ASSOCIATION OF LUNAR AND PLANETARY OBSERVERS

The Strolling Astronomer

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In This Issue

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Las Cruces, New Mexico

THE

STROLLING ASTRONOMER

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ANNOUNCEMENTS

Errors in June and July, 1953 Issues. There was some confusion about the labellings of Figure 1 on pg. 85 and Figure 2 on pg. 86. Both are moon model photographs referred to in the article by Mr. Edward Lindemann. On pg. 90 insert the following in the right column seven lines from the bottom of the page: "1933, Mar., Type 7. The Spot is 27° long. The Bay is 37° long." On pg. 105, right column, lines 7 and 8 read "more or less square enclosures."

HONOR PAID TO H. P. WILKINS. His many friends in the A.L.P.O. will be very glad to learn that H. P. Wilkins, the Lunar Director of the British Astronomical Association and the maker of the 300-inch map of the moon, received early this year an honorary Doctor's Degree from the University of Barcelona, Spain. We congratulate Dr. Wilkins on this richly deserved distinction.

JUNIOR ASTRONOMICAL SOCIETY. Such is the name of a recently formed astronomical society in the British Isles. The Director of the Overseas Section is T. J. Croston, 40 Lynton St., Leigh, Lancs., England. The word "Junior" here means those who are beginners in astronomy rather than an age-group. The overall objective of the Junior Astronomical Society is to help these beginners. Inquiries will be welcomed warmly.

MORE ON LUNAR RAINBOWS. Our mention on pg. 96 of our July, 1953 issue of a lunar rainbow observed at Hot Springs, New Mexico on July 25, 1953 has produced some correspondence from C. W. Battels of Akron, Ohio and Patrick Moore of East Grinstead, Sussex, England. Mr. Battels directs attention to some material about lunar rainbows in Thomas Dick's famous old book, The Practical Astronomer, published by Harper and Brothers, New York, 1846. Dick mentions several lunar rainbows, including two witnessed by himself in Scotland and one recorded by Aristotle; he also warns against confusing these objects with luminous arches of the Aurora Borealis. Mr. Moore writes of a lunar rainbow he saw on March 28, 1945 from an aircraft at an elevation of about 2,000 feet above North Scotland. The bow was almost colorless because of its faintness and was nearly a complete circle.

SUBSCRIPTIONS TO VEGA. Mr. R. M. Baum requests that subscriptions to the international periodical Vega be sent to him at 1 Dee Banks, Boughton, Chester, England. Mr. Baum has kindly offered a special subscription rate of 10 shillings per year, or about $1.40 in American money, to A.L.P.O. members. Vega carries many articles of value to the lunar and planetary observer, and Mr. Baum himself is among our active contributors.

IN MEMORIAM

We have learned with much sorrow of the death on August 30, 1953 of Mr. John J. O'Neill, the Science Editor of the New York Herald Tribune. He was one of our charter members and several times contributed to this periodical. Many times he generously mentioned the A.L.P.O. and Strolling Astronomer articles in his writings in the Herald Tribune. It was the Editor's good fortune to meet Mr. O'Neill in New York in the autumn of 1950 so that there is also a sense of personal loss.

Our late colleague was one of the early science reporters in the daily press and spent 45 of his 64 years in newspaper work. Though he had little formal technical education, he had a keen and inquiring mind and wrote about all phases of modern science, including atomic energy, guided missiles, medicine, and planets. He was possessed of a proper scientific skipticism toward much that is now accepted as fact, and indeed we cannot doubt that some of today's scientific fashions will be tomorrow's nonsense. He received a number of prizes for his reporting over the years and was the author of several books, including Prodigal Genius. The Life of Nicola Tesla and Enter Atomic Energy. Among the societies to which he belonged are the American Newspaper Guild, the American Geographic Society, the American Association for the

Advancement of Science, the Amateur Astronomers' Association (New York), the American Geophysical Union, and the Academy of Political Science. He was a charter member and a former president of the National Association of Science Writers.

We extend to the family and friends of Mr. O'Neill our sympathy in their loss.

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JUPITER: THE 1952-53 APPARITION

by Elmer J. Resse and Robert G. Brookes

Date of Opposition: November 8, 1952
Declination: 15° N.
Equatorial Diameter: 49.3 seconds of arc.

INTRODUCTION: This report is based on observations made by the following members of the Association of Lunar and Planetary Observers:

R. M. Adams, 3-1/4-in. refr., 10-in. refl., Neosho, Mo.; N. L. Allinger, 6-in. refl., Los Angeles, Calif.; D. P. Avigliano, 3-in. refr., 6 & 8-in. refls., Sierra Madre, Calif.; Rex Bohannon, 16-1/2-in. refl., La Crescenta, Calif.; J. T. Carle, 8-in. refl., Fresno, Calif.; I. A. Courtright, Jr. 12-1/2-in refl., Venice, Calif.; Eugene Epstein, 10-in. & 20-in. refls., Pasadena, Calif.; R. R. Fink, 6-in. refl., Milwaukee, Wisc.; M.B.B. Heath, 10-in. refl., Kingsteignton, England; L.T. Johnson, 10-in. refl., La Plata, Md.; F. W. Kelly, 12-in. refl., Tulsa, Okla.; A. P. Lenham, 3-1/4-in. refr., Swindow, England; R. C. Maag, 8-in. refl., Sedalia, Mo.; Toshihiko Osawa, 6-in. refl., Osaka, Japan; O. C. Ranck, 4-in. refr., Milton, Pa.; E. J. Reese, 6-in. refl., Uniontown, Pa.; J. R. Smith, 8-in. & 16-in. refls., Eagle Pass, Tex.; H. P. Squyres, 6-in. refl., El Monte, Calif.; Don Strayhorn, 3-3/4-in. refr., Wilmington, N.C.; J. A. Westphal, 12-in. refl., Tulsa, Okla.

