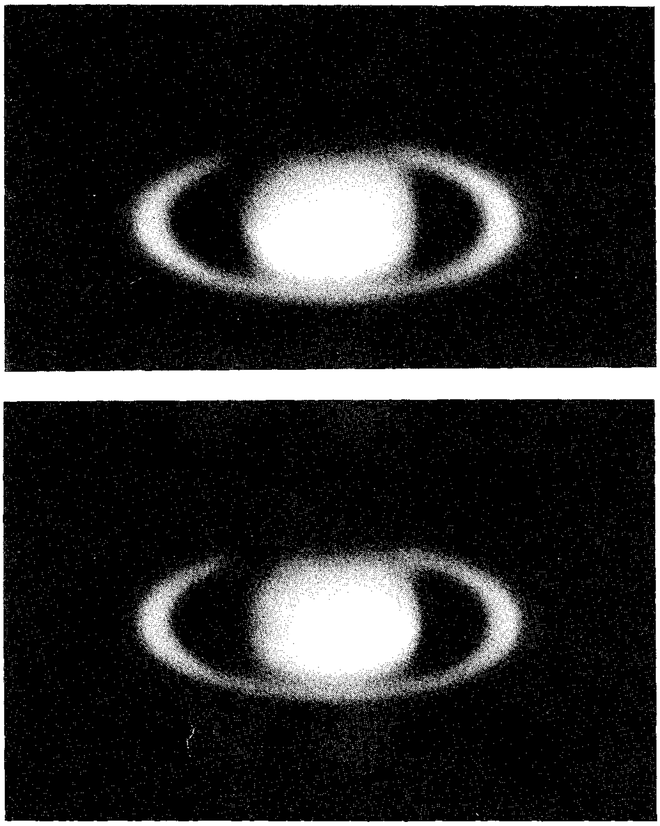
ISSN 0039-2502

The Journal Of The Association Of Lunar And Planetary Observers

The Strolling Astronomer

Volume 36, Number 2 **Published July, 1992**



Two photographs of Saturn taken by Isao Miyazaki of Okinawa, Japan, with a 40-cm (16-in) Newtonian reflector at an equivalent focal ratio of f/100; 20 sec. on Kodak TP2415 Film, developed in Rodinal 1:50 for 12 min. at 20°C. South at top, celestial east to the right. Upper view: 1990 Oct 08, 11h 01m UT, System I Central Meridian 063°; the following portion of the Great White Spot (GWS) is near the preceding (left) limb. Lower view: 1990 Oct 10, 11h 23m UT, CM(I) 324°; the GWS is near the Central Meridian. See the Saturn Apparition Report on pages 49-62 of this issue.

THE ASSOCIATION OF LUNAR
AND PLANETARY OBSERVERS
c/o Dr. John E. Westfall, Director/Editor
Membership Secretary, Harry D. Jamieson
P.O. Box 143
Heber Springs, AR 72543 U.S.A.

ASSOCIATION OF LUNAR & PLANETARY OBSERVERS
ALPO
Founded in 1947

IN THIS ISSUE

THE 1990-91 APPARITION OF SATURN: VISUAL AND PHOTOGRAPHIC OBSERVATIONS

By: Julius L. Benton, Jr., A.L.P.O. Saturn Recorder

ABSTRACT

Visual and photographic studies of the planet Saturn and its Ring System were done by 35 A.L.P.O. Saturn Section observers between 1990 MAR 02 and DEC 11 with instruments from 7.5 to 50.8 cm in aperture. The number of observers increased dramatically since 1988-89, probably due to a substantial increase in atmospheric activity on Saturn. The highlight of the 1990 observing season was the appearance of the Great White Spot (GWS) in the Equatorial Zone (EZ) of Saturn during late September, which feature lasted to the end of the apparition. Several persons made central-meridian (CM) transit timings of atmospheric detail on Saturn, particularly of the GWS, allowing useful rotation rates to be derived. The inclination of the Rings to our line of sight, **B**, reached a maximum of +24°.25 during 1990-91, exposing the Northern Hemisphere of the Globe and the north face of the Rings to our view. This report is accompanied by references, drawings, photographs, graphs, and tables.

INTRODUCTION

An extremely satisfying collection of visual and photographic observations of the planet Saturn and its Rings was contributed throughout the 1990-91 Apparition. These observations were made between 1990 MAR 02 and DEC 11, and constitute the basis of this report. There were substantially more observers and observations than in the immediately preceding apparition. Selected drawings and photographs accompany this report in order to enhance the reader's understanding of the material. [Note that all dates and times in this report are in Universal Time, or "UT."]

Table 1, below, gives pertinent geocentric data for the 1990-91 Apparition of Saturn. Note that the saturnicentric latitude of the Earth, **B**, referred to the ring plane and positive when north, ranged from +22°.23 on 1990 MAY 02 to +24°.25 on 1990 SEP 25, while the saturnicentric latitude of the Sun, **B'**, decreased from +24°.18 on 1990 MAR 02 to +22°.15 on 1990 DEC 11. [8]

Table 1. Geocentric Phenomena for Saturn in the 1990-91 Apparition. [8]

Conjunction	1990 JAN 06, 21^h
Opposition	1990 JUL 14, 18
Conjunction	1991 JAN 18, 08

Opposition Data:

Visual Magnitude	+0.1
B	+23°.27
B'	+23°.28
Declination of Saturn	-21°.57
Globe Diameter: Equatorial	18".40
Polar	16".73
Rings: Major Axis	41".94
Minor Axis	16".57

Table 2 (below and on p. 50) lists the 35 persons who submitted a total of 271 observations to the A.L.P.O. Saturn Section for the 1990-91 Apparition, together with their observing sites, number of dates of observations, and descriptions of their telescopes.

Table 2. Contributing Observers, 1990-91 Apparition of Saturn.

Observer & Location	No. of Dates	Telescope Data*
Donald Abbes	2	31.5-cm (12.4-in) N
Victoria, Australia		
Barry Adcock	4	31.5-cm (12.4-in) N
Victoria, Australia		
Julius L. Benton, Jr.	20	15.2-cm (6.0-in) R
Wilmington Island, GA		
Paul H. Bock, Jr.	4	12.7-cm (5.0-in) R
Hamilton, VA		
Daniel Boyar	4	25.4-cm(10.0-in) N
Boynton Beach, FL		
Phillip W. Budine	5	10.2-cm (4.0-in) R
Walton, NY		
Lawrence M. Carlino	2	15.2-cm (6.0-in) R
Lockport, NY		
Jean Dragesco	6	35.6-cm (14.0-in) S
St. Clement-la-Riviere, France		
Jack Eastman	1	50.8-cm (20.0-in) R
Sheridan, CO	10	32.0-cm (12.6-in) N
Marc A. Gelinas	10	15.2-cm (6.0-in) R
N.D. Ile Perrot, Quebec		
Massimo Giuntoli	4	10.2-cm (4.0-in) R
Montecatini, Terme, Italy		
David L. Graham	5	40.0-cm (15.8-in) N
Brompton-on-Swale,	8	15.0-cm (5.9-in) R
N. Yorkshire, UK		
Francis G. Graham	1	17.8-cm (7.0-in) R
East Pittsburgh, PA	1	24.1-cm (9.5-in) R
Charles S. Green	1	25.4-cm (10.0-in) N
Blakeslee, PA		
Walter H. Haas	6	20.3-cm (8.0-in) N
Las Cruces, NM	36	31.8-cm (12.5-in) N
Charles B. Haun	17	33.0-cm (13.0-in) N
Morristown, TN	7	44.5-cm (17.5-in) N

— *Table 2 continued on p. 50* —

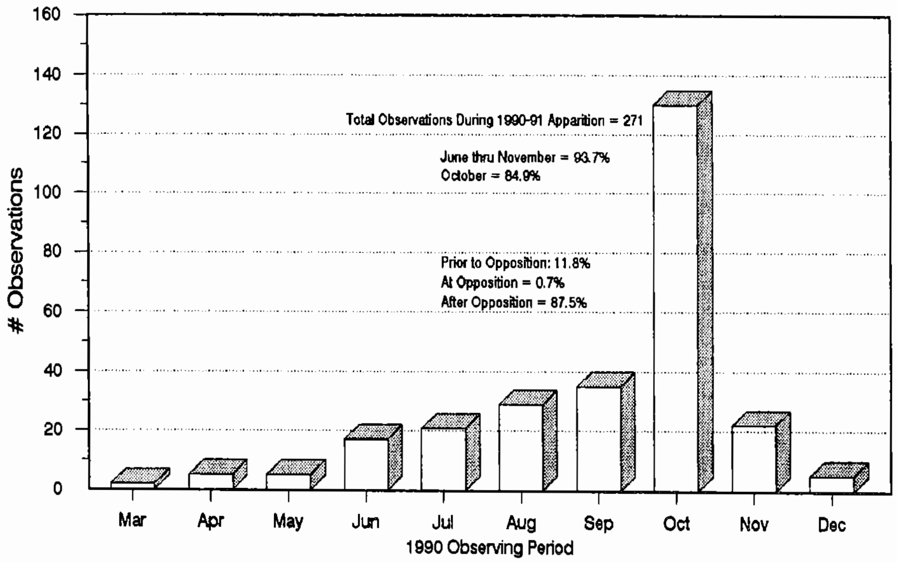


Figure 1. Distribution of observations of Saturn by month during the 1990-91 Apparition .

Table 2—Continued.

Observer & Location	No. of Dates	Telescope Data*
Alan W. Heath	16	30.5-cm (12.0-in) N
Nottingham, UK		
Richard Hill	3	35.6-cm (14.0-in) S
Tucson, AZ		
Gus Johnson	1	8.0-cm (3.2-in) R
Swanton, MD	1	12.8-cm (5.1-in) N
	1	15.2-cm (6.0-in) R
	1	20.3-cm (8.0-in) N
Craig MacDougal	3	15.2-cm (6.0-in) N
Tampa, FL		
Frank J. Melillo	4	20.3-cm (8.0-in) S
North Valley Stream, NY		
Isao Miyazaki	14	40.0-cm (15.8-in) N
Okinawa, Japan		
Gary T. Nowak	2	7.5-cm (3.0-in) R
Essex Junction, VT	1	20.3-cm (8.0-in) S
J. Park	1	31.8-cm (12.5-in) N
Victoria, Australia		
Donald C. Parker	1	40.6-cm (16.0-in) N
Coral Gables, FL		
Stuart Porter	2	10.2-cm (4.0-in) R
Rangaria, New Zealand		
Robert Robotham	1	8.3-cm (3.3-in) R
Scarborough, Ontario	2	15.2-cm (6.0-in) N
G. Samolyk	4	32.0-cm (12.6-in) N
Grenfield, WI		
Richard W. Schmude, Jr.	4	25.4-cm (10.0-in) N
Los Alamos, NM		
Kenneth Schneller	3	20.3-cm (8.0-in) N
Euclid, OH		
Michael E. Sweetman	24	15.2-cm (6.0-in) R
Tucson, AZ		
Bob Talaga	11	44.5-cm (17.5-in) N
Tucson, AZ		
Daniel M. Troiani	4	25.4-cm (10.0-in) N
Schaumburg, IL		
Jean-Francois Viens	3	11.4-cm (4.5-in) N
Charlesbourg, Quebec	3	25.4-cm (10.0-in) N
John E. Westfall	7	25.4-cm (10.0-in) C
San Francisco, CA		
Total Observations	*271*	
Total Observers	*35*	

*** Notes: C = Cassegrain; N = Newtonian; R = Refractor; S = Schmidt-Cassegrain.**

Figure 1 (above) gives the distribution of observations by month in 1990, showing that 93.7 percent of the observations were for the months of June through November, 1990. Also, only 11.8 percent of the observations were made before opposition, 0.7 percent on the date of opposition (1990 JUL 14), and 87.5 percent after that date. [This extremely lopsided coverage is doubtless due to the observer interest sparked by the eruption of the Great White Spot in late September. Ed.] It is usual that the maximum observational coverage of Saturn falls near, or slightly after, opposition. This of course creates observational bias; and we encourage all observers to try to maintain a consistent surveillance of Saturn, starting as early in each apparition as possible, and continuing until Saturn nears the time of conjunction with the Sun.

Figure 2 (p. 51) shows our observers by nation of observation; usually also of residence. Slightly over one-third of our observers were located outside the United States, in Europe, Canada, and elsewhere, demonstrating the continuing international scope of our work.

Finally, *Figure 3* (p. 51) graphs the 1990-91 observations by type of instrument. Telescopes of classical design predominate as in other recent apparitions, due chiefly to their overall proven performance, soundness of design, and consistent favorable image contrast

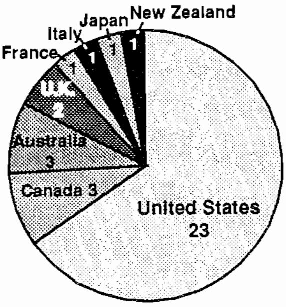


Figure 2. Distribution of Saturn observers by nation of observing site for the 1990-91 Apparition.

and resolution; all desirable for planetary work. Also, 91.5 percent of the observations were made with instruments of 15 cm (6 in) aperture or greater.

During the 1990-91 Apparition, seeing conditions averaged about 5.0 on the A.L.P.O. Seeing Scale, which ranges from 0.0 for the worst possible seeing to 10.0 for perfect conditions. Atmospheric transparency, expressed as the magnitude of the faintest star visible to the unaided dark-adapted eye near the object being observed, averaged about +4.0 during the same period.

The writer expresses his warmest gratitude to all the dedicated colleagues mentioned in *Table 2* who carried out their observations as part of the A.L.P.O. Saturn Section. We continue to encourage and coordinate intensified and more comprehensive international coverage of Saturn. Interested observers, regardless of experience, are invited to join with us

THE GLOBE OF SATURN

The descriptions that follow have been derived from an analysis of the reports contributed to the A.L.P.O. Saturn Section throughout the 1990-91 Apparition. For the purpose of brevity, except when the identity of an individual is pertinent to the discussion, the names of observers are not given in the text. Numerical tables, graphs, drawings, and photographs accompany the text; and readers should refer to them while reading this report. Features on the Globe are discussed in north-to-south order and can be identified by the nomenclature diagram in *Figure 4* (p. 52). Southern-Hemisphere features are not described because most of that portion of the Globe was hidden from view by the Ring System and was tilted away from the Earth in 1990-91. Central-meridian (CM) transit timings of atmospheric detail on Saturn, particularly of the Great White Spot (GWS), are discussed in the appropriate sections below.

