these marks, System I is more convenient to employ than is System II, despite the latitude being outside the normal domain of the former.

for the rotation periods of the 16 marks are listed; an identifying number correlating each mark in the chart and table has been assigned.

TABLE II

No.	*Dates*	*Number of Transits*	*Change of Long. (I) in 30 days*	*Rotation Period*		
1	July 4 - Feb. 10	15	−52°	9h.	49m.	20s.
2	July 2 - Feb. 28	14	−51	9	49	22
3	June 30 - Feb. 19	18	−54	9	49	17
4	July 23 - Sept. 29	8	−63	9	49	05
5	Sept. 6 - Feb. 19	9	−58	9	49	12
6	Nov. 30 - Feb. 19	3	−53	9	49	19
7	July 21 - Dec. 23	9	−54	9	49	17
8*a*	June 26 - Mar. 1	18	−46	9	49	29
9*b*	Oct. 27 - Nov. 17	2	−54	9	49	17
10	June 15 - Nov. 8	15	−55	9	49	16
11*c*	Aug. 18 - Sept. 3	2	−53	9	49	19
12*a*	Sept. 1 - Mar. 19	7	−53	9	49	19
13	Aug. 29 - Jan. 11	10	−62	9	49	07
14	Aug. 20 - Sept. 24	4	−79	9	48	44
15	Sept. 1 - Feb. 23	13	−59	9	49	11
16	Oct. 26 - Jan. 11	11	−61	9	49	08

Mean: 9h. 49m. 14s.

Notes.—*a* Final section of drift very uncertain as chosen.
b Observed by Johnson only.
c Observed by Haas only.

The mean rotation period comes out one-third minute greater than the result obtained by Peek for 1939-40: there can be almost no doubt that the increase is real. It is interesting to note that this deceleration apparently was most effective *between* the apparitions, *i.e.*, from January-February to June, 1940, for *in general* the graph forms on both Peek's and the present chart are linear. This deceleration in motion, probably irregular, together with a possible increase in the number of observed spots, would make practically impossible an attempt to identify any of the 1940-41 objects with those of 1939-40 by means of drift-extrapolation. In fact, we do not know whether any of the 1939-40 individual spots is a survivor over the three or four months when the planet was not observed, but surely we may safely call the 1940-41 group as a whole a continuation of the eruption of the previous apparition.

There are certain sinuosities in the drifts which probably represent actual variations in the rates of motion of the spots more than errors of observation, for it is believed that chance errors in visual transit work are of an order less than five minutes or three degrees longitude.[6] In spots Nos. 12, 13, 14, and 15, we seem to

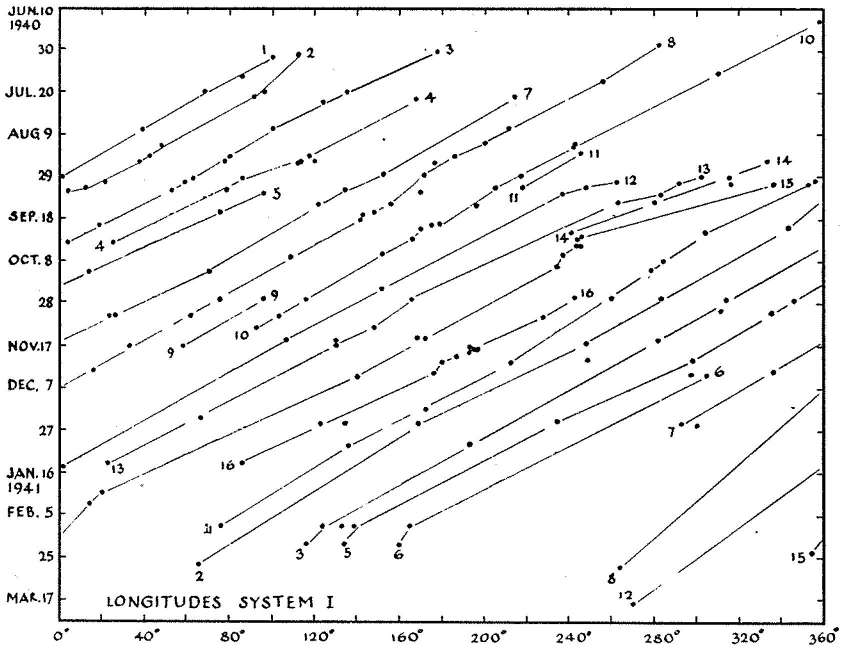

Fig. 1.—Longitude drifts of N. Temp. B_s spots.

have cases of extraordinary motion, though it must be admitted that the interpretation of drifts among their early transit plots is tentative and requires confirmation. Briefly, however, these four spots appear to have originated between longitudes 262_1° and 336_1° at a later period (August 20 to September 1) than most of their fellows, and to have begun with "abnormally" rapid motion, decelerating to "normal" motion in a few weeks. There is good

[6]But all N. Temp. $B._s$ transits before August 15 (which are by Johnson) may be systematically early by about five minutes.

evidence that spot No. 15 was *abruptly* slowed between September 27 and October 10. Spots Nos. 14 and 15 were peculiar in being "quite (or) very small" at their first transits, but Nos. 12 and 13 were apparently of medium size.