GENERAL DESCRIPTION
BELTS

South South Temperate Belt: The SSTB remained constant during the apparition; it appeared as a dull-dusky gray.

South Temperate Belt: The STB was dark brownish-gray until late October; then it became a dusky brownish-gray with less brown. (See below: RS).

South Equatorial Belt: The belt displaying the most change during the apparition was the SEB. From August to late October the SEB components were very faint and thin (Figure 1). Some observers failed to record these belts at all, but others recorded the belt as very faint and resolved it into its components on several occasions. During this interval the SEB, the SEB Interior Zone, and the EZ all exhibited a pale bluish color.

On or shortly before October 22, 1952

Figure 1.
Jupiter.
T. Osawa.
6-inch refl.
Aug. 29, 1952
$20^h 0^m$, U.T.
C.M.$_1$ = 95°.
C.M.$_2$ = 239°.

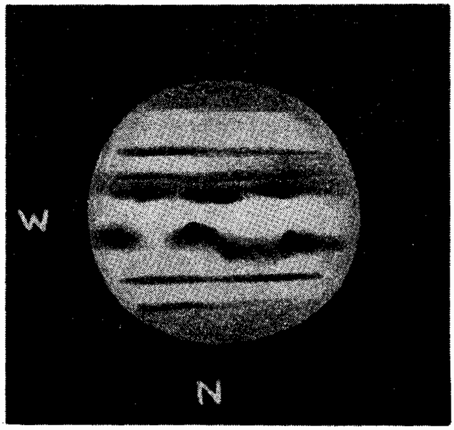

Figure 2. Jupiter. D. P. Avigliano. 8-inch refl., 188X. March 17, 1953. $3^h\ 15^m$, U.T. C.M.$_1$ = 98°. C.M.$_2$ = 162°.

there was a violent disturbance in the SEB. The longitude (II) of the initial outbreak was 204°. Following this outbreak the SEB began to darken, and the EZ became brighter and whiter. These changes occurred rather gradually during November, December, and January. After mid-December the SEB was recorded on many occasions as being fully as conspicuous as the NEB in some longitudes (Figure 2) -- this is a rather unusual aspect in recent years.

From mid-December to early February the following general color pattern was observed in the SEB: From the preceding end of the SEB disturbance to the longitude (II) of the initial outbreak (204°) the SEB displayed beautiful orange and red-brown hues. From the longitude of the initial outbreak to the RS region, the color was dull tan or muddy. From the RS region to the preceding end of the disturbance, the SEB components were neutral or even bluish-gray while the Interior Zone was clear and bright white.

North Equatorial Belt: The NEB remained very dark during the apparition. Its color changed from red-brown to brown as the apparition progressed. During December and January this belt was a beautiful and striking red-brown or burnt sienna color from longitude (II) 200° through 360° to 50°. However, an expanding brownish-gray section centered near longitude (II) 130° was quite colorless. The belt generally became less red during the apparition.

North Temperate Belt: This belt remained constant appearing as a dusky-gray.

North North Temperate Belt: This belt remained constant appearing as a dark brown-gray.

North North North Temperate Belt: This belt remained constant appearing as a dark brown-gray.

The appearance of the belts and zones north of the NTB varied considerably in different longitudes. The NTB was thin, faint, and quite uniform in all longitudes. The NTeZ was narrow and dull between longitudes (II) 213° and 324° and wide and bright from 30° to 180°. The NNTeZ was wide and bright between 210° and 350° and very dusky and narrow from 70° to 160°. The varying widths of the NTeZ and NNTeZ were caused by a slanting NNTB which lay near the NTB near longitude (II) 250° and near the NNNTB near longitude (II) 137°.

ZONES

South Temperate Zone: The STeZ appeared as a dull zone growing duller as the apparition progressed. The long-enduring brighter sections of this zone continue to exist. (See: Long-Enduring Brighter Sections in the South Temperate Zone of Jupiter, The Strolling Astronomer, March, 1952; W. H. Haas, Some Long-Enduring Features in the South Temperate Zone of Jupiter, The Griffith Observer, January, 1953.)

South Tropical Zone: This zone appeared as a bright white, but after mid-November it became a dusky tan preceding the RS.

South Equatorial Belt Zone: This zone was a dull bluish-white at the beginning of the apparition, becoming darker as the apparition progressed.

Equatorial Zone: The EZ was pale bluish-white in all longitudes from August through October. During November a pale yellow-gray section developed between

Figure 3. Jupiter.
T. Osawa. 6-in. refl.
Sept. 11, 1952. $16^h 18^m$, UT
C.M.$_1$ = 213°. C.M.$_2$= 259°.

longitudes (I) 119° and 184°, the rest of the zone remained pale bluish-white. Subsequent to mid-December the EZ was very bright and white in all longitudes.

North Tropical Zone: The NTrZ remained constant, a bright white zone.

North Temperate Zone: The NTeZ was a slightly shaded white. (See above: NTB)

North North Temperate Zone: A dull yellowish-white (See above: NTB).

The Polar Regions: The SPR remained constant during the apparition. Its color was dusky gray. The NPR became less brown and more gray as the apparition progressed.