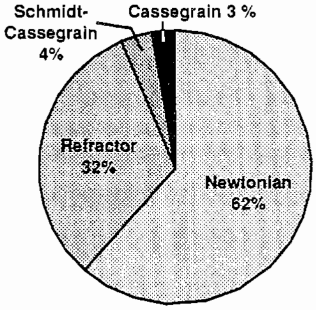


Figure 3. Distribution of observations of Saturn by type of instrument for the 1990-91 Apparition.

Northern Portions of the Globe.—The 1990-91 Apparition began without any extraordinary changes noted in the appearance of the belts and zones in Saturn's Northern Hemisphere. After all, atmospheric features on the Globe are characteristically ill-defined and transient, and it takes a great deal of perseverance and meticulous visual monitoring to recognize any subtle variations.

By late September, 1990, this all changed. Saturn rewarded the faithful who had been following the planet in recent apparitions with the appearance of a truly spectacular white spot in the northern portion of the Equatorial Zone (EZ), the first time such a brilliant feature had emerged since 1933. This spot was so bright that it was easily visible in telescopes as small as 5.0 cm (2.0 in) in aperture! Walter Haas, our Director Emeritus, and a veteran Saturn observer, said, ".. the bright EZ oval now present is the brightest and most conspicuous feature I have ever seen." He has been following the planet visually from 1935 to the present apparition, and his impression that this was the most spectacular outburst recorded in the EZ since the 1930's was confirmed after examining A.L.P.O. Saturn Section files dating back to 1947 and other records, such as those of the B.A.A. (British Astronomical Association) going much further back. Other observers agreed with Haas that something truly remarkable had occurred in the Northern Hemisphere of Saturn.

This eruption of activity in the Northern Hemisphere was not totally unexpected. [7] Visual-observation records of the A.L.P.O. Saturn Section contain recognizable seasonal and other long-term patterns of belt and zone intensities; and the emergence of what is now called the "Great White Oval of 1990" fits into a sequence of previous EZ-spot activity occurring at intervals of nearly 30 years [i.e., near the period it takes Saturn to orbit the Sun]. The historical data suggest a model of such features spreading, differentiating into components, and fading over a period of several weeks following their initial detection. The results obtained in 1990 are consistent with this model.

In addition to the GWS, other bright spots were reported in the EZ. These spots were persistent, but were considerably smaller and not quite so conspicuous as the GWS. Otherwise, the Northern Hemisphere of Saturn showed fairly limited activity during 1990. Other discrete features in the belts and zones did not

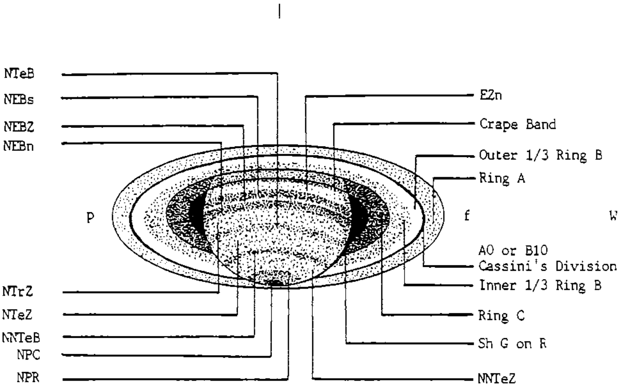


Figure 4. The general appearance of Saturn slightly after opposition (1990 JUL 14), with nomenclature of the major Globe and Ring features that were easily detected with moderate apertures in good seeing. South is at the top; and global features move across the planet from right to left in this normal inverted view (i.e., as seen in an astronomical telescope near culmination in the Earth's Northern Hemisphere without a prismatic diagonal or other device that would reverse the image). East (E) and West (W) are shown in the International Astronomical Union (IAU) convention; in the celestial convention, East would be to the right. The numerical value of **B** is +24°. The text discusses the Globe and Ring features shown here. Some minor features that are not depicted include the: North Polar Belt (NPB), encircling the NPR; North North North Temperate Belt (NNNTeB), immediately north of the NNTeZ; Shadow of the Rings on the Globe (Sh R on G); Terby White Spot (TWS), adjacent to the shadow of the Globe on the Rings (Sh G on R); Encke's Division (A5), when detected about midway between Cassini's Division (A0 or B10) and the outer edge of Ring A; and any intensity minima in several Ring components, as mentioned in the text. The easternmost and westernmost extensions of the Rings are called the *ansae*. "p" stands for preceding and "f" for following. [1, 2]

last long enough for satisfactory transit timings.

As in prior Saturn observing reports, the following summary of Northern-Hemisphere atmospheric features compares data between apparitions, in order to help the reader to appreciate the subtle but recognizable variations that may be underway, both seasonally and longer-term.

Table 3 (p. 53) gives the brightness intensities of Saturn's features, using the A.L.P.O. Standard Numerical Relative Intensity Scale, where 0.0 is total black and 10.0 is the brightest possible condition. This scale is normalized by setting the outer third of Ring B at a standard brightness of 8.0. The numerical sign of an intensity change is found by subtracting a feature's 1988-89 intensity from its 1990-91 intensity. It is often maintained that the varying tilt of Saturn's rotational axis with respect to the Sun and Earth plays a rather significant role in any recorded changes in belt and zone intensities. Note, however, that a change of only ±0.1 mean intensity points is considered to be of no significance; indeed, a change is not likely to be significant unless it is greater than about 3 times the intensity's standard deviation.

The latitudes of features in the Northern Hemisphere of Saturn's Globe are given in *Table 4* (p. 55). These were estimated by observers using the visual method developed by Haas many years ago. In this, one estimates the fraction of the polar semidiameter of the planet's disk that is subtended on the central meridian (CM) between the northern or southern limb and the feature whose latitude is sought. This method is easy to use, and its results compare well with similar values obtained using filar micrometers. It must be remembered, however, that is is often risky to place too much confidence on results derived from only a few observers. Yet, Haas particularly has been using this technique for a number of years with consistent results. His method is slowly catching on among other observers, who are encouraged to employ this simple procedure whenever possible, even if a filar micrometer is also available. Comparative data from both visual estimates and micrometer measurements would be particularly useful. A full discussion of this visual technique can be found in the *Saturn Handbook.* [2] In the discussions of individual features that follow, latitude data are noted when appropriate.

North Polar Region (NPR).—The brightness of the yellowish-grey NPR increased slightly (+0.6 mean intensity points) from 1988-89 to 1990-91. The intensity of the NPR was mostly uniform throughout. The dusky yellowish-grey NPC (North Polar Cap) was usually easy to see in the extreme north throughout most of 1990-91, and since the previous apparition had brightened somewhat (by a mean intensity value of +1.4). Missing in the 1988-89 reports, the NPB (North Polar Belt) was seen in 1990-91 and was described as a continuous greyish linear feature encircling the NPR.

North North Temperate Zone (NNTeZ).- This feature was not referred to in any observational reports submitted for 1990-91.

North North Temperate Belt (NNTeB).— This feature was not referred to in any observational reports submitted for 1990-91.

North Temperate Zone (NTeZ).—When seen in 1990-91, the yellowish-white NTeZ showed occasional intensity differences, but these were always poorly defined. Other than the EZ, the NTeZ was the brightest of Saturn's zones during 1990-91, and it showed an increase in overall brightness of +0.9 mean intensity points from 1988-89 to 1990-91.

Table 3. Visual Numerical Intensity Estimates and Colors: Saturn, 1990-91.

Globe/Ring Feature	Relative Intensity (1990-91) Number of Estimates	Mean and Standard Deviation	Change Since 1988-89	"Mean" Derived Hue (1990-91)
ZONES AND OTHER BRIGHT AREAS:				
NPC	19	5.1 ± 0.54	+1.4	Dusky Yellowish-Grey
NPR	25	4.7 ± 0.81	+0.6	Yellowish-Grey
NTeZ	5	6.1 ± 0.47	+0.9	Yellowish-White
NTrZ	24	5.6 ± 0.76	-0.4	Dull Yellowish-White
NEB Z	19	4.7 ± 0.63	-0.6	Yellowish-Grey
EZn	70	7.1 ± 0.50	+0.2	Pale Yellowish-White
GWS	29	8.5 ± 0.89	---	Brilliant White
Globe North of NEB (entire)	64	5.3 ± 0.55	0.0	Dusky Yellowish-Grey
BELTS:				
NPB	28	3.8 ± 0.19	---	Greyish
NTeB	21	3.9 ± 0.62	-0.1	Greyish
NEB (entire)	48	3.5 ± 0.47	+0.1	Greyish-Brown
NEBn	27	3.6 ± 0.16	+0.2	Greyish-Brown
NEBs	28	3.3 ± 0.17	0.0	Dark Greyish-Brown
EB	5	4.3 ± 0.39	+0.5	Yellowish-Grey
RINGS:				
Ring A (entire)	70	5.9 ± 0.91	0.0	Dull White
Ring A (outer half)	6	6.5 ± 1.20	-0.3	Dusky White
Encke's Division (A5; ansae)	4	3.9 ± 0.25	+0.1	Dark Grey
Ring A (inner half)	6	6.3 ± 0.60	-0.3	Dusky White
Cassini's Division (A0 /B10; ansae)	37	1.0 ± 0.49	+0.1	Greyish-Black
Ring B				
Ring B (outer third)	98	8.0 **[Standard]**		White.
Ring B (inner two-thirds)	48	7.3 ± 0.39	0.0	Yellowish-White
Intensity Minimum (B1; ansae)	4	2.8 ± 0.04	0.0	Dark Grey
Ring C (ansae)	55	0.9 ± 0.53	-0.1	Greyish-Black
Crape Band	46	2.8 ± 0.80	-0.4	Very Dark Grey
Sh G on R	46	0.5 ± 0.26	0.0	Dark Greyish-Black
TWS	30	7.6 ±0.13	-0.1	White

Notes: For nomenclature see text and *Figure 4* (p.52). A letter with a digit (e.g., A5) refers to a location on the Ring specified in terms of units of tenths of the distance from the inner edge to the outer edge. Visual numerical relative intensity estimates (visual surface photometry) are based upon the A.L.P.O. Intensity Scale, where 0.0 denotes complete black (shadow) and 10.0 refers to the most brilliant condition (very brightest Solar System objects). The adopted scale for Saturn uses a reference standard of 8.0 for the outer third of Ring B, which appears to remain stable in intensity for most Ring inclinations. All other features on the Globe or in the Rings are compared systematically using this scale, described in the *Saturn Handbook*, which is issued by the A.L.P.O. Saturn Section. [2] The "Change Since 1988-89" is in the sense of the 1988-89 value subtracted from the 1990-91 value, "+" denoting an increase in brightness and "-" indicating a decrease (darkening). When the apparent change is less than about 3 times the standard deviation, it is probably not statistically significant.

North Temperate Belt (NTeB).—This belt was frequently reported as narrow, usually uniform, greyish in hue, and extending across the Globe from limb to limb. The NTeB was essentially the same intensity during 1990-91 as it had been in 1988-89 (with an apparent decrease of only -0.1 mean intensity points).

North Tropical Zone (NTrZ).—The NTrZ showed a slight drop in brightness (by -0.4 mean intensity points) from 1988-89 to 1990-91. Observers assigned it a dull yellowish-white color in 1990-91, and it was usually constant in intensity from limb to limb throughout the observing season.

North Equatorial Belt (NEB).-The greyish-brown NEB was sometimes seen in 1990-91 as differentiated into the NEBn and NEBs, where **n** refers to the North Component and **s** to the South Component, separated by the NEB Z (North Equatorial Belt Zone). This aspect was fairly common in 1990-91; yet most often the NEB was recorded as a single feature during the apparition. As a whole, the NEB was essentially the same intensity in 1990-91 as it had been in 1988-89, and was actually the darkest belt on the Globe during both apparitions.

The greyish-brown NEBn showed only a slight increase in mean brightness from 1988-89 to 1990-91 (+0.2 mean intensity points). Observers saw some poorly defined features within the NEBn, but none lasted long enough for usable CM transit timings.

The greyish-brown NEBs was the darkest belt on the Globe of Saturn in 1990-91, as a component even darker than the NEB as a whole, which had been the case in 1987-88 and for several other recent apparitions. The NEBs showed the same overall intensity in 1990-91 as it had in 1988-89. Occasionally, the NEBs exhibited dark condensations and other dusky features in 1990-91. Although CM transit timings were made of some of these phenomena, none lasted a sufficient length of time for rotation rates to be derived.

The NEB Z was yellowish-grey throughout 1990-91, showing a mean intensity decrease of -0.6 since 1988-89. As in the last two apparitions, the NEB Z was one of the darkest zones on Saturn, but was visible because it contrasted significantly with the darker NEBn and NEBs which bounded it. The NEB Z showed no activity during the 1990-91 Apparition, and remained uniform in intensity throughout the observing season.

In conjunction with the emergence of the spectacular Great White Spot (GWS) in late September, 1990, the NEBn, the NEBs, and the NEB taken as a whole faded slightly in the region adjacent to the EZ and the GWS for the remainder of the apparition, brightening by about +0.3 mean intensity points. Also, vague dark condensations were seen occasionally in late October, hugging the south border of the NEBs adjacent to the location of the p (preceding) end of the GWS.