Distribution.—Hardly more than a glance at the chart, Fig. 1, is enough to suggest that the number of N. Temp. $B._s$ spots may be distributed unevenly with respect to time, possibly with a periodic concentration. While it seems worth while to investigate the idea more carefully, it must be remembered that very precise information cannot be obtained because of the lack of sufficiently numerous and standardized observational data.

The simplest method for determining real variations in number of N. Temp. $B._s$ spots is a count of their number per unit of *observing* time. However, this requires an exact knowledge of the time spent observing each night for each observer, which we do not have, and it neglects spurious effects on the visibility of the marks resulting from variations in seeing, telescope, etc. But let us assume that the total real number of marks on the remainder of the planet remains constant, and that real numbers of N. Temp. $B._s$ spots and extra-N. Temp. $B._s$ spots are reduced to observed numbers by a visibility factor common to both groups, all approximately. Acceptance of these plausible assumptions enables us to express real variations in number of N. Temp. $B._s$ spots by the ratio $n/(N-n)$, where n and N are the *observed* numbers, per unit of time, of N. Temp. $B._s$ spots and all surface marks, respectively. Choosing the interval of time 10 days[7] in which to group transit numbers, and noting that the first N. Temp. $B._s$ spot transit came on June 15, 1940, and the last on March 18, 1941, we make 28 consecutive intervals the first of which begins June 15, 0h. In Table III we tabulate all the transits falling in these intervals; column one giving interval number; column two, limiting interval dates; column three, number of N. Temp. $B._s$ spot transits; column four, number of all transits; and column five, $n/(N-n)$.

[7]This interval should be large enough to include significant numbers of transits yet small compared with the frequency of variation we can investigate.

TABLE III

No.	*Dates, 0h*	*n*	*N*	*n/(N−n)*
1	June 15-25	1	13	.083
2	June 25—July 5	4	63	.068
3	July 5-15	3	107	.029
4	July 15-25	6	84	.077
5	July 25—Aug. 4	1	103	.010
6	Aug. 4-14	5	191	.027
7	Aug. 14-24	14	178	.085
8	Aug. 24—Sept. 3	16	168	.105
9	Sept. 3-13	17	149	.129
10	Sept. 13-23	8	113	.076
11	Sept. 23—Oct. 3	10	95	.118
12	Oct. 3-13	5	64	.085
13	Oct. 13-23	4	26	.182
14	Oct. 23—Nov. 2	10	73	.159
15	Nov. 2-12	8	76	.118
16	Nov. 12-22	12	84	.167
17	Nov. 22—Dec. 2	11	75	.172
18	Dec. 2-12	0	21	.000
19	Dec. 12-22	3	22	.158
20	Dec. 22—Jan. 1	5	56	.098
21	Jan. 1-11	2	46	.045
22	Jan. 11-21	3	43	.075
23	Jan. 21-31	1	17	.063
24	Jan. 31—Feb. 9	1	34	.030
25	Feb. 9-19	5	33	.179
26	Feb. 19—Mar. 1	5	37	.156
27	Mar. 1-10	1	18	.059
28	Mar. 10-20	1	20	.053

The tabulated ratios in the last column of Table III seem to show that quite significant variations in real number of N. Temp. $B._s$ spots occurred. These variations are more clearly shown in a graph of the form in Fig. 2, where abscissae are time and ordinates the ratios of column five, Table III. This graph may be interpreted as *roughly* representing[8] a complex curve whose principal characteristic is a short period frequency of very nearly 30 days. The evidence for reality of this period seems fairly strong. It will be noted that we supposed the phases of these variations occurred simultaneously

[8]Perhaps within the errors of the observations and methods by which it was derived.

in all longitudes. The more secular variations are certainly due in part to the observers' varying personal attention; *e.g.*, Haas recorded no N. Temp. $B._s$ spots until the seventh interval though he contributed other transits in the first six intervals. Table II

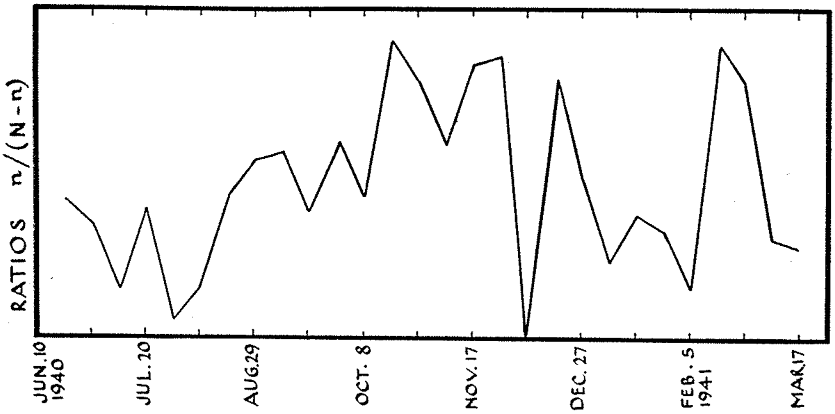

Fig. 2.—Apparent variation in observed number of N. Temp. $B._s$ spots.

also indicates that the real number of these marks simultaneously existing also varied, though we must not take limiting dates of observation for limiting dates of existence, necessarily.

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September 7, 1941.