THE GREAT RED SPOT

During the early months of the apparition the RS appeared as an ellipse slightly flattened on the south side, having, generally, a brighter interior (Figure 3). The Hollow or Bay was very faint as a result of the faintness of the SEB. During this period the STB was very dark, showing a complicated structure near the RS. It would seem that during this period (August through mid-October) the RS displayed the appearance of type 7 or 8 as described by Reese in his paper, The Changeable Appearance of the Great Red Spot, The Strolling Astronomer, June, 1953.

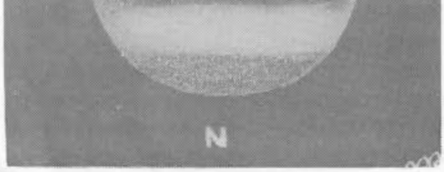

Figure 4. Jupiter. D. P. Avigliano
3-inch refr. 171X. Feb. 2, 1953.
$5^h 15^m$, U.T. C.M.$_1$ = 231°.
C.M.$_2$ = 262°.

During November several dusky columns were seen crossing the STrZ near the preceding end of the RS. These columns were accompanied by a number of very dark condensations on the SEBs. By mid-November the preceding shoulder of the Bay was fairly dark and distinct. During December and January the STrZ was very dull preceding the RS region, and the aspect of the RS was uncertain. At times it resembled the Spot with a bright interior and dark border while at other times it resembled the Hollow. J. R. Smith observed the spot on January 22 and the Hollow on February 3 and 8. D. P. Avigliano observed the Hollow on February 2 (Figure 4). By March the aspect was clearly that of the Hollow (type 1) - a bright yellow-ochre ellipse surrounded by a dark tan border.

The RS was usually described as being very dusky and yellow-ochrė.

SATELLITE PHENOMENA

Lenham contributed the following Satellite magnitude estimates:

Date	Time (UT)	Satellite magnitude I	II	III	IV
Nov. 3	19:55	6.3	7.0	6.0*	6.5
Nov. 7	18:00	6.3	6.8	6.0*	6.5
10	21:00	6.5	7.0	6.0*	6.6
11	18:00	7.0	5.9	6.0*	6.5
13	18:00	6.6	6.5	6.0*	6.3
14	21:30	6.4	6.1	6.0*	6.8
23	18:00	6.5	6.3	6.0*	6.5
24	18:30	6.45	6.4	6.0*	6.4
Dec. 3	18:50	6.6	---	6.0*	6.3
4	18:00	6.8	6.6	6.0*	6.4

*Satellite III assigned the arbitrary value of 6.0 magnitude.

The results of twenty-four observations of Satellite phenomena made by Reese, from August 26, 1952 to February 22, 1953, are summarized below:

Satellite	t_o-t_c	2nd contact - 1st contact	No. of Obs.
I	-1.^{m}3	3.^{m}7	12
II	-1.^{m}2	4.^{m}5	9
III	-0.^{m}4	10.^{m}5	3

t_o = Observed time
t_c = Computed time from the American Ephemeris and Nautical Almanac.

From the above table it can be seen that the observed times and the calculated times from the A.E.N.A. are not in agreement. This difference of observed and predicted (A.E.N.A.) times has been noticed by several observers in recent years to be systematic and persistent.

PHOTOGRAPHS

L. T. Johnson secured a fine series of photographs during the apparition with his excellent 10-in. reflector. He used microfile film developed in D-76-F. A photograph on November 13, 1952 at 3:26 U.T. shows the dark RS preceded by two dusky columns in the STrZ. The following belts were recorded: NEB, STB, NNTB, (east of C.M. only), SEBs, SEBn, NNNTB and NTB.

T. Osawa submitted one photograph. It was taken on August 23, 1952 at 19:30 U.T. through the eyepiece (power not given) of a 6-in. reflecting telescope. A fine grain panchromatic plate was used, exposure 1/3 sec., image size on negative 1-1/2 mms. On a print enlarged approximately 10 times the NEB is clearly visible.

SOME INTERESTING OBSERVATIONS

J. T. Carle observed on November 17 1952 at 6:10 U.T. what he described as ".. a particularly interesting streamer, with marked, intensely black dots or knots evenly spaced along it." It lay across the EZ its ends terminating in the NEB and the SEB (Figure 5). Courtright observed this same festoon on November 16, 1952 at 0:30 U.T. extending completely from the NEB to the STB! It didn't seem to resemble any type festoon that he had seen before as

Figure 5. Jupiter
J. T. Carle. 8-inch. refl. 400X.
Nov. 17, 1952. 6^h 10^m, U.T.
$C.M._1 = 349°$. $C.M._2 = 248°$.

it was so large. It was distinct and was even darker than the belts, although it blended with them as it reached them. The south end of this festoon, which Courtright observed, was the RS.

E. Epstein made some observations with a telescope which will probably be of interest to the reader. Mr. Epstein writes: "Some of the observations were made with the 20-in. telescope of the California Institute of Technology. The telescope is a 1/10 scale model of the 200-in. Hale telescope and was built merely to test out certain structural features that were incorporated in the 200-in. telescope. Very little emphasis was placed on the optics. Consequently, the instrument has very poor definition. I can see much more detail with my own 10-in. reflecting telescope."

A. P. Lenham observed on November 23, 1952 a belt between the N. edge STB and the SEBs. (W. H. Haas has on rare occasions recorded a belt on this latitude). Also, on November 3, 1952 Mr. Lenham recorded 64 transits between 18:14 and 22!59 U.T. - a remarkable piece of work!