Figure 5 (below) shows the mean eccentric latitudes of the north and south edges of the NEB, plotted against time from 1990 APR 14 through DEC 07. [For an explanation of the different latitude systems, see the notes for *Table 4* on p. 55.] This figure shows that some very curious behavior of the NEB may have occurred. Note that the north edge of the NEB lay initially at about +22°-24° mean eccentric latitude in April, 1990; but by late October and November it had shifted north to about +34°-36°, remaining fairly steadily at this new northern location into December. The south edge of the NEB showed a similar northward movement; it lay near mean eccentric latitude +16°-18° in April, but had moved to about +26°-28° by late October and early November, likewise remaining there into December. *Figure 5* plots two other Northern-Hemisphere features, the center of the NTeB and the south edge of the NPB. There is some indication of a similar northward movement of the center of the NTeB, although data for late October through December, 1990, were not reported. However, the south edge of the NPB appeared to shift northward earlier in the apparition; from May to about August, after which its latitude remained somewhat constant.

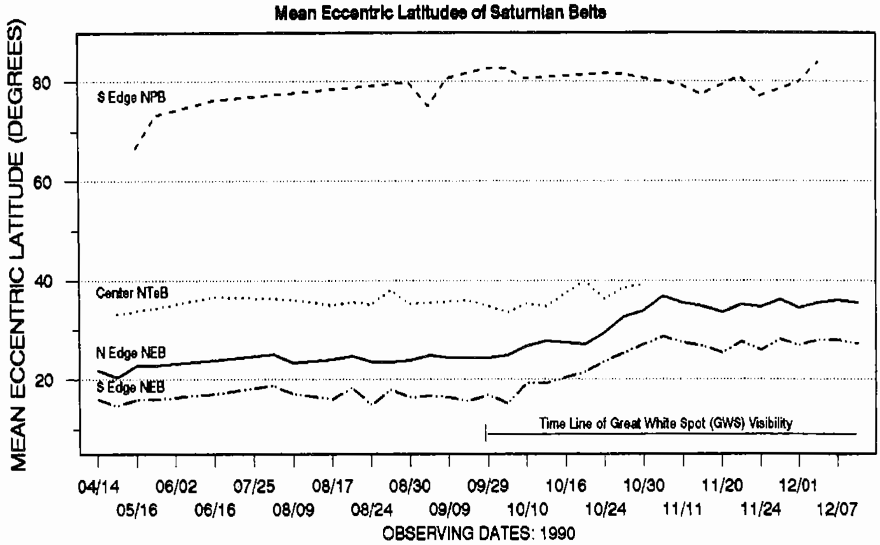


Figure 5. Mean eccentric latitudes of selected Saturnian belts during the 1990-91 Apparition.

Table 4. Latitudes of the Belts of Saturn in the 1990-91 Apparition.

	Type of Latitude					
	(Change from 1988-89 in parentheses)					
Saturnian Belt	Planetocentric		Eccentric		Planetographic	
	° °	°	° °	°	° °	°
Center EB	-4.1 ±2.6	(---)	-4.6 ±2.9	(---)	-5.2 ±3.3	(---)
South edge NEB	+19.0 ±4.7	(+3.0)	+21.1 ±5.1	(+3.3)	+23.3 ±5.5	(+3.5)
North edge NEB	+25.9 ±5.0	(+4.5)	+28.5 ±5.4	(+4.8)	+31.3 ±5.6	(+5.1)
Center NTeB	+33.1 ±1.8	(- 2.3)	+36.1 ±1.8	(- 2.4)	+39.1 ±1.9	(- 2.5)
South edge NPR	+72.4 ±2.2	(- 2.9)	+74.2 ±2.0	(- 2.6)	+75.8 ±1.8	(- 2.4)
North edge NPB	+77.6 ±4.6	(---)	+78.9 ±4.1	(---)	+80.0 ±3.7	(---)

Notes: For nomenclature see *Figure 4* (p. 52). Latitudes are calculated using the appropriate geocentric tilt, **B**, for each date of observation. Planetocentric latitude is the angle between the equator and the feature as seen from the center of the planet. Planetographic latitude is the angle between the surface normal and the equatorial plane. Eccentric, or "Mean," latitude is the arc-tangent of the geometric mean of the tangents of the other two latitudes. The change shown in parentheses is the result of subtracting the 1988-89 latitude value from the 1990-91 latitude value.

One is tempted to relate such northward shifts in latitude to pressure from the expanding GWS (see the discussion below). However, from April through September, 1990, observers tended to observe Saturn at random times, and thus estimated latitudes at all Saturnian longitudes. However, after the announcement of the appearance of the GWS, during October-December most latitude estimates were made for features near the longitude of the GWS because observers tended to watch Saturn only when the GWS was on the disk. Even with this bias, the northward shift in latitude appears real. Interestingly, many of the drawings and photographs accompanying this report show the GWS clearly intruding into the NEB during October through December!

Equatorial Zone (EZ).–The pale yellowish-white EZ showed only a minor brightness increase during the period of March-late September, 1990; by +0.2 mean intensity points when compared with the 1988-89 Apparition. (Our data concentrate on the EZn, which is referred to hereafter.) During those months of the 1990-91 observing season, the EZn was already the brightest zone on Saturn, closely matching the inner two-thirds of Ring B in overall intensity. Also from March through most of September, there was very little activity in the EZn other than short-lived wispy festoons projecting from the NEBs.

By late September, 1990, a large, exceedingly brilliant white spot appeared in the EZ. It later became known as the Great White Spot (GWS) of 1990, and radically changed the appearance of the EZn, and of the Globe of Saturn as a whole, in even the smallest telescopes. The media called attention to sightings of the GWS in the EZn on the evening of September 24, 1990 (1990 SEP 25 UT) by amateurs Stuart Wilber of Las Cruces, NM, and Alberto Montalvo of Burbank, CA. The first participating Saturn Section observers to report the GWS were Michael Sweetman of Tucson, AZ (September 25); Bob Talaga of Tucson (September 28); and Donald Parker of Coral Gables, FL (September 30)

Figure 6 (p. 56) shows the System I longitudes (CM I) of the preceding end (**p**), center (**c**), and following end (**f**) of the GWS, plotted against date of observation between 1990 SEP 25 to NOV 20, based on CM transit timings by A.L.P.O. Saturn Section observers. [*System I* applies to the equatorial regions of the Globe, with a rotational rate of 844°.3 per day. *Preceding* and *following* are used in the sense shown in *Figure 4*.]

Drift in longitude of the GWS in the EZn can be seen in *Figure 6*. Shortly after discovery, timings placed the center of the GWS at CM I longitude 335°. Then, from 1990 OCT 03 to about OCT 25, the center of the GWS lay at approximately CM I 336°, with its following end at CM I 357°. During that period, timings of the preceding end of the GWS exhibited considerable scatter as shown in *Figure 6*. Because the GWS was usually brighter and sharper in its following portions, as compared with its preceding parts, it is not surprising that it was often difficult to determine the exact terminus of its preceding end. Also, it was nearly impossible for observers to place the center of the GWS accurately midway between the preceding and following ends.

From late October through mid-November, 1990, the System I longitude of the GWS decreased, as can be seen in *Figure 6*.

In its early stages of development, from late September through mid-October, 1990, the mean intensity of the GWS was 8.5. However, as the spot spread out longitudinally in October and November, its brightness lessened slightly. The GWS also become significantly more diffuse during the same period. It was during this period of noticeable spreading and drifting in longitude that the interaction of the GWS and the NEB and the northward shift in latitude of the NEB were observed. By late November, observers reported that the GWS had spread out along the EZn so much that the bright feature nearly encircled the Globe of Saturn at that latitude. By then, Saturn was approaching its conjunction with the Sun so that CM transit timings and other attempts to follow the GWS became more difficult.

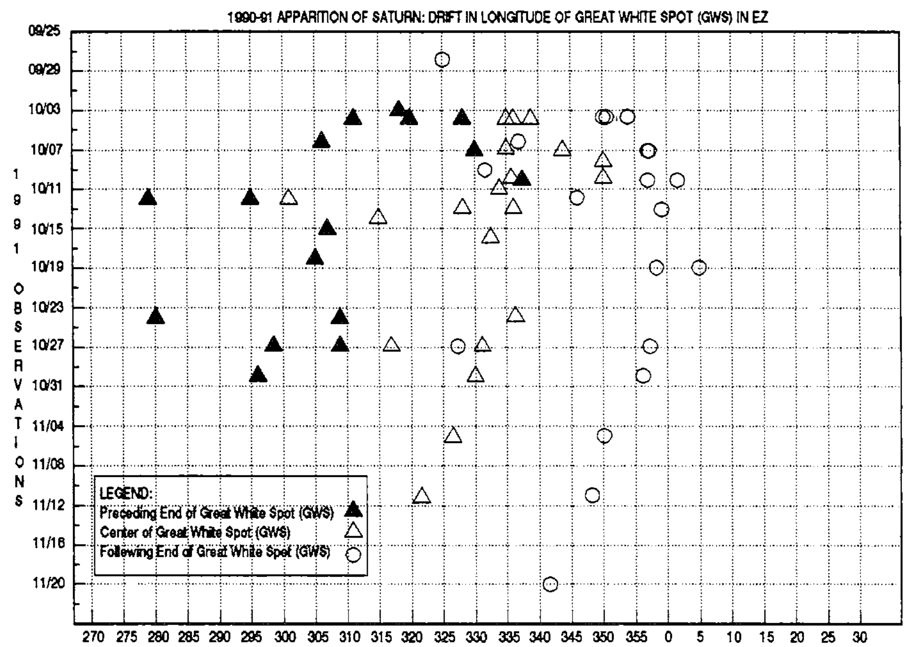


Figure 6. System I longitudes of center and ends of the Great White Spot (GWS), 1990 SEP 25-NOV 20.

Looking at historical records, the same pattern of acceleration of the GWS that was observed in 1990 was characteristic of Hay's White Spot of 1933, except that the shift toward decreasing longitude began sooner after discovery for the 1933 feature than with the GWS of 1990-91. [1]

Historically, brilliant white-spot activity has been noted on Saturn during 1876, 1903, 1933 (Hay's Spot), 1960 (Botham's or Dollfus' Spot), and 1990 (GWS). [Note that in 1903 and 1960 there were no brilliant white areas in the EZ. Ed.] These dates suggest a periodicity of 27 to 30 terrestrial years, and when they occurred Saturn's ecliptic longitude was 290° to 315°. Note also that Saturn's sidereal period of revolution about the Sun is 29.4 years. Thus, it can be seen why the 1990-91 outburst was predictable, and perhaps can be used to predict the occurrence of future spectacular white-spot activity on Saturn.

The CM transit timings of the GWS implied a rotation period of 10h 14m 22.35s (843°.79/day) for the center of the GWS in the EZn. The established rotation period for System I (CM I), usual for the latitude of the EZn, is 10h 14h 00.0s (844°.3/day) **[8]**, as adopted by the A.L.P.O. Saturn Section. [These values apparently refer to the early stages of the GWS; as *Figure 6* shows, its longitude decreased, indicating a *decreasing* rotational period, in October-November. Ed.]

Some observers sighted several smaller white spots in the EZn, at CM I longitudes 30° and 70° during late November. However, CM transit timings of them were too few in number to provide rotation periods. Along with the emergence of these "secondary" EZn features, observers suspected a noticeable darkening of other zones, such as the NTrZ.

The Equatorial Band (EB) was detected infrequently during the 1990-91 Apparition, including occasionally after the sighting of the GWS. When seen, the EB was yellowish-grey, very narrow, and discontinuous along its linear extent across the Globe. The EB was slightly brighter than it had appeared in 1988-89 (by +0.5 mean intensity points).

Shadow of the Rings on the Globe (Sh R on G).—This feature was not described by any of the observers who submitted data to the A.L.P.O. Saturn Section for 1990-91.

Shadow of the Globe on the Rings (SH G on R).—When reported, this feature was always seen as dark greyish-black in 1990-91, and as regular in form. However, any deviation from the true black condition (intensity 0.0) can be attributed to poor Seeing and the possible scattering of light in our atmosphere, the telescope, and even the observer's eye.

THE RINGS OF SATURN

This section covers the analysis of the observations of Saturn's Ring System that were submitted throughout the 1990-91 Apparition, together with a continuing comparative study of the mean intensity data as has been done for previous apparitions. As noted in the Introduction, the northern face of the Rings was very well presented to our view during the 1990-91 observing season

Ring A.—Taken as a whole, Ring A was dull white throughout the 1990-91 Apparition, maintaining the same mean intensity as in 1988-89. There were only a few sightings of Encke's Division (**A5**) made during the apparition, at the Ring ansae in favorable Seeing;

and there were no other intensity minima recorded in Ring A in 1990-91.

On rather infrequent occasions, Ring A was described as having distinct outer and inner halves in terms of intensity. In 1990-91, the outer half of Ring A was dusky white and was +0.2 mean intensity points lighter than the dusky white inner half. Compared with the 1988-89 Apparition, the outer and inner halves of Ring A were slightly darker in 1990-91 (both by a mean intensity factor or -0.3); and both areas remained stable in overall intensity throughout 1990-91.

Ring B.—The outer third of Ring B is the adopted standard of reference for the A.L.P.O. Saturn Intensity Scale, with an assigned value of 8.0. Throughout 1990-91, this portion of Ring B appeared white, stable in intensity, and easily the brightest feature on either Saturn's Globe or its Rings, with the definite exception of the dazzling GWS in the EZn..

The inner two-thirds of Ring B, chiefly yellowish-white in hue, was of the same mean intensity in 1990-91 as it had been in the immediately preceding apparition. It was also mostly uniform in intensity throughout 1990-91, although observers intermittently sighted intensity minima at **B1**, **B2**, and **B5** (i.e., at 0.1, 0.2, and 0.5 of the distance, respectively, from the inner to the outer edge of Ring B). B1 appeared to be the most conspicuous of the three minima, was dark greyish; and, like the other two minima, was visible only at the ansae. Such intensity minima are not permanent features, as was shown by the Voyage Missions.

On 1990 AUG 03, at 07h 12m UT, using a 15.2-cm. (6.0-in.) refractor at 290× and with good Seeing and no filter (integrated light), Michael Sweetman sighted what he described as "dusky fans" at both ansae extending halfway out in Ring B. He also noted that the features were not apparent when he used a red filter. Richard Hill gave a similar account on 1990 OCT 06, 03h 05m UT, using a 35.6-cm (14.0-in) Schmidt-Cassegrain at 154×, with good Seeing and no filter; and on 1990 OCT 10, 01h 09m UT, with the same telescope at 308×.