T. Osawa recorded on August 29, 1952 that the longitude of the RS was "extraordinarily increased", Its longitude was 262°, which was a 12° increase from August 27 when the RS longitude was 250°. On Aug. 30 the RS longitude had decreased to 252°. Mr. Osawa saw the SPR divided into several slender belts on October 17, 1952 at 16:20 U.T., $C.M._2$ 247°.

O. C. Ranck submitted a splendid set of 21 full-disc drawings of Jupiter from Aug. 29, 1952 to January 29, 1953.

ROTATION PERIODS

Three observers (Epstein, Lenham, and Reese) contributed a total of 1,550 transit observations. Seventy-five spots on the Giant Planet were observed well enough to enable their drifts in longitude to be determined. From these drifts mean rotation periods for eleven of the Jovian atmospheric currents have been determined. With very few exceptions the drifts presented in the following tables were deduced only for marks observed at least four times and followed for at least 30 days.

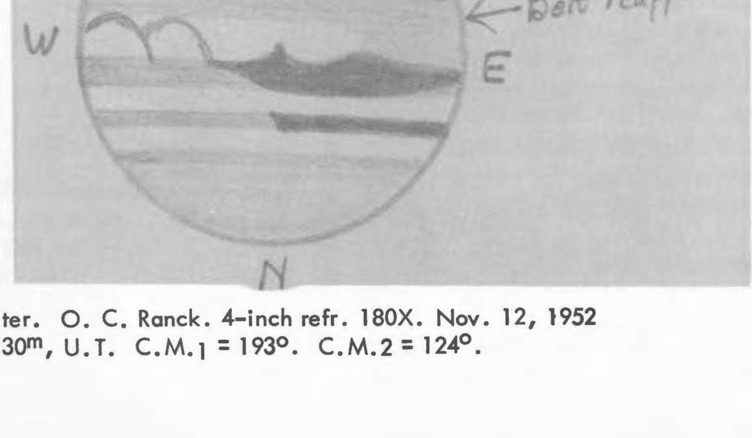

Figure 6. Jupiter. O. C. Ranck. 4-inch refr. 180X. Nov. 12, 1952
23^h 30^m, U.T. $C.M._1 = 193°$. $C.M._2 = 124°$.

S. Temperate Current (S. edge STB., STeZ), System (II)

No.	Mark	Limiting Dates	Limiting L.	L.*	Transits	Drift in 30^d
B	Df	Sep. 29–Feb. 8	42° - 304°	12°	15	-22.3°
C	Wf	Sep. 14–Mar. 14	79° - 300°	37	16	-23.0
D	Df	Aug. 26–Feb. 2	156° - 36°	102	10	-22.5
E	Dp	Aug. 26–Feb. 2	179° - 71°	130	17	-20.3
5	Wf	Aug. 18–Feb. 2	256° - 84°	180	7	-30.7
F	Df	Aug. 18–Feb. 24	300° - 171°	244	26	-20.4
A	Dp	Sep. 14–Mar. 6	304° - 190°	268	24	-19.8

Mean drift in 30 days -21.4
Mean rotation period $9^h\ 55^m\ 11^s$

*Longitude at opposition.

Prior to the apparition of 1939-40, the average rotation period of markings along the S. edge of the STB had been about $9^h\ 55^m\ 19^s$ according to the reports of the Jupiter Section of the British Astronomical Association. Since 1940, however, the period has varied between $9^h\ 55^m\ 2^s$ and $9^h\ 55^m\ 11^s$. Three bright areas about 90° long appeared in the STeZ in 1940 and have persisted to the present time. They have been drifting very slowly northward into the STB and contracting in longitudinal extent. At present they are about 25° long and appear as bright ellipses in the northern part of the STeZ forming deep bays in the S. edge of the STB. These bright areas are identified in the table by the same letters used previously (The Strolling Astronomer, Vol. 6, pp. 35, 46). The bright area, F-A, is clearly shown just south of the RS on photographs SP 21 and 22 taken with the Hale 200-inch telescope on October 24, 1952.

Middle of S. Temperate Belt, System (II):

No.	Mark	Limiting Dates	Limiting L.	L	Transits	Drift in 30^d
1	Wp	Sep. 29–Feb. 10	28° - 276°	355°	7	-25.1°
2	Wc	Sep. 29–Jan. 13	37° - 307°	5	8	-25.5
3	Wf	Sep. 29–Feb. 6	43° - 300°	12	11	-23.8
4	Dp	Sep. 25–Feb. 4	138° - 64°	124	8	-16.8

Mean drift in 30 days -24.8
Mean rotation period $9^h\ 55^m\ 8^s$

S. Tropical Current (StrZ), System (II):

1	Dp	Dec. 28–Feb. 18	207° - 147°	---	7	-34.6
2	Wf	Dec. 17–Feb. 8	296° - 307°	---	5	6.2

Rotation Period No. 1 $9^h\ 54^m\ 53^s$
Rotation Period No. 2 $9^h\ 55^m\ 49^s$

As in 1947, 1948, and 1949, the Red Spot region seems to have had a dominant influence on the STrZ drifts. In longitudes preceding the Red Spot, the dusky markings in the STrZ drifted rapidly in decreasing longitude; in longitudes following the Red Spot, the markings drifted very slowly in the direction of increasing longitude.

Red Spot and Hollow, System (II):

RSp	Aug. 18-Feb. 22	253 - 256	255	26	0.5
RSc	Aug. 18-Feb. 15	266 - 271	269	29	0.8
RSf	Aug. 18-Feb. 10	279 - 287	283	24	1.4
RSHp	Nov. 28-Mar. 16	254 - 260	---	9	1.7
RSHc	Dec. 17-Mar. 16	268 - 272	---	3	1.4
RSHf	Dec. 17-Mar. 16	281 - 286	---	4	1.7

Adopted rotation period $9^h\ 55^m\ 42^s$

The Red Spot region continued to drift slowly in the direction of increasing longitude during the apparition. Since 1937 the Spot has drifted eastward 130° relative to System II. The transition of the Red Spot to the Hollow late in the apparition was accompanied by a slight acceleration in the motion of this famous region.

Middle of S. Equatorial Belt, System (II):

No.	Mark	Limiting Dates	Limiting L.	L	Transits	Drift in 30^d
1	Dp	Oct. 23-Feb. 5	202° - 262°	155°	11	-85.8
2	Wc	Nov. 17-Dec. 30	160° - 48°	---	4	-78.2
3	Dp	Nov. 5-Dec. 28	179° - 60°	175	6	-67.4
4	Dc	Oct. 22-Nov. 17	204° - 183°	190	6	-24.2
5	Df	Oct. 22-Dec. 29	206° - 204°	205	10	-0.9
6	Dc	Dec. 17-Feb. 10	210° - 216°	---	4	3.3

Mean drift in 30 days -43.3
Mean rotation period $9^h\ 54^m\ 41^s$

The initial outbreak of a major disturbance in the SEB occurred on or shortly before Oct. 22. On that date an intensely dark spot was observed in the SEB Interior Zone at longitude (II) 204°. By October 25 the spot had twisted into the shape of a horse-shoe and was centered at 198° according to K. Komoda (Tanakami Astronomical Circular-Letter #1173). Thereafter, the disturbance began to expand; and the detail in the SEB became very complex. The preceding end of the disturbance (drift No. 1) moved very rapidly in decreasing longitude with a period of $9^h\ 53^m\ 44^s$; while the following end (Nos. 5 & 6), which seemed to be the root of the disturbance, remained nearly stationary in longitude with a period of $9^h\ 55^m\ 43^s$. The SEB Interior Zone became very dark following the advancing front of the disturbance, but reamined clear and bright preceding the disturbance. As the preceding end of the disturbance approached the following end of the Red Spot late in January, the bright clouds in the Interior Zone were apparently forced to flow into the STrZ and over the SEBn by the repelling action of the Red Spot. These clouds caused the unusually long rotation periods which were observed in the SEBn during February and March.

S. Equatorial Current (SEBn, S, part EZ), System (I)

No.	Mark	Limiting Dates	Limiting L.	L	Transits	Drift in 30^d
1	Dc	Nov. 14-Mar. 6	79° - 36°	82°	5	-11.5°
2	Dp	Dec. 28-Feb. 3	81° - 74°	---	4	- 5.7
3	Dc	Nov. 14-Feb. 5	114°-109°	115	7	- 1.8
4	Dc	Nov. 14-Feb. 5	135°-119°	136	5	- 5.8
5	Dp	Nov. 5-Jan. 13	146°-144°	147	4	- 0.9
6	Dc	Sep. 13-Feb. 3	175°-158°	168	9	- 3.6
7	Dc	Nov. 28-Mar. 16	183°-195°	---	7	3.3
8	Wp	Feb. 5-Mar. 14	215°-249°	---	6	27.6
9	Dc	Nov. 11-Feb. 10	265°-263°	265	7	- 0.7
10	Dc	Dec. 4-Feb. 24	285°-296°	---	5	4.0

Mean drift in 30 days -2.5 Mean rotation period $9^h\ 50^m\ 27^s$

N. Equatorial Current (S. edge NEB, N. part EZ), System (I)

1	Wc	Aug. 18-Feb. 2	21 - 358	11	6	-4.1
2	Dc	Nov. 3-Feb. 4	20 - 8	19	5	-3.9
3	Dc	Sep. 28-Feb. 4	38 - 27	34	7	-2.6
4	Wc	Sep. 28-Mar. 6	47 - 47	47	9	0.0
5	Dc	Aug. 14-Jan. 13	66 - 60	63	7	-1.2
6	Wc	Aug. 14-Nov. 14	84 - 76	77	6	-2.6
7	Dc	Nov. 3-Jan. 13	101 - 80	100	7	-8.9
8	Wc	Nov. 14-Mar. 6	107 - 85	108	6	-5.9
9	Dc	Nov. 12-Jan. 13	112 - 99	113	8	-6.3
10	Dc	Nov. 14-Feb. 23	119 - 117	119	10	-0.6
11	Wc	Oct. 24-Dec. 18	125 - 130	126	6	2.7
12	Dc	Sep. 23-Dec. 10	159 - 140	145	9	-7.3
13	Wc	Sep. 25-Dec. 28	161 - 159	158	13	-0.6
14	Dc	Nov. 28-Dec. 30	156 - 150	160	5	-5.6
15	Dc	Sep. 13-Mar. 16	174 - 158	169	17	-2.6
16	Dc	Sep. 13-Mar. 16	198 - 187	193	11	-1.8
17	Dc	Oct. 18-Dec. 7	233 - 217	225	4	-9.6
18	Dc	Oct. 18-Feb. 14	260 - 236	249	7	-6.1
19	Dc	Aug. 18-Dec. 4	320 - 254	270	6	-18.3
20	Wc	Aug. 26-Feb. 19	319 - 240	273	10	-13.4
21	Wc	Oct. 10-Dec. 4	297 - 270	285	4	-14.7
22	Dc	Aug. 26-Feb. 24	329 - 248	293	16	-15.0
23	Wc	Aug. 18-Dec. 29	338 - 278	301	6	-13.5
24	Dc	Oct. 14-Jan. 14	319 - 284	311	7	-11.4
25	Dc	Aug. 18-Feb. 24	351 - 294	330	8	-9.0