Cassini's Division (A0 or B10).—This feature was usually visible at the ansae in 1990-91, and it was often seen extending all the way around the Rings in good Seeing. It had a grayish-black appearance in 1990-91, equal in intensity to its 1988-89 appearance. As with the Sh G on R, the deviation from a true black appearance is due to scattered light. Observers with even the smallest apertures had little difficulty in finding this feature during the observing season.

Ring C.—In 1990-91, observers reported Ring C as fairly easy to see at the ansae, grayish-black in color, and largely unchanged in appearance when compared with 1988-89. Note that faint or narrow Ring features are usually easier to perceive, and thus misleadingly appear darker, when the Rings are open to the extent that they were in 1990-91.

The Crape Band, or Ring C as projected onto the Globe, was -0.4 mean intensity points darker in 1990-91 than in the immediately preceding apparition. In the more recent apparition, observers described this feature as uniform in intensity and very dark grey in color. During the past several apparitions, the Saturnicentric latitudes of the Sun and Earth have conspired to bring about the near-coincidence of the Crape Band with the Shadow of Ring C on the Globe.

Ring Components Other than A, B, or C.—Neither Ring D (inside Ring C) or Ring E (outside Ring A) was reported in 1990-91. Of course, these Ring components are exceedingly difficult to observe except under the best conditions and with large apertures.

Terby White Spot (TWS).—The TWS is an occasionally-reported brightening of the Rings adjacent to the Sh G on R. Several observers during 1990-91 recorded a bright, whitish TWS, not nearly so conspicuous in this and other recent years as in the early to mid-1980's. Nonetheless, it was the brightest object in Saturn's Rings or on the Globe this apparition, except for the outer third of Ring B and the dazzling GWS in the EZn. The TWS is probably a contrast phenomenon and is not usually considered to be an important, or intrinsic, Saturnian feature. [See, however, *Figure 2* {p. 4] of *J.A.L.P.O.*, Vol. 36, No. 1, where CCD images plainly show the TWS. Ed.] Even so, it would be interesting to investigate any correlation that may exist between the brilliance of the TWS and varying Ring tilt, as well as its prominence or appearance in colored filters.

Bicolored Aspect of the Rings.—This phrase refers to reported differences in color between the two ansae of the Rings. Several persons attempted to observe this phenomenon in 1990-91, and variations were seen in the brightness of the east and west ansae (IAU system) when compared with W47 (Wratten 47) or W80A blue filters and W25 or W23A red filters. *Table 5* (p. 58) lists the circumstances of these observations. The reader should note that the directions in *Table 5* refer to Saturnian or IAU directions, where west is to the right in a normally-inverted telescopic image which has south at the top; also see *Figure 4* (p. 52) for the proper orientation.

This Recorder cannot emphasize too strongly the critical need for observers to participate in a simultaneous observing program which stresses, among other projects when viewing Saturn, a meaningful study of the bicolored aspect of the Rings. Increased observer participation in this program during 1990-91 was noted, but this effort yielded no simultaneous sightings of the bicolored aspect of the Rings. The more persons taking part in this effort, making systematic visual and photographic filter estimates, the greater is the chance of shedding some new light on this intriguing and yet-to-be-understood phenomenon.

Table 5. Observations of the Bicolored Aspect of Saturn's Rings in 1990-91.

Notes: Telescope types are as in *Table 2* (pp. 49-50). Seeing is on the 0-10 A.L.P.O. scale (see p. 51). Transparency is the limiting visual magnitude in the vicinity of Saturn. Under "Filter," **B** refers to the blue W47 or W80A filters, **IL** to integrated light (no filter), and **R** to the red W25 or W23A filters. **E** means that the east ansa was brighter than the W, **W** that the west ansa was brighter, and = means that the two ansae were equally bright.

Observer	1990 UT Date and Time (entire observing period)		Telescope Type and Aperture	Magnification	Seeing	Transparency	Filter		
							B	IL	R
Haas	Apr 14	10:26-11:30	N 20.3 cm (8.0 in)	231X	4.0	4.0	E	=	=
Haas	May 09	10:30-11:30	N 31.8 cm (12.5 in)	303X	4.0	3.5	W	=	=
Haas	May 16	10:37-11:27	N 20.3 cm (8.0 in)	231X	3.0	4.0	E	=	=
Haas	May 21	10:16-11:07	N 31.8 cm (12.5 in)	303X	4.0	4.0	E	=	=
Haas	Jun 04	11:02-11:30	N 31.8 cm (12.5 in)	321X	3.0	4.0	E	=	=
Gelinas	Jun 12	07:30-08:00	R 15.2 cm (6.0 in)	261X	5.5	4.0	W	=	=
Haas	Jun 16	10:18-11:02	N 31.8 cm (12.5 in)	285X	4.0	4.0	E	=	=
Haas	Aug 05	03:25-04:45	N 20.3 cm (8.0 in)	231X	3.5	4.0	E	=	=
Gelinas	Aug 15	03:51-04:14	R 15.2 cm (6.0 in)	305X	7.0	4.0	=	=	E
Haas	Aug 17	03:11-04:09	N 31.8 cm (12.5 in)	366X	4.0	3.5	E	=	=
Haas	Aug 19	02:47-04:00	N 31.8 cm (12.5 in)	366X	4.5	3.5	E	=	=
Haas	Aug 24	03:12-03:41	N 20.3 cm (8.0 in)	231X	4.0	4.0	E	=	=
Haas	Aug 30	02:33-04:05	N 31.8 cm (12.5 in)	321X	3.0	4.0	E	=	=
Haas	Sep 01	03:12-03:51	N 20.3 cm (8.0 in)	203X	4.0	3.5	E	=	=
Haas	Sep 09	02:03-03:17	N 31.8 cm (12.5 in)	366X	3.5	3.5	E	=	=
Haas	Oct 03	03:00-05:13	N 31.8 cm (12.5 in)	321X	3.5	3.5	E	=	=
Haas	Oct 04	01:40-02:50	N 31.8 cm (12.5 in)	321X	3.5	4.0	E	=	=
Haas	Oct 06	04:31-04:36	N 20.3 cm (8.0 in)	203X	2.0	3.5	E	=	=
Haas	Oct 10	01:20-03:32	N 31.8 cm (12.5 in)	321X	3.5	3.5	E	=	=
Haas	Oct 13	01:20-03:18	N 31.8 cm (12.5 in)	321X	4.0	3.5	E	=	=
Haas	Oct 15	03:06-03:24	N 31.8 cm (12.5 in)	321X	3.0	2.5	E	=	=
Haas	Oct 18	02:20-03:00	N 31.8 cm (12.5 in)	321X	3.5	2.5	E	=	=
Haas	Oct 19	01:06-02:02	N 31.8 cm (12.5 in)	321X	3.5	3.0	E	=	=
Haas	Oct 24	02:15-02:59	N 31.8 cm (12.5 in)	321X	3.0	2.5	E	=	=
Haas	Oct 27	01:40-02:45	N 31.8 cm (12.5 in)	321X	3.5	3.5	E	=	=
Haas	Oct 30	00:27-02:36	N 31.8 cm (12.5 in)	321X	3.0	3.5	E	=	=
Haas	Nov 05	01:10-02:09	N 31.8 cm (12.5 in)	321X	3.0	3.5	E	=	=
Haas	Nov 11	00:40-01:35	N 31.8 cm (12.5 in)	321X	3.5	4.0	E	=	=
Haas	Nov 14	00:28-01:21	N 31.8 cm (12.5 in)	321X	3.5	3.5	E	=	=
Haas	Nov 16	00:20-00:58	N 31.8 cm (12.5 in)	321X	3.0	3.5	E	=	=
Haas	Nov 20	00:15-00:47	N 31.8 cm (12.5 in)	321X	3.0	3.5	E	=	=
Haas	Nov 23	00:04-01:02	N 31.8 cm (12.5 in)	321X	3.0	4.5	E	=	=
Haas	Nov 29	00:04-00:42	N 31.8 cm (12.5 in)	321X	2.5	4.5	E	=	=
Haas	Dec 01	00:10-00:21	N 31.8 cm (12.5 in)	321X	3.0	4.0	E	=	=
Haas	Dec 07	00:09-00:56	N 31.8 cm (12.5 in)	321X	2.0	3.5	E	=	=
Haas	Dec 08	00:10-00:45	N 31.8 cm (12.5 in)	321X	2.0	3.5	E	=	=

SATURN'S SATELLITES

Very few of our observers in 1990-91 submitted visual studies of Saturn's satellites. No truly systematic program of visual magnitude estimates was undertaken, nor any other investigations of the satellites. We encourage observers to pursue satellite studies as outlined in the *Saturn Handbook.* [2]

SIMULTANEOUS OBSERVATIONS

There was an increasing number of simultaneous observations in the 1990-91 Saturn Apparition; where persons independently observed at the same date and time. If more observers carried out all of the routine programs discussed in this report, there would be more chance for them, for example, to make drawings, intensity estimates, or central-meridian (CM) transit timings at the same time.

Simultaneous observations during 1990-91 confirmed well the appearance of Saturn, particularly the characteristics and behavior of the GWS in the EZn. These confirming observations strengthen the confidence level of our data; we invite our readers to contact us about how to maximize the number of simultaneous observations in the coming observing seasons.

CONCLUSIONS

A.L.P.O. Saturn Section observers will long remember the 1990-91 Apparition and the way that the appearance of Saturn changed when the Great White Spot (GWS) burst upon the scene in late September. Individuals anxiously awaited the start of the 1991-92 apparition, as they anticipated possible continued white-spot activity in the EZn. Without a doubt, therefore, a tremendously meaningful series of observations were contributed during 1990-91, and the writer expresses his sincere gratitude for the enthusiasm, cooperation, and dedication of all of the individuals who helped make this report possible. We encourage anyone who desires to contact the A.L.P.O. Saturn Section for information on how to participate in our team effort to further worthwhile scientific research and increase our knowledge about the planet Saturn.

REFERENCES

1. Alexander, A.F. O'D. *The Planet Saturn.* London: Faber and Faber, 1962.
2. Benton, J.L., Jr. *Visual Observations of the Planet Saturn: Theory and Methods (the Saturn Handbook).* Savannah, GA: Review Publishing Company, 1988 (5th revised edition).
3. ________. "Monitoring Atmospheric Features on Saturn in 1991." *J.A.L.P.O., 35,* No. 1 (March, 1991), pp. 24, 25, front cover.
4. ________. "The 1988-89 Apparition of Saturn: Visual and Photographic Observations." *J.A.L.P.O., 34,* No. 4 (November, 1990), pp.160-169.
5. ________. "Observing Saturn in 1991." *Sky & Telescope, 81,* No. 4 (April, 1991), pp. 404-406.
6. "The Great White Spot on Saturn." *J.A.L.P.O., 34,* No. 4 (November, 1990), p. 191.
7. Melillo, Frank J. "A White Oval Watch on Saturn." *J.A.L.P.O., 33,* Nos. 7-9 (July, 1989), p. 138.
8. United States Naval Observatory. *The Astronomical Almanac.* Washington: U.S. Government Printing Office. (Annual publication; the 1990 and 1991 editions were used for this report, published in 1989 and 1990, respectively.)

SELECTED DRAWINGS AND PHOTOGRAPHS, 1990-91 APPARITION OF SATURN

NOTE: For the drawings and photographs in *Figures 7-20,* unless otherwise stated, **Seeing** is given on the 0-10 A.L.P.O. Scale, and **Transparency** is the limiting naked-eye visual magnitude in the vicinity of Saturn. South is at the top in these views, and celestial east to the right. **CM(I)** is the central-meridian longitude in rotational System I; **CM(II)** is the same in System II. (System I applies to the NEBs, EZ, and SEBn, with a rate of 844°.0 per day; System II to the rest of the Globe, at 812°.0 per day.) **B** is the Saturnicentric latitude of the Earth, and **B'** that of the Sun. *See also front cover.*

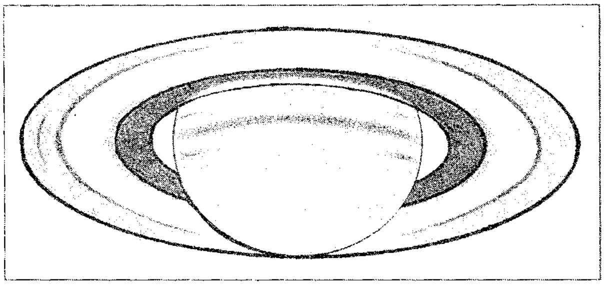


Figure 7. Drawing by Michael E. Sweetman. 1990 JUL 25, 07h04m-07h45m UT. 15-cm (6-in) refractor, 290X. No filter. Seeing 7; Transparency +5.75. CM(I) = 323-347°; CM(II) = 307-330°. B = +23°5; B' = +23°.2. Note equatorial light area (brightness 7.5 on the 0-10 A.L.P.O. scale) to right of CM.

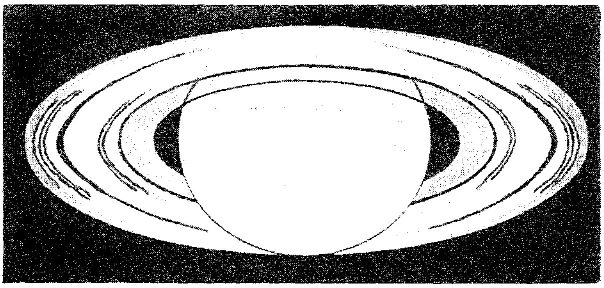


Figure 8. Drawing by Ken Schneller. 1990 AUG 02, 02h30m-03h47m UT. 20-cm (8-in) Newtonian, 305X, 435X, 564X, 742X.. W11 (yellowish-green), W15 (yellow), W23 (red), and W80 (blue) Filters. Seeing 6-8; Transparency 4 (0-5 scale). CM(I) = 077-122°; CM(II) = 169-213°. B = +23°7; B' = +23°.2. Ring divisions and belt positions based on micrometer measurements.