Mean drift in 30 days -6.5
Mean rotation period $9^h\ 50^m\ 21^s$

Middle of N. Equatorial Belt, System (II):

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift in 30^d
1	Wc	Oct. 19-Nov. 14	200°-68°	---	5	-152.3°
2	Wc	Feb. 5-Feb. 22	254 -184	---	4	-123.5
3	Wf	Feb. 6-Feb. 22	256 - 191	---	4	-121.9

Mean drift in 30 days -132.6
Mean rotation period $9^h\ 52^m\ 40^s$

N. Tropical Current (N. edge NEB, NTrZ,), System (II)

1	Dc	Sep. 29-Nov. 14	38 - 16	19	4	-14.4
2	Wc	Sep. 29-Dec. 4	49 - 26	39	6	-10.5

Mean drift in 30 days -12.4
Mean rotation period $9^h\ 55^m\ 24^s$

N. Temperate Current (NTeZ), System (II):

1	Dp	Nov. 16-Mar. 14	266 - 301	264	7	8.9
2	Dp	Aug. 18-Dec. 17	239 - 291	275	13	12.9
3	Dc	Aug. 18-Dec. 17	251 - 309	290	12	14.4
4	Df	Jan. 13-Mar. 14	322 - 341	---	8	9.5
5	Df	Aug. 18-Jan. 13	265 - 336	305	15	14.4

Mean drift in 30 days 12.0
Mean rotation period $9^h\ 55^m\ 57^s$

A very dark, mottled streak (Nos. 2, 3, and 5) near latitude 35° N. was followed from August 18 to December 17. The streak appeared to lie on a fairly dark belt north of the delicate NTB. The belt was near the normal latitude of the NNTB; however, the rotation period of the streak suggests that the belt was the NTBn.

N.N.N. Temperate Current (NNNTB), System (II):

1	Dc	Aug. 26-Nov. 5	124 - 85	83	4	-16.5
2	Dp	Jan. 14-Mar. 10	97 - 73	---	4	-13.1
3	Dc	Oct. 19-Jan. 19	138 - 116	134	8	-7.2
4	Df	Dec. 9-Feb. 5	157 - 131	---	6	-13.4
5	Df	Sep. 28-Feb. 10	262 - 202	244	7	-13.3

Mean drift in 30 days -12.7
Mean rotation period $9^h\ 55^m\ 23^s$

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JUPITER'S OTHER FAMILY

by James C. Bartlett, Jr.

And lifts his mighty arm across the sky,
And strikes the sun as it goes roaring by,
The firey world with whiter heat now glows,
While a vast flood of flame behind it flows,
That curling, forms bright comets, meteors...

-The Epic of Izdubar

The foregoing was inscribed in cuneiform on a tablet of moist clay which afterward was baked to imperishable hardness, and subsequently entered as a volume in a Babylonian library some 3,950 years ago. It is currently to be seen in the British Museum; and the author, though unknown, is traditionally supposed to have been one Sin-like-unini, a scribe; a poet whose style somewhat reminds us of Pope and obviously a cosmologist of rare parts; but this is not and exercise in antiquarianism.

Sufficient to note that our unknown Babylonian seems to have anticipated the Tidal Theory of the Solar System by some millenia; for we note that following a "striking" of the sun by the hand of Deity, the solar globe gives off a trailing plume of solar matter which later condenses into comets, meteors, and also planets as the unquoted portion of the poem tells us. We are here, however, specifically interested in comets and remark, perhaps with some astonishment, that the ancient cosmologist-poet correctly placed them as indigenous members of the Solar System.

What is a comet? Whence do comets derive? What interest do they have for planetarians?

The first and second questions may be answered very simply and completely - No one knows. The third question may be answered in two ways. The intimate relation of short-period cometary orbits to the orbits of the giant planets bring them legitimately within the province of planetary astronomy; while we are further attracted by theories which would have the giant planets to be the parents of their respective cometary families, a view very strongly promoted by R. A. Proctor.[1]

In this paper we shall consider only the cometary family of Jupiter, which in addition to his extensive menage of satellites also supports no less than fifty comets. Unfortunately we cannot observe these ghostlier members of the Jovian family with the same ease with which we may examine the Galilean satellites; and their relation to Jupiter is apparent only after a study of their orbits in relation to the orbit of the planet. Moreover, until they have come quite close to the sun they are not even visible; whence it follows that the Jovian comets make a poor spectacle when compared to the Jovian moons. The relation of the cometary orbits of the Jovian family to the planet is not a simple one, in the sense that the satellite orbit relations are simple ones. The Jovian comets do not simply revolve around Jupiter, but rather around the sun in elongated ellipses which have their aphelion points near to the planet's orbit. In some cases the aphelion point lies exterior to the orbit of Jupiter, the comet moving through an ellipse which has the san at one focus and the planet at the other, broadly speaking; but in other cases, notably Encke's comet, the aphelion point lies near to but well within the orbit of Jupiter so that the comet's orbit never actually crosses the orbit of the planet. Nevertheless such comets are classified as members of the Jovian family because it is believed that the giant planet has altered their orbits into the paths now observed by "capture" in some period of the past. Finally it may be noticed that the orbits of the Jovian comets make many and various angles with the orbit of the planet, and if plotted on paper the design resembles a number of elliptical hoops, all having the sun at one focus, but otherwise scattered at random. The cometary family of Jupiter is therefore quite differently oriented, with respect to the planet, than the family of satellites.

The total number of comets present within the confines of the Solar System is thought to be enormous, since it seems very probable that great numbers of them go undetected. For this reason the rather insignificant total of fifty comets in Jupiter's system would indicate that they have all simply been captured from prior orbits of much greater extent as they chanced to pass near the great planet; which, it is thought, altered the orbits into much smaller ellipses and thus reduced the comets' periods proportionately. But whence did they come in the first place?

Apparently it is a very old idea that comets are interstellar wanderers, for in the mythology of the ancient Chinese we find these "broom stars" (as they called them) regarded as celestial ambassadors between the Courts of Heaven and the domain of the sun. Curiously, Western speculation, on the whole, reduced them to mere atmospheric phenomena; and though it is evident that both Seneca and Plato knew better, the idea that comets were only a kind of terrestrial vapors persisted until Tycho Brahe demonstrated that the comet of 1577 showed no sensible parallax when viewed from Prague and from the Baltic island of Hveen, and thus that it was more remote than the moon and so truly celestial.[2] In subsequent thought the idea gained ground that most, if not all, comets came into the solar system from interstellar space; an idea which seemed to be supported by the observed fact that the orbits of most comets appear to be parabolas and some even hyperbolas.

Yet if comets are of interstellar origin then, as Crommelin showed, they should approach the Solar System with greater frequency from that hemisphere containing the apex of the sun's way than from the opposite; because in the former case we should be moving toward them as they moved toward us, while in the latter case we should be moving away from them and they would have to overtake us if moving in our direction. Statistical analysis shows that between 1862 and 1927 only 61 comets came from the direction of the apex of the sun's way and no less than 96 from the direction of the anti-apex.[3] Moreover, as Watson remarks, if comets come from interstellar space then we should meet at least a few of them "head-on" and observe highly hyperbolic orbits.[4] Such is not the case and it is questionable if a truly hyperbolic orbit has ever been observed.

Such considerations have led to a revision of ideas, and now the thought is developing that most - perhaps all - comets originate within the Solar System. There are difficulties in this conception; for the cometary orbits lie in various planes, oriented apparently at random with respect to the ecliptic, and some move in retrograde orbits. Moreover all of the greater comets retreat to enormous distances from the sun, and the periods of some have been calculated to be on the order of 1000 years and more; which would carry them far into interstellar space even if they did not originate there. However, the fact that new comets of relatively short periods are constantly being discovered has suggested to some investigators that they are even now being formed somewhere and somehow within the Solar System; though it should be recognized that the same effect would be observed if numbers of new comets coming into the system from outside should have their orbits altered by the perturbations of the giant planets into short-period ellipses. A mere study of cometary orbits, therefore, would seem incapable of settling the question of their origin.

Returning now to the Jupiter family, we may consider the hypothesis of R.A. Proctor. Proctor totally rejected the capture theory and pointing to the close association of so many comets with the giant planets, maintained that such was cause and effect; that the comets of these planets had been born of them in titanic volcanic upheavals. Let us see how this idea fares on analysis.

Although no one knows what a comet is in the cosmological sense, its anatomy has been fairly well established. A comet consists of a star-like nucleus, a nebulous head, and, for a short fraction of its period, a tail. Percival Lowell defined a comet as "A bag-full of nothing." Actually, the quantity of solid matter in the head may run into the millions of millions of tons; but it is dispersed through so huge a volume that the average density is everywhere, save perhaps in the nucleus, extremely low. This state of affairs was graphically illustrated when Halley's Comet transited the sun in 1910. Notwithstanding that Halley's is one of the Great Comets, it is yet so tenuous that not a trace of it could be seen against the photosphere![5] The solid particles within the head, or coma, must be hardly larger than stream gravel; and this is a reasonably true picture of all comets.

The enormous volume of the coma, we may notice, means that comets are bodies of planetary dimensions. The brighter ones are estimated, on the average, to be from 40,000 to 50,000 miles in diameter with reference to the head or coma. According to Young, the diameter of Donati's Comet (1858) was about a quarter of a million miles.[6] These figures, of course, do not include the tail; the length of which may run from 5,000,000 to 10,000,000 miles and has been observed even to exceed 100,000,000 miles. According to Young, comets with a diameter of less than 10,000 miles would be likely to go undetected. Hence all that we see are bodies of planetary size, and mostly of rather large planetary size.

It is difficult therefore to see how bodies of such dimensions could be ejected from Jupiter, or from any of the other giant planets. For instance, a comet whose coma measured 50,000 miles in diameter would be about 58% the diameter of Jupiter itself. Assuming both Jupiter and the comet to be spheres as a matter of convenience, then by the well known formula

$$V = \frac{4\pi r^3}{3}$$

we may obtain their volumes. Dropping zeros, and taking π to be 3.1416, then we find that the volume of the comet is to the volume of Jupiter as 65 is to 331. In other words, such a comet would have not only 58% of the diameter but nearly 20% of the volume of the planet. Such figures make it rather plain that even an average comet could not possibly be ejected from Jupiter as a comet. Of course, this objection applies with even greater force to the three smaller giants, Saturn, Uranus, and Neptune.