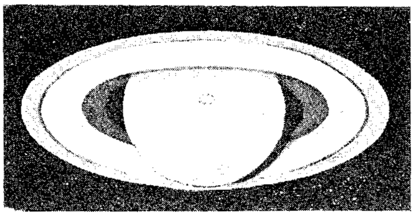


Figure 9. Drawing by Bob Talaga. 1990 SEP, 28, 02h15m-03h30m UT. 44.5-cm (17.5-in) reflector, 300X. W21 (orange) Filter. Seeing 4; transparency +4. CM(I) = 313-357°; CM(II) = 004-046°. B = +24°2; B' = +22°.7. Note Great White Spot (GWS) in EZn close to CM.

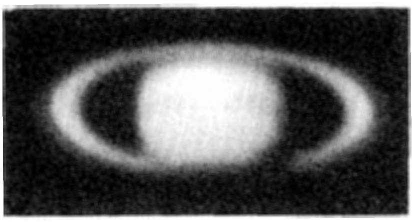


Figure 10. Photograph by Isao Miyazaki. 1990 OCT 01, 12h54m UT. 40-cm (16-in) Newtonian, f/100. 20 seconds exposure on Kodak Technical Pan TP2415 Film, developed in Rodinal 1:50 at 20°C for 12 min. CM(I) = 335°; CM(II) = 275°. B = +24°.2; B' = +22°.7. GWS near CM.

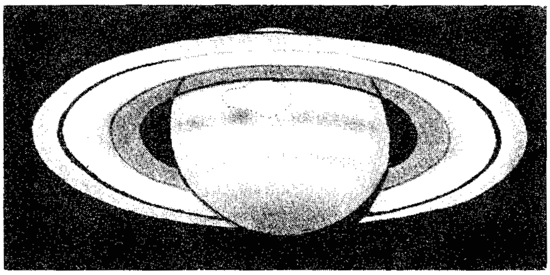


Figure 11. Drawing by Jean Dragesco. 1990 OCT 02, 19h45m UT. 35.6-cm (14.0-in) Schmidt-Cassegrain, 244X. Very poor Seeing. CM(I) = 345°; CM(II) = 244°. B = +24°.2; B' = +22°.7. GWS near CM. Three rotations after *Figure 10.*

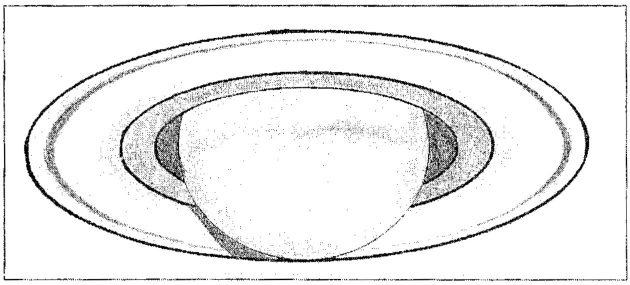


Figure 12. Drawing by Richard Hill. 1990 OCT 04, 02h20m-02h42m UT. 35.6-cm (14.0-in) Schmidt-Cassegrain,154X. Seeing = 3-5 arc-seconds; Transparency = +3 (Full Moon). CM(I) = 341-354°; CM(II) = 198°-210°. B = +24°.2; B' = +22°.7. GWS near CM, beginning to spread in longitude. Drawing laterally reversed. Three rotations after *Figure 11.*

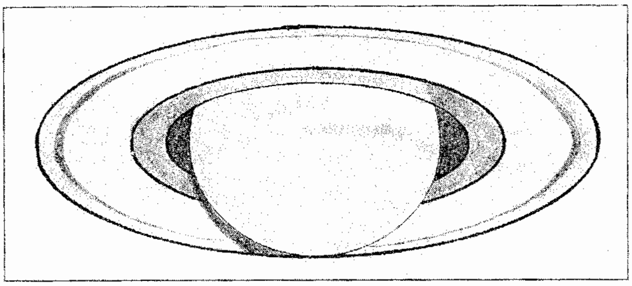


Figure 13. Drawing by Richard Hill. 1990 OCT 06, 03h05m-03h20m UT. 35.6-cm (14.0-in) Schmidt-Cassegrain,154X. Seeing = 3-5 arc-seconds; Transparency = +3 (Full Moon). CM(I) = 256-264°; CM(II) = 047-056°. B = +24°.2; B' = +22°.7. Drawing laterally reversed.

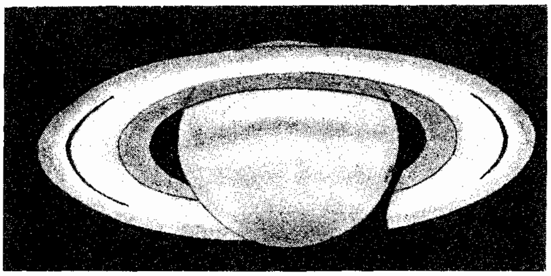


Figure 14. Drawing by Jean Dragesco. 1990 OCT 11, 18h20m UT. 35.6-cm (14.0-in) Schmidt-Cassegrain, 244X. Very bad Seeing; Transparency variable, with clouds. CM(I) = 333°; CM(II) = 303°. B = +24°.2; B' = +22°.6. GWS near CM, now larger and less brilliant.

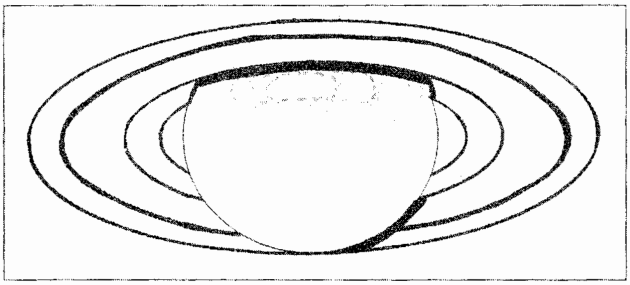


Figure 15. Drawing by Daniel M. Troiani. 1990 OCT 13, 01h14m-01h19m UT. 25-cm (10-in) Newtonian,374X. No filter. Seeing = 8; Transparency = +6.0. CM(I) = 340-343°; CM(II) = 268-271°. B = +24°.2; B' = +22°.6. GWS near CM; note additional white ovals in EZ.

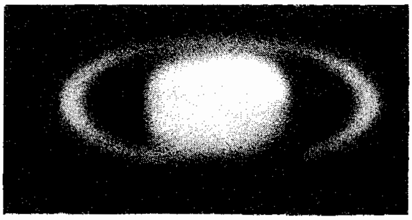


Figure 16. Photograph by Isao Miyazaki. 1990 OCT 13, 10h19m UT. 40-cm (16-in) Newtonian, f/100. 20 seconds exposure on Kodak Technical Pan TP2415 Film, developed in Rodinal 1:50 at 20°C for 12 min. CM(I) = 299°; CM(II) = 215°. B = +24°.2; B' = +22°.6. GWS near right (following) limb, encroaching on NEB. Approximately 1 rotation later than *Figure 15.*

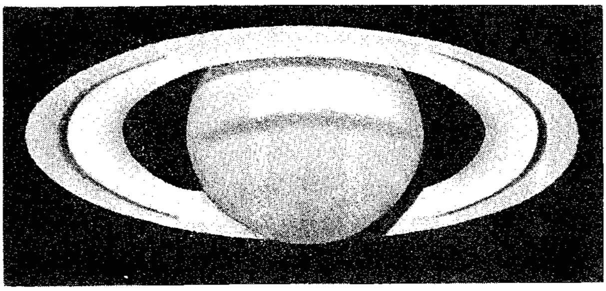


Figure 17. Drawing by David L. Graham. 1990 OCT 14, 17h30m-18h30m UT. 15-cm (6-in) refractor,166X.. Seeing = II (Antoniadi; good). CM(I) = 316-352°; CM(II) = 190-224°. B = +24°.2; B' = +22°.6. GWS near CM. Three rotations after *Figure 16.* Feature positions shown for 17h30m UT.

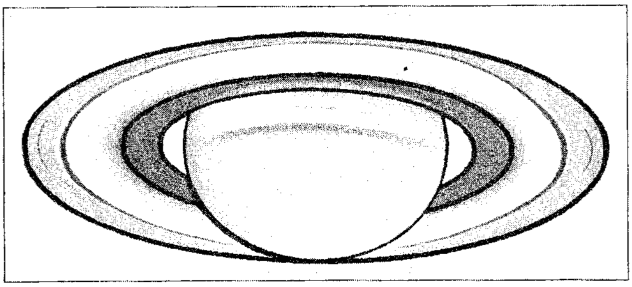


Figure 18. Drawing by Michael E. Sweetman. 1990 OCT 18, 01h54m-02h23m UT. 15-cm (6-in) refractor, 382X. No filter. Seeing = 6; Transparency = +4.5. CM(I) = 264-281°; CM(II) = 030-046°. B = +24°.1; B' = +22°.6. GWS to left (preceding) CM; brightness 9.0 on A.L.P.O. 0-10 Scale. Drawing laterally reversed.

Figure 19. Drawing by Jean-Francois Viens. 1990 OCT 27, 22h10m-22h30m UT. 25-cm (10-in) Newtonian, 189X. No filter. Seeing = 7-8; Transparency = 10 on a Scale of 0-10. CM(I) = 295-306°; CM(II) = 102-114°. B = +24°.0; B' = +22°.5. GWS to right of (preceding) CM, centered at System I longitude 317°.

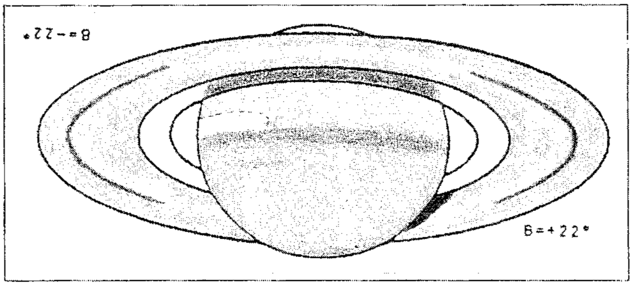


Figure 20. Drawing by Richard W. Schmude, Jr. 1990 OCT 30, 02h18m-02h51m UT. 25-cm (10-in) reflector, 301X. W47 (blue), W58 (green) Filters. Seeing = 5; Transparency = +5. CM(I) = 328-348°; CM(II) = 066-084°. B = +24°.0; B' = +22°.5. GWS on preceding limb (left).

GALILEAN SATELLITE ECLIPSE TIMINGS: THE 1989/90 APPARITION

By: John E. Westfall, A.L.P.O. Assistant Jupiter Recorder, Eclipse Timings

ABSTRACT

The A.L.P.O. Jupiter Section received 969 visual timings of the eclipses of Jupiter's four Galilean satellites for the 1989/90 Apparition. For each satellite, eclipse disappearance and reappearance timings were adjusted for telescope aperture and were then combined for comparison with the Jet Propulsion Laboratory's "E-2" Ephemeris. The observed positions of Europa and Ganymede fitted the ephemeris well, and that of Callisto was not significantly different. However, events for Ganymede tended to occur significantly earlier than predicted.

INTRODUCTION

The 1989/90 Apparition of Jupiter was the thirteenth studied by the A.L.P.O. Jupiter Section's Galilean Satellite Eclipse Timing Program. This was our most successful apparition yet, with 969 visual timings received. The satellites so timed were Io (*1*), Europa (*2*), Ganymede (*3*); and Callisto (*4*), which began to undergo eclipses once more during this apparition. Visual observers timed the "first speck" visible when the satellite reappeared from Jupiter's shadow (*reappearance*), or the "last speck" seen when the satellite disappeared into the shadow (*disappearance*). Reports for previous apparitions are listed under "References" (p. 67).˙ [Westfall 1983-84, 1986a, 1986b, 1987, 1988, 1989, and 1991]

Table 1 (below) lists some significant dates for the 1989/90 Jupiter Apparition.

Table 1. 1989/90 Jupiter Apparition Chronology.

		d	*h*
Conjunction with the Sun	1989 JUN	09	09
First Eclipse Timing	1989 JUL	05	20
Closest Approach to Earth	1989 DEC	26	09
Opposition to the Sun	1989 DEC	27	14
Last Eclipse Timing	1990 JUN	14	08
Conjunction with the Sun	1990 JUL	15	06

The *apparition* is the period between successive conjunctions, while the *observing season* covers the period of actual observation. The observing season began only 26 days after conjunction, with Jupiter 19° west of the Sun; and ended 31 days before the next conjunction, at solar elongation 22° east. During the apparition, the jovicentric declination of the Sun decreased from 2°.6 to 1°.3 north, meaning that Io, Europa, and Ganymede were eclipsed throughout the apparition, as always, while Callisto began to be eclipsed near the beginning of December, 1989.

At closest approach, Jupiter's distance from the Earth was 4.1655 A.U. (astronomical units), with an equatorial diameter of 47".26, and a visual magnitude of -2.74. Its geocentric declination at opposition was +23°.2, so this apparition favored observers in the Earth's Northern Hemisphere.

OBSERVATIONS

The timings received for 1989/90 bring our thirteen-apparition total to 5322 visual timings. Most of the timings were submitted to the A.L.P.O. directly, or by a coordinating individual (589; 60.8 percent of the total ,of 969), we were fortunate to also receive 213 timings (22.0 percent) by 16 New Zealand and Australian observers from the Royal Astronomical Society of New Zealand, 64 timings (6.6 percent) by 11 members of the Belgian group, Verenigung Voor Sterrenkunde; and 103 timings (10.6 percent) by 20 Spanish observers from three groups: the Agrupación Astronòmica de Barcelona, Agrupación Astronòmica de Sabadel, and Grup d'Estudis Astronòmics. All in all, 106 individuals or teams made observations. The timings themselves are listed in *Table 8* (pp. 68-73), followed by the list of observers. However, we wish here to single out those observers who have, as of the 1989/90 Apparition, contributed observations for at least five apparitions. *Table 2* (below) gives their names and, in parentheses their nations and number of apparitions (note that not all those listed timed eclipses during the 1989/90 Apparition).