It might be thought that perhaps the cometic material, which would be a very insignificant percentage of Jupiter's mass, is first ejected as a stream of particles which later on, when in free space, gathers itself together into the loose swarm which is the head of the comet. Thus diameter and volume could be accomodated to a Jovian origin. If this were so, however, the material would have to be ejected with such incredible force that it would be carried beyond Roche's Limit. Otherwise it could never so gather itself, but instead would be distributed in multiple elliptical orbits around the planet and so make a ring around Jupiter instead. For Jupiter, Roche's Limit in round numbers would be 104,920 miles; assuming that the material was fluid and of the same density as the planet - both very doubtful assumptions. Under such assumptions Roche's Limit would be defined as equalling 2.44 radii of Jupiter. Moreover, since the individual masses within the head of a comet are so small, it is equally incredible that the weak gravitational forces acting between them could ever assemble them into a swarm however dispersed. The disruptive influences of the Jovian satellites would seem to be quite sufficient to prevent any such aggregation from taking place. And if we are bold enough to imagine a force of ejection so great that the material would be expelled entirely out of the satellite system, then the perturbations of the planets would have to be considered.

There is yet a more potent objection to this theory. The velocity of escape from Jupiter is no less than 37 miles per second; which is strictly comparable to observed velocities of 40 miles per second with which many meteors enter the earth's atmosphere. At such velocities, all save the very largest meteors are completely burned up. In order for Jupiter to eject solid matter so far from the planet that the ejected matter would describe an orbit around the sun, rather than around the planet, it would be necessary for the matter to attain an initial velocity of many times 37 miles per second. In such a case, how could the matter escape incineration within the Jovian atmosphere before ever getting out of it? Of course if the matter were gaseous, or even liquid, when ejected this objection would be removed. To determine whether it could have been so, we should have to make a physical examination of actual cometic matter - an enterprise attended with some small difficulty. Yet perhaps not entirely hopeless, for many authorities hold that meteorites were originally cometic particles; whence it follows that the solids within the coma of a comet are essentially common meteors, distinguished from ordinary streaming meteors only by their order of aggregation.

It has been repeatedly observed that a stream of meteors may occupy the same orbit as a given comet. Moreover, on the disintegration of a comet (Biela's is the classic example) the position of the former comet is found to be occupied by a swarm of meteors. Hence there is very sound reason for supposing that meteorites represent cometic debris.

Now a meteorite is simply a meteor which has fallen to earth. Therefore it may well be that we have been analyzing actual cometic matter for many years. If so, then it is clear that such matter does not represent any sudden condensation from the gaseous or liquid phase; which would be the case if meteoritic-cometic matter were shot out of Jupiter in such a phase. Meteorites are of three major types; the stones, the stony-irons, and the irons, grading into one another so insensibly that one can scarcely doubt a common origin for all three. The stones show a very complex - and so far unexplained - structure which includes fragmented crystals, apparent inclusions, recemented fractures, mineral veins, and even faults; all of which conclusively proves a slow rate of cooling over a very long period of time as part of the crustal materials of some unknown body of planetary size. The irons - mainly a composition of nickel-iron-appear to represent core material rather than crustal, while the stony-irons are intermediate forms. All three give overwhelming evidence of having arrived in the solid phase through a gradual cooling under pressure. In short meteoritic-cometic matter appears to be magnetic in origin; and hence must represent the debris of some cosmic disaster. This is further indicated by the great quantities of occluded gases found in the stones; which gases appear to form the coma, or head, of the comet.

We seem driven to the conclusion that despite the intimate association of Jupiter with his fifty comets, the evidence is all against his being their sire. Consequently the relationship must indicate captures from space, though not necessarily from interstellar space. This is the modern view; and yet it cannot be denied that there are almost as many difficulties in this theory as in the theory of a Jovian origin. To cite but a few, we notice that all of the Jovian comets have direct motions as pointed out by Payne, another ejection-theory enthusiast.[7] If captured at random from space, we might expect some at least to move in retrograde orbits. Another not easily explained circumstance is the fact that the aphelion points of the majority of the Jovian comets lie within the orbit of Jupiter, i.e. between Jupiter and the sun. Again, the vast majority of their aphelia lie on one side of the Jovian orbit. As Payne put it: "If Jupiter obtained his family by capture, why should he be more successful on one side of the orbit than on the other?" The circumstance of so many of the aphelion points being on the sunward side of the orbit might perhaps be explained by supposing these comets to have been ejected from the sun rather than from Jupiter. Proctor was also strongly of the opinion that many comets had a solar origin (and also a stellar origin); but the physical nature of meteorites is all against such an origin.

Therefore factors telling against both the capture and ejection theories would appear to be almost equally weighty; and perhaps we would do better to frankly confess that the type meaning of the relation of Jupiter to his cometary family is unknown, though rather certain that it is not that of parent to child. However the Giant Planet acquired his puzzling family, the idea that comets are even now being formed within the solar system is contradicted by the physical evidence from meteorites; while the thought that they are truly interstellar is contradicted by the absence of hyperbolic orbits. On the other hand, the observed elliptical and parabolic orbits may be only planet-induced modifications of original hyperbolas. The evidence is abundant, but it all adds up to nothing.

We know a very great deal about the Solar System and its denizens; but if you would like to gain some idea of what we don't know, just ask the nearest authority to explain a comet!

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