Table 2. Long-Term Participating Observers, Galilean Satellite Eclipse Timing Program.

William Abrahams (Australia, 5);
Sandro Baroni (Italy, 6);
Alastair Brickell (New Zealand, 5);
Henk Bulder (Netherlands, 6);
Dietmar Büttner (Germany, 8);
Ricard Casas (Spain, 5);
Odilon Correa (Brazil, 6);
A. Luis da Silva (Brazil, 10);
Harold F. Gray (United States, 5);
Walter Haas (United States, 6);
Phillip Kearney (Australia, 6);
Stephen Kerr (Australia, 6);
Thomas Langhans (United States, 10);
Brian Loader (New Zealand, 9);
Dennis Lowe (Australia, 5);
Craig MacDougal (United States, 5);
Chris Newbill (United States, 7);
John Priestly (New Zealand, 6);
Geert Vandenbulcke (Belgium, 5);
John Westfall (United States; 13).

Timings for the 1989/90 Apparition were made by observers in 15 countries, as shown in *Table 3* (below), giving us our best geographical distribution yet. However, there remain longitude gaps in our coverage; the absence of observers from France, Japan, and the United Kingdom is surprising.

Table 3. Nationalities of Observers and Observations, 1989/90 Apparition.

Nation of Residence	Number of Observers	Number of Observations
United States	24 (23 %)	252 (26 %)
Spain	17 (16 %)	103 (11 %)
Australia	16 (15 %)	178 (18 %)
Belgium	11 (10 %)	64 (7 %)
Portugal	6 (6 %)	85 (9 %)
Germany	6 (6 %)	43 (4 %)
Brazil	6 (6 %)	29 (3 %)
Italy	5 (5 %)	31 (3 %)
New Zealand	4 (4 %)	41 (4 %)
Denmark	3 (3 %)	44 (5 %)
P.R. China	2 (2 %)	36 (4 %)
India	2 (2 %)	14 (1 %)
Hungary	2 (2 %)	10 (1 %)
Netherlands	1 (1 %)	32 (3 %)
Czechoslovakia	1 (1 %)	7 (1 %)

Table 4 (below) gives summary statistics for the timings in terms of the satellite and the type of event. Note that the "Number of Events Total" refers to the number of events that occurred during the entire apparition.

Table 4. Summary Statistics By Event Type, 1989/90 Apparition.

(1 = Io; 2 = Europa; 3 = Ganymede; 4 = Callisto; D = Disappearance; R = Reappearance)

Event Type	Number of Timings	Number of Events Total	Timed	
1D	161	115	60	(52 %)
1R	287	113	65	(58 %)
1	448	228	125	(55 %)
2D	84	56	31	(55 %)
2R	143	60	33	(55 %)
2	227	116	64	(55 %)
3D	97	45	29	(64 %)
3R	83	45	27	(60 %)
3	180	90	56	(62 %)
4D	63	12	10	(83 %)
4R	51	14	11	(79 %)
4	114	26	21	81 %)
D	405	228	130	(57 %)
R	564	232	136	(59 %)
TOTAL	969	460	266	(58 %)

As usual, more timings were made for Io than for Europa, and more for Europa than for Ganymede. This appears largely to be a result of their orbital periods increasing, and the frequency of their eclipses decreasing, outwards from Jupiter. Overall, reappearances constituted 58 percent of all timings, but actually were predominate only for Europa and Io, while disappearances were the more frequently timed events for the other two satellites. With both Io and Europa, 55 percent of the possible events were timed. The degree of completeness was slightly higher for Ganymede. It was considerably higher for Callisto, perhaps because it had been three years since Callisto's last eclipse!

As is the usual case, the number of timings varied from month to month, as shown in *Table 5* (below).

Table 5. Number of Timings by Month, 1989/90 Apparition.

(Solar elongation range in parentheses)

1989	JUL	(019-038°W)	3	Timings
	AUG	(038-062°W)	21	
	SEP	(062-087°W)	36	
	OCT	(087-117°W)	68	
	NOV	(117-149°W)	106	
	DEC	(149°W-176°E)	107	
1990	JAN	(176-141°E)	183	
	FEB	(141-111°E)	150	
	MAR	(111-082°E)	170	
	APR	(082-056°E)	76	
	MAY	(056-032°E)	47	
	JUN	(032-022°E)	2	
Before Opposition			331	(34.3 %)
After Opposition			638	(65.8 %)

The period of the most intense observing was the three months after opposition, when the planet was conveniently placed in the evening sky. We have an ongoing bias toward post-opposition timings, and we request participants to make more pre-opposition timings in the future, recognizing that this involves observing after midnight.

The one remaining significant factor in the observations was the size of telescope used. The 155 telescopes used are summarized by aperture in *Table 6* (below).

Table 6. Number of Telescopes Used, By Aperture, 1989/90 Apparition.

Aper. (cm)	No.Tele.	Aper. (cm)	No.Tele.
2.5	1	13.8-14.0	2
4.0	2	15.0-15.2	16
5.0	4	16.0	3
5.4	1	20.0-20.5	25
6.0-6.3	15	20.7-21.0	3
7.0	2	22.0	1
7.5-7.7	7	25.0-25.4	11
8.0	10	26.0	1
8.9-9.0	3	30.0	2
10.0-10.2	10	31.8	2
11.3-11.5	10	33.0-33.3	3
12.0	4	35.0	3
12.5-12.7	5	40.0	3
13.0	1	41.0	2
13.5	1	51.0	1
		75.0	1

Note that apertures within a few millimeters of each other have been grouped together above.

For the first time, instruments as small as 4 cm and even 2.5 cm aperture were used; with successful results. In terms of the number of observers, the most popular aperture continues to be 20 cm, with the median somewhat less; 13.9 cm. Twenty-three small telescopes, 6.3 cm aperture or less, were used, comprising 15 percent of the instruments. The 17 fairly large telescopes, 30 cm or larger, constituted 11 per cent of those used. The range of apertures continues to be large; from 2.5 to 75 cm, showing that almost any telescope can be used in our program.

REDUCTION

The first step in reduction was to segregate the timings by satellites and by the type of event; disappearance versus reappearance. Observations were compared with the predictions of the "E-2" Ephemeris developed by Dr. Jay H. Lieske of the Jet Propulsion Laboratory. [Lieske, 1981] The predicted time of each event was then subtracted from the observed time; a positive residual meant that an event was "late"; a negative residual, that it was "early." These residuals are given in the right-hand column in *Table 8*. The next step was to correct for aperture with a linear regression model in which the dependent variable was the residual (**y**) and the independent variable was the reciprocal of the telescope aperture, measured in centimeters (**x**). The form of the model is:

$$\mathbf{y} = \mathbf{A} + \mathbf{B}\mathbf{x},$$

where **A** and **B** are the regression coefficients. The final residual for each satellite is equal to the mean of its disappearance and reappearance regression models' predictions of the residual for an "infinite" aperture (i.e., with the reciprocal of the aperture equal to zero).

A few timings were not used because they differed by many minutes from the predictions and could not be reconciled. For Callisto, several observations were reports that an eclipse was only partial. Finally, a number of timings were rejected because of differences of over 2 standard errors (see *Table 7*) from the regression model. For the 1989/90 Apparition, 108 timings (11.1 percent) were so rejected for the above reasons, and are shown by italicized residuals or by "n.e.*" ("no eclipse") in *Table 8*. This proportion of timings rejected in somewhat high and is probably due to the fact that this was the first apparition of timing eclipses for many of the observers.

As a check of the method above, the writer estimated the diameter of each satellite by taking the differences between its predicted disappearance and reappearance residuals, which should give the amount of time it took Jupiter's shadow edge to cross the satellite's disk. Then, taking into account each satellite's velocity and average angle of entry or exit from the shadow, the diameter in kilometers was calculated.

The method of analysis is described in more detail in our 1975-82 report [Westfall, 1983-84], and the criteria for the rejection of timings are in the report for 1985/86 [Westfall, 1987].

1989/90 RESULTS

The orbital residuals for Io, Europa, Ganymede, and Callisto for all thirteen apparitions from 1976/77 through 1989/90 are graphed in *Figure 21* (p. 67). In that figure, the error bars represent a ±1 standard-error range, and a significant deviation from the ephemeris would have to be at least about ±2 standard errors. Details for the 1989/90 Apparition follow in *Table 7* (p. 66). This table gives results for each of the four Galilean satellites in a separate column. Each column is divided into four parts, "Disappearance," "Reappearance," "Orbital Residual," and "Diameter." For both disappearances and reappearances, the number of timings is given first, followed in parentheses by the number actually used in the regression analysis. The next item is the mean residual for the timings that were retained, followed by the coefficient of variation ("R-squared"), which is the proportion of the variance among the timings that is explained by the aperture model. Fourth, the two regression coefficients are given with their 1-standard error uncertainty ranges; in *Table 7*, all such uncertainty ranges are preceded by the "±" symbol. Next is the standard error of estimate for the regression model. Last are the predicted residuals for four commonly used telescope apertures.

The disappearance and reappearance data are combined in order to give the orbital residuals, expressed as how far "ahead" (negative) or "behind" (positive) the satellite was in terms of the E-2 Ephemeris. This value and its 1-standard error uncertainty range are given in seconds of time, degrees of orbital arc, and kilometers.

The results of the satellite diameter check described above are given at the bottom of each column, where the estimated satellite diameter is given in seconds of time and in kilometers. The latter value is corrected for the angle of entrance into or out of Jupiter's shadow. This quantity is then compared with the "standard" Voyager-derived satellite diameter (Io, 3632 km; Europa, 3126 km; Ganymede, 5276 km; and Callisto, 4820 km).

Table 7 also shows the statistical significance of the differences of the following values from zero; "R-squared," the orbital residual (in seconds of time only), and the difference between the estimated and the standard satellite diameters. The statistical significance is shown by "-" for not significant, "*" for significant at the 5-percent level, and "**" for significant at the 1-percent level.

There are eight types of events listed in *Table 7*; eclipse disappearances and reappearances for each of the four satellites. As shown by the R-square values, in all eight cases the aperture-regression model significantly reduced the variance among the timings. The average uncertainty of the timings is indicated by the standard error which was roughly the

Table 7. Galilean Satellite Timings Compared With E-2 Ephemeris, 1989/90.

Satellite:	Io	Europa	Ganymede	Callisto
Disappearance				
Number of Observations	161 (147)	84 (77)	97 (90)	63 (54)
Mean Residual	+86.5±1.5	+93.5±3.7	+241.4±6.5	+494.6±33.4
Coefficients:				
R-squared	.1236**	.3151**	.3574**	.1771**
A (seconds)	+97.6±2.8	+122.2±5.8	+295.7±9.5	+667.3±60.0
B	-151±33	-381±65	-645±92	-1975±582
Standard Error (seconds)	±16.8	±27.4	±50.0	±224.5
Aperture Residual (seconds):				
6-cm	+72±3	+59±7	+188±9	+343±55
10-cm	+82±2	+84±4	+231±5	+472±31
20-cm	+90±2	+103±4	+263±6	+570±37
40-cm	+94±2	+113±5	+280±8	+619±48
Reappearance				
Number of Observations	287 (249)	143 (128)	83 (74)	51(42)
Mean Residual	-79.4±1.5	-103.2±2.7	-273.5±6.0	-455.5±36.5
Coefficients:				
R-squared	.3188**	.2809**	.4018**	.1067*
A (seconds)	-100.3±2.3	-125.8±3.9	-325.7±8.8	-594.4±72.5
B	+278±26	+265±38	+646±93	+1345±615
Standard Error (seconds)	±19.0	±25.6	±40.1	±226.6
Aperture Residual (seconds):				
6-cm	-54±3	-82±4	-218±9	-370±52
10-cm	-72±1	-99±2	-261±5	-460±35
20-cm	-86±1	-113±3	-293±5	-527±48
40-cm	-93±2	-119±3	-310±7	-561±60
Orbital Residual				
Seconds	-1.3±1.8-	-1.8±3.5-	-15.0±6.4*	+36.4±47.1-
Orbital Arc (degrees)	-0.0032±.0043	-0.0021±.0041	-0.0087±.0038	+.0091±.0117
Kilometers	-23±31	-25±48	-163±70	+299±387
Diameter				
Seconds	197.9±3.6	248.0±7.3	621.4±12.9	1261.7±94.1
Kilometers	3349±61	3164±93	5736±119	5493±410
Compared with Standard	-283±61** (-7.8 %)	+38±93- (+1.2 %)	+460±119** (+8.7 %)	+673±410- (+14.0 %)

same for disappearance and reappearance timings, but increased going outward from Jupiter; about ±17-19 seconds for Io, ±26-27 seconds for Europa, ±40-50 seconds for Ganymede, and ±225-227 seconds for Callisto. This trend is not surprising because the satellites move more slowly, and Jupiter's shadow penumbra becomes broader, as one moves away from the planet. Also, Callisto began its current period of eclipses during this apparition, and consequently entered Jupiter's shadow very obliquely. Thus, its results are subject to considerable uncertainty.These factors also are reflected in the increasing numerical values of the B-coefficients with distance from Jupiter; these values measure the effect of aperture variations on the reported times of events.

There were more timings than in the 1988/89 Apparition, and thus their standard errors tended to be smaller than before.

The orbital residuals, expressed in seconds of time, are the simple means of the disappearance and reappearance A-coefficients of each satellite. These values have also been expressed in units of degrees of orbital arc and in kilometers.

The timing results for the Galilean satellites Io, Europa, and Callisto did not differ significantly from the E-2 Ephemeris. However, Ganymede was reported as being eclipsed significantly earlier than predicted. This 15-second discrepancy was significant at the 5-percent confidence level (i.e., it would be expected to occur due to the errors of observation less than one-twentieth of the time).

The accuracy of our method of analysis is roughly assessed by using the A-coefficients to estimate the diameters of the satellites, and then to compare these estimates with the accurate diameters that were derived from the Voyager Missions. In the cases of Io and Ganymede there were significant differences, but of different signs. Io was estimated as too small, but Ganymede was estimated as too large. The estimated diameters of Europa and Callisto did not differ significantly from the Voyager values, although our result for Callisto is very uncertain.

One Callisto event was controversial; its predicted eclipse of 1989 NOV 26, which was to have begun its current 3-year cycle of eclipses by Jupiter. On that date, four of the six observers reported that the eclipse was

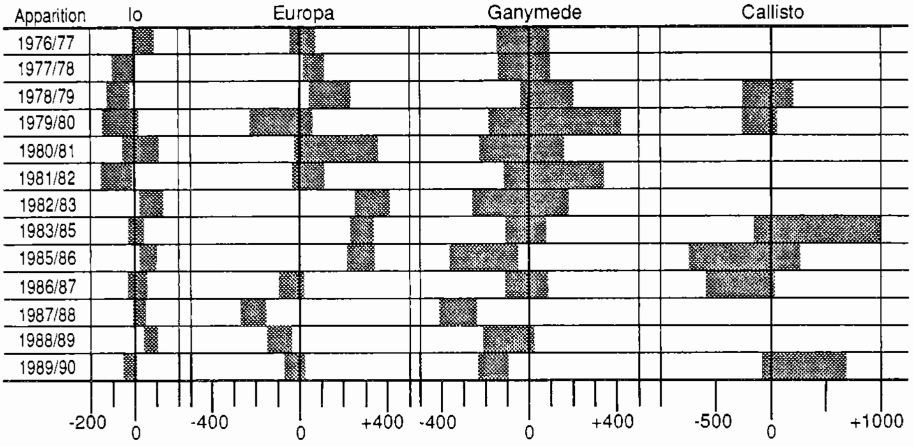


Figure 21. Graphs of deviations of the Galilean satellites from the E-2 Ephemeris for the 1976/77 through the 1989/90 Apparitions. Units are in kilometers. The width of each bar represents ±1 standard error. Note the different scale for Callisto, which was not eclipsed in every apparition.

only partial; with no "disappearance" and consequently no "reappearance." Those reporting a complete eclipse used 10- and 20-cm telescopes under poor conditions. Those with larger apertures (20, 25, 30 cm), better conditions, or both, saw Callisto remain visible throughout the predicted period of eclipse.

The next Callisto eclipse, on 1989 Dec 13, was reported as total by all seven of its observers. However, one observer reported the much later eclipse of Callisto on 1990 Feb 01 as a partial event. Fourteen other observers reported this to be a total eclipse of the satellite, so the single report of no total eclipse remains unsubstantiated and unexplained.

CONCLUSION

No electronic timings, either by photoelectric photometers or by CCD cameras, were reported for this apparition. We realize that scattered light from Jupiter poses a problem for photometry. However, a handful of observers have reported very successful results by using CCD cameras for photometry. These units record brightness for a two-dimensional arrangement of "pixels," allowing the scattered light from Jupiter to be accurately modeled and subtracted from the brightness of any satellite being measured. Thus, we encourage suitably-equipped observers to use their CCD cameras to time the eclipses of Jupiter's four major satellites. However, it is clear that visual timings are at present the mainstay of our program. The more visual timings, the more accurate our results, so it is gratifying that a record number was received for 1989/90. (It already is clear that the 1990/91 Apparition has also been observed well.) Naturally, we hope that the present observers will continue and new ones will join us. For information on this program, please write to the author, whose address is given on the inside back cover. Along with instructions, he can send you a timing report form, which should be returned at the end of the current apparition (*not* of the calendar year). You will also need predictions of these events, which are published each year in the *A.L.P.O. Solar System Ephemeris*.

We are very grateful to the many observers who participated in our project for the 1989/90 Apparition of Jupiter. Remember that your results become more accurate as you accumulate experience. Thus we hope to hear from you again!

REFERENCES

Lieske, J.B. (1981). "Catalog of Eclipses of Jupiter's Galilean Satellites, 1610-2000." *Astron. Astrophys. Supl. Ser.*, *44*, 209-216 (May). [The full catalog is available on microfiche.]

Westfall, John E. (1983-84). "Galilean Satellite Eclipse Timings: 1975-82 Report." *J.A.L.P.O.*, *30*; 45-53 (Oct.), 105-115 (Jan.), and 145-154 (Apr.).

________ (1985). "Modest Suggestions for Galilean Satellite Eclipse Photoelectric Photometry." *J.A.L.P.O.*, *31*, 45-47 (Oct.).

________ (1986a). "Galilean Satellite Eclipse Timings: 1982/83 Report." *J.A.L.P.O.*, *31*, 105-119 (Jan.).

________ (1986b). "Galilean Satellite Eclipse Timings: 1983/85 Report." *J.A.L.P.O.*, *31*; 198-206 (July) and 249-258 (Nov.).

________ (1987). "Galilean Satellite Eclipse Timings: 1985/86 Report." *J.A.L.P.O.*, *32*, 114-128 (Oct.).

________ (1988). "Galilean Satellite Eclipse Timings: 1986/87 Report." *J.A.L.P.O.*, *32*, 245-257 (Oct.).

________ (1989). "Galilean Satellite Eclipse Timings: 1987/88 Report." *J.A.L.P.O.*, *33*, 157-167 (Oct.).

________ (1991). "Galilean Satellite Eclipse Timings: The 1988/89 Apparition." *J.A.L.P.O.*, *35*, 14-24 (Mar.).

Table 8. Galilean Satellite Eclipse Timings, 1989-90 Apparition.

UT Date	Geom-etry		Ob. No.	Con.	Res.
mmdd	r	°		stb	sec.
--------- **Io Disappearances** ------					
1989					
0705	0.4	+16	103	202	+63
0728	0.7	+15	20a	202	*+235*
0813	0.8	+15	83a	211	+88
0819	0.9	+15	96	100	+79
			12	111	+81
			95	200	+85
			92b	111	+107
0820	0.9	+15	67	212	+66
0826	0.9	+15	33a	210	+96
			36b	000	+111
0831	1.0	+15	17	001	+97
0904	1.0	+15	68a	111	*-14*
0905	1.0	+15	6	100	+78
			83a	101	+109
0909	1.0	+14	75	000	+57
0911	1.0	+14	68a	111	+69
0912	1.1	+14	67	000	+90
0916	1.1	+14	65	002	+116
			71a	001	+116
0918	1.1	+14	95	110	+97
			96	000	+103
0919	1.1	+14	88	- - -	+44
0925	1.1	+14	75	000	+82
			65	111	+92
0927	1.1	+14	26	110	+61
			68a	000	+69
			36b	200	+72
			33a	210	+86
			40a	- - -	+99
			97	110	+101
0928	1.1	+14	6	101	+77
			5a	011	+90
1004	1.1	+14	68	000	+82
			76	100	+89
			22	000	+93
			40a	- - -	+94
			63	012	+103
			96	000	+113
			36b	000	+118
1005	1.1	+14	90	010	+75
			15	002	+80
1009	1.1	+14	104	000	+70
			75	000	+78
1011	1.1	+14	62	100	+45
			27	000	+71
			33a	100	+99
1012	1.1	+14	89	100	+46
			72	011	+89
1014	1.1	+14	6	201	+66
			15	011	+77
			67	222	+85
			83	122	+85
			52	200	+101
1020	1.1	+14	62a	101	+95
			33a	101	+97
1021	1.0	+14	90	111	*+40*
			6	112	+74
			15	001	+89
			67	011	+102
1023	1.0	+14	59a	100	+110
1025	1.0	+14	58	111	+122
			102	100	+125
1027	1.0	+14	22	100	+92
			68	000	+98
1028	1.0	+14	26a	110	+46
			88	- - -	+46
1030	1.0	+14	70a	111	+92
			83a	101	+103
1101	1.0	+14	102	000	+117
1104	0.9	+13	101	110	+69
			72a	200	+74
			22	111	+98
1106	0.9	+13	90	001	*+2*
			15	00 -	+90
			87b	101	+113
1110	0.9	+13	75	000	+67
			104	100	+89
			41	111	+94
			104a	100	+109
1112	0.8	+13	22	000	+90
			40a	- 2 -	+97
			12	101	+101
			11b	001	+109
1113	0.8	+13	67	001	+97
1115	0.8	+13	84	002	+63
1117	0.8	+13	104	000	+43
			43	000	+93
			104a	100	+98
1119	0.7	+13	85	111	+75
			75	000	+81
			39	111	+84
			24a	200	+86
			43	000	+104
			50	111	+104
1120	0.7	+13	101	110	*+50*
			48	010	+63
			12	110	+93
			96	100	+99
			11b	200	+101
1122	0.7	+13	67	111	+90
			83b	201	+107
1124	0.7	+13	65	000	+105
1126	0.6	+13	75	222	*+17*
			85a	111	+77
			40a	- 2 -	+84
			41	11 -	+89
			84	010	+95
			65	100	+100
			31	111	+127
1127	0.6	+13	48	102	+66
			87	001	+88
			27a	110	+99
			33a	100	+106
1129	0.6	+13	6	110	+67
			15	00 -	+94
			67	010	+94
			87b	211	+108
1201	0.5	+13	15	222	+64
			104	000	+65
			1	100	+82
			104a	100	+94
1203	0.5	+13	104	110	*+38*
1203	0.5	+13	104a	110	+80
			41a	11 -	+90
			11b	102	+117
1205	0.5	+13	48	112	+65
			45	010	+67
			22a	221	+95
			40a	- 1 -	+102
1206	0.4	+13	15	000	+65
			3	111	+75
			72	110	+80
			67	010	+92
			40a	2 - -	+101
1208	0.4	+13	104	021	*+31*
			15	112	+64
			67	211	+70
			6	201	+71
			1	020	+81
			104a	021	+85
			52	100	+98
1210	0.4	+13	104	000	+70
			104a	100	+92
1212	0.3	+13	30	000	*+55*
			41	111	+57
			65	111	+85
1213	0.3	+13	15	110	+70
			3	101	+82
1217	0.2	+13	59a	200	*-106*
1219	0.2	+13	104	000	+78
			43	100	+87
			65	211	+89
			104a	100	+105
1220	0.1	+13	79	21 -	+85
1222	0.1	+13	6	201	*+20*
1224	0.1	+12	20	100	*+18*
			6	100	*+44*
			52	200	+59
			104a	202	+71
1226	0.0	+12	104a	202	*+42*
			71	102	+57
-------- **Io Reappearances** -------					
1989					
1228	0.0	+12	65	100	-67
1229	0.0	+12	36b	000	-87
			33	010	-72
			86b	001	-40
1231	0.1	+12	6	200	-33
1990					
0102	0.1	+12	70a	110	-95
			15	110	-82
			104a	001	-82
			104	101	-38
			28	100	*+54*
0104	0.2	+12	60	210	-97
			69	000	-83
			7	000	-61
			104a	101	-44
			104	001	*-14*
0105	0.2	+12	35a	010	-99
			36b	010	-58
			78	101	-43
			82	001	-39
0107	0.2	+12	36b	101	-85

Table 8. Galilean Satellite Eclipse Timings, 1989-90 Apparition—*Continued.*

UT Date mmdd	Geometry r	Geometry °	Ob. No.	Con. stb	Res. sec.
Io Reappearances—Cntd.					
1990					
0107	0.2	+12	69	102	-59
			22a	- - -	*+1254*
0109	0.3	+12	20	110	-89
			15	000	-57
			28	000	-26
0111	0.3	+12	102	001	-102
			64	001	-47
0113	0.4	+12	102	000	-103
			65	111	-100
			33a	00 -	-76
			43	000	-73
			29a	002	-71
			64	100	-40
			69	100	-40
0114	0.4	+12	35a	222	-103
			62b	000	-103
			36b	000	-101
			72a	100	-91
			27b	000	-90
			33	000	-83
			78a	121	-60
			3	121	-59
			48	200	-57
			46	210	*-28*
			13	111	*+61*
0116	0.4	+12	52	100	-98
			6	101	-80
			67	010	-79
			15	000	-72
			90	000	-20
0118	0.5	+12	104a	200	*-35*
			104	100	*-17*
			28	220	*+22*
0120	0.5	+12	33a	100	*+46*
			65	222	*+46*
			40	- 2 -	*+65*
0121	0.5	+12	35a	111	-111
			36b	000	-102
			72a	000	-101
			11b	010	-99
			10a	110	-84
			13	000	-58
			77	101	-37
			101	220	*-9*
			37	100	*+18*
			48	200	*+29*
0123	0.6	+12	67	110	-88
			15	000	-74
			82	000	*+6*
			28	110	*+15*
0125	0.6	+12	56a	100	-96
			52	200	-92
			20a	100	-89
			6	200	-78
			28	000	-44
			70	110	-37
0127	0.6	+12	102	000	-114
			104a	000	-70
			104	000	-63
0129	0.7	+12	65	100	-105
			11b	000	-104
0129	0.7	+12	93	100	-103
			71a	000	-102
			66a	010	*-93*
			16	000	-89
			51	000	-85
			30	000	-80
			77	001	-58
			37	111	*+38*
0130	0.7	+12	35a	022	-107
			99	100	-106
			76	200	-82
			13	011	-75
0201	0.7	+12	67	011	-108
0203	0.7	+12	94a	000	-102
0205	0.8	+12	35a	011	-108
			71a	000	-108
			84	000	-104
			93	000	-103
			11b	011	-95
			29a	001	-78
			55	- - -	-77
			30	000	-73
			23	- - -	-55
			82	001	-32
0206	0.8	+11	99	010	-109
			12	102	-90
			40a	2 - -	-84
			66a	022	-83
			87	110	-81
			27	000	-71
			13	111	-43
			82	101	-43
			68a	001	-41
0210	0.8	+11	28	001	-52
			5a	121	*+94*
0212	0.9	+11	102	000	-121
			43	011	-93
			51	000	-75
0213	0.9	+11	29a	000	-90
			27a	121	-79
			77	001	-75
			82	010	-59
			19	121	*-21*
0217	0.9	+11	83b	111	-111
			74	110	-99
			47	010	-95
			5a	000	-93
			20a	100	-90
			42	000	-42
0221	1.0	+11	58	000	-124
			11b	100	-111
			16	000	*-107*
			65	002	-97
			7a	000	-95
			71	000	-77
			30	000	-68
0222	1.0	+11	69	012	*-137*
			35a	000	-128
			11b	000	-114
			99	000	-109
			96	000	-106
			12	100	-95
0222	1.0	+11	66a	010	*-92*
			72a	000	-91
			91	101	-88
			37a	011	-85
			76	101	-83
			33	011	-77
			21	110	-69
			68a	000	-64
			77	001	-57
			82	010	-54
			101	000	*+34*
0224	1.0	+11	6	100	-87
0228	1.0	+11	102	000	-117
			44	000	-106
0301	1.0	+11	40a	22 -	-80
			33a	110	-79
			72a	200	-79
			99	222	-79
			37	100	-43
			77	111	-30
0305	1.0	+11	47	000	-95
			34	101	-83
			5a	201	-78
			28	001	-66
			59a	101	-57
			49	021	-38
0307	1.1	+11	102	001	-118
			44	100	-105
			94a	000	-92
			65	000	-91
			41a	111	-76
			25	001	-48
0308	1.1	+11	30	000	-76
			69	000	-54
			16	010	-50
			37	000	*-27*
0312	1.1	+11	52	000	-105
			20a	000	-94
			6	101	-73
			28	001	-61
			42	102	-56
			49	001	-55
0316	1.1	+11	61	000	-111
			11b	210	-98
			33a	000	-93
			66a	120	-19
0317	1.1	+11	35a	000	-110
			99	000	-109
			96	000	-106
			66a	001	*-105*
			11a	000	-104
			91	000	-96
			33a	002	-91
			12	101	-89
			22a	- - -	-84
			40a	- 2 -	-79
			68a	000	-78
			77	101	-78
			101	011	-72
			69	100	-57
			10	002	-46
			78	222	*-15*

Table 8. Galilean Satellite Eclipse Timings, 1989-90 Apparition—*Continued.*

UT Date	Geometry		Ob. No.	Con.	Res.
mmdd	r	°		stb	sec.
Io Reappearances-Cntd.					
1990					
0319	1.1	+11	67	010	-95
			15	000	-75
0321	1.1	+11	74	000	-94
			70	100	-71
			59a	010	*-22*
0323	1.1	+10	102	000	-110
			44	000	-104
			60	201	-99
			41b	11 -	-73
			25	001	-71
			39	111	*+21*
0324	1.1	+10	11b	000	-105
			33a	100	-102
			10a	100	-89
			29a	000	-82
			86	120	-77
			78	212	*-11*
0328	1.1	+10	52	000	-93
			6	000	-88
			4	000	-69
			42	000	-67
			20	110	-66
			59a	000	-64
			70a	210	*-15*
0331	1.1	+10	11b	200	-117
			96	100	-96
			16	110	-82
			101	101	*-33*
0404	1.1	+10	106	001	-58
0406	1.1	+10	59a	000	-79
			70	002	*+33*
0408	1.1	+10	44	001	-100
			7a	000	-90
			61	100	-85
			75	111	-45
0409	1.1	+10	11b	002	-111
			95	202	-101
			96	001	-101
			33a	200	-98
			22a	- - -	-93
			66a	001	-88
			101	001	-82
			68a	000	-80
			77	101	-78
			8	001	-73
			11	002	-47
0413	1.0	+10	103a	001	-115
			70	120	*+49*
0415	1.0	+10	65	100	-114
			44	000	-106
0416	1.0	+10	13	111	*-117*
			73	000	-94
			33a	110	-89
			48	001	-85
			38	100	-75
			36	100	-67
0422	1.0	+10	51a	000	-69
0423	1.0	+10	81	000	-72
0427	0.9	+10	15	000	-62
0429	0.9	+10	59	220	*+34*
0502	0.9	+10	99	001	-113
0502	0.9	+10	35a	202	-99
			86a	101	-95
			72a	100	-82
			38	001	-77
0506	0.9	+9	54	200	-66
			6	111	-61
			20	201	-42
			28	000	-34
0508	0.9	+9	44	100	-96
			41b	211	-58
0509	0.8	+9	95	200	-70
			30	000	-55
0515	0.8	+9	104a	100	-54
			104	000	-25
0520	0.7	+9	15	200	-41
0529	0.6	+9	28	000	-75
			6	201	*-27*
			54	111	*-12*
0531	0.6	+9	65	101	-71
			41b	221	-66
0601	0.6	+9	81	010	-54
---- Europa Disappearances ---					
1989					
0725	0.9	+29	56	002	+41
0816	1.3	+28	12	102	+105
0826	1.5	+27	103	100	+124
0830	1.5	+27	75	111	-13
			60	110	+113
0906	1.6	+27	17	000	+121
			60	012	+127
0924	1.7	+26	26b	101	+104
			33a	120	+136
0927	1.7	+26	6	000	+73
			15	111	+74
			83a	111	+117
			20	100	+126
1001	1.7	+26	71a	000	+138
1008	1.7	+25	75	000	+71
			71a	020	+111
1011	1.7	+25	18	111	+105
			99	011	+130
1015	1.7	+25	41b	111	+115
1019	1.6	+25	62a	111	+107
			14	011	+145
1022	1.6	+25	15	221	+60
			103	200	+123
1026	1.6	+25	26a	010	+85
			60	211	+107
			43	200	+115
			9	020	+134
1029	1.5	+24	6	220	+78
			52	020	+99
			83b	101	+129
1102	1.5	+24	43	110	+99
			60	110	+122
1105	1.4	+24	90	110	+28
			67	011	+112
1109	1.4	+24	104	000	+82
			104a	100	+102
1112	1.3	+24	80	110	+54
			101	112	+81
			96	101	+129
1112	1.3	+24	9	101	+141
1116	1.2	+24	104	002	+63
			104a	101	+131
1120	1.1	+24	75	111	+42
			24a	2111	+61
			40a	- 2 -	+72
			31	111	+101
			43	000	+109
			11b	200	+118
1123	1.0	+23	67	110	+81
			1a	100	+138
1127	0.9	+23	75	000	+72
			7	020	+75
			84	010	+82
			43	000	+103
			102	000	+145
1130	0.8	+23	6	200	+74
			83b	211	+121
			52	000	+137
1204	0.7	+23	104	000	+64
			30	000	+79
			104a	100	+92
			11b	002	+117
			102	000	+130
1207	0.6	+23	101	111	*+32*
			68a	000	*+36*
			87	222	+48
			98	110	+58
			67	010	+65
			66a	012	+82
			33a	110	+87
			15	000	+91
			40a	- - -	+91
			9	110	+130
1211	0.5	+23	104	101	+27
			104a	201	+84
1214	0.4	+23	3	21 -	+22
1218	0.3	+22	59a	100	*-104*
			20	110	*-3*
			6	210	*+22*
			56	100	+54
			83a	211	+104
1222	0.2	+22	79	11 -	*-509*
			11b	000	+71
1225	0.1	+22	67	010	*+37*
---- Europa Reappearances ----					
1989					
0924	0.0	+25	71a	001	-68
			65	001	*-11*
1229	0.0	+21	104a	202	-86
1990					
0101	0.2	+21	36b	100	-107
			21	000	*+4*
			48	011	*+43*
			35	222	*+46*
			101	220	*+70*
0105	0.3	+21	104a	000	-113
			104	100	-35
			70a	121	*0*
0108	0.4	+21	33a	101	-166
			35a	111	-133
			36b	001	-130

Table 8. Galilean Satellite Eclipse Timings, 1989-90 Apparition—*Continued.*

UT Date	Geom-etry		Ob. No.	Con.	Res.
mmdd	r	°		stb	sec.
Europa Reappearances-Cntd.					
1990					
0108	0.4	+21	40a	- - -	-104
			22a	- - -	-103
			3	101	-81
			76	201	-79
0112	0.5	+21	52	100	-126
			6	201	-125
			20	000	-108
			15	222	-99
			1	002	-97
			70a	001	-85
			34	201	-80
			5a	001	-56
			64	101	*+13*
0116	0.6	+20	102	000	-154
			33a	000	-124
			7a	000	-117
			60	110	-117
			35a	211	-109
			81	000	-87
			30	000	-81
			36	100	-44
			16	000	-39
0119	0.8	+20	6	110	-71
			90	000	-49
			4a	020	*+152*
0123	0.9	+20	102	000	-151
			35a	111	-136
			65	000	-135
			60	100	-124
			51	000	-113
			36	000	-91
			104a	000	-89
			75	111	-63
			104	100	-60
0126	1.0	+20	67	010	-98
0130	1.1	+20	102	000	-156
			17	000	-107
0202	1.1	+20	99	010	-155
			35a	011	-146
			11b	020	-131
			38	000	-128
			3	101	-109
			13	111	-99
			101	001	-89
0206	1.2	+20	59	000	-119
			64	101	-84
0209	1.3	+19	35a	011	-147
			11b	001	-143
			86b	101	-137
			87a	010	-133
			72a	011	-118
			29a	002	-115
			33a	110	-108
			101	112	-102
			36a	110	-88
			66	121	-71
			77	121	*-31*
0213	1.4	+19	52	000	-121
			6	000	-116
			15	000	-99
			49	021	-63
0213	1.4	+19	42	120	-23
			20	020	*+60*
0217	1.5	+19	11b	000	-144
			66a	010	-118
			27	000	-105
			13	111	-88
			36	100	-80
			78	111	-80
0220	1.5	+19	4	000	-86
0224	1.6	+19	41a	11 -	-78
0306	1.7	+18	38	000	-137
			13	111	-122
			40a	- - -	-117
			22a	- - -	-115
			77	001	-79
			72a	120	*-46*
0310	1.7	+18	56a	200	-129
			70	202	-88
0313	1.7	+18	27a	011	-144
			33a	000	-142
			36b	000	-135
			86a	011	-133
			72a	000	-130
			27	011	-120
			37	110	-91
			48	022	-91
			82a	001	-74
			77	111	-57
0317	1.7	+18	52	000	-147
			103	020	-139
			4a	000	-106
			74	210	-93
			42	200	-89
			28	000	-79
			70	200	-58
			49	010	-49
			106	001	-29
0321	1.8	+18	33a	221	-81
0324	1.8	+18	15	000	-92
0328	1.8	+17	44	000	-145
			51a	010	-139
			58	100	-132
			7a	000	-130
			39	000	-114
			41b	11 -	-106
			75	000	-83
			25	111	-80
0404	1.7	+17	44	100	-120
			41a	111	-93
0411	1.7	+17	74	100	-137
			59a	100	-126
			70	101	-57
0414	1.7	+17	38	010	-110
			36	100	-105
0421	1.6	+16	81	221	-61
0513	1.3	+15	47	120	-112
			20	100	-79
			54	021	*+128*
			70	222	*+211*
0516	1.2	+15	11b	211	-136
			33a	000	-115
			96	101	-113
0516	1.2	+15	66a	101	-82
			36	101	-77
			38	020	-76
			101	211	*+13*
0520	1.2	+15	67	111	-101
0614	0.7	+14	54	111	*+61*
- Ganymede Disappearances -					
1989					
0811	2.0	+41	6	202	+175
0826	2.3	+40	33a	210	+325
			36b	000	+340
0902	2.4	+39	75	000	+189
			65	010	+284
			71a	001	+357
0916	2.6	+39	56a	100	+332
1001	2.7	+38	92	011	+190
			26	011	+220
			92a	011	+230
			92b	011	+280
			68a	000	+300
			72a	001	+323
			97	011	+355
1015	2.7	+37	75	000	+218
1029	2.4	+36	52	220	+254
1105	2.3	+36	67	012	+310
			11b	210	+322
1113	2.0	+35	80	010	+206
			35a	- 22	+243
			27a	000	+321
			9	101	+366
1120	1.8	+35	71	110	+230
			75	000	+242
			85	000	+252
			12	111	+292
			11b	210	+319
			102	100	+359
1127	1.5	+35	104	000	+247
			104a	100	+295
1204	1.1	+34	104	000	+209
			15	111	+218
			104a	100	+261
1211	0.8	+34	5a	101	+257
			67	012	+287
			83b	012	+327
1218	0.4	+33	101	220	*+93*
			48	222	*+119*
			45	010	+214
			33	110	+222
			67	012	+231
			37a	110	+241
1226	0.1	+33	48	022	*+90*
			66a	000	+120
			22a	121	+217
1990					
0130	0.1	+31	76	200	*+127*
			13	111	+151
			48	001	+181
			99	100	+257
			35a	201	+299
0207	0.4	+30	13	111	+90
			66a	112	+203
			81	010	+206

Table 8. Galilean Satellite Eclipse Timings, 1989-90 Apparition—*Continued.*

UT Date mmdd	Geom-etry r	°	Ob. No.	Con. stb	Res. sec.
Ganymede Disappear.—Cntd.					
1990					
0207	0.4	+30	40a	22 -	+231
			11b	001	+232
			43	011	+258
			35a	222	+265
			7a	001	+283
			61	101	+286
0214	0.6	+30	60	210	+274
			102	010	+300
0221	0.8	+30	70	111	+163
			74	000	+302
0228	0.9	+29	4	010	+151
			1	000	+253
0314	1.1	+28	69	110	+130
			36	100	+157
			77	101	+209
			37	110	+221
			29a	000	+230
			66a	000	+231
			96	010	+257
			33a	100	+259
			36b	100	+259
			11b	021	+277
0322	1.1	+28	39	000	+154
			75	000	+179
			25	000	+215
			81	121	+247
			61	100	+273
			7a	000	+303
0329	1.1	+27	25	111	+209
0405	1.0	+27	59a	000	+196
0419	0.8	+26	90	100	*-25*
0426	0.7	+26	37	001	+139
			27	111	+145
			38	010	*+150*
			45	010	+197
			33a	100	+228
			72a	100	+232
0426	0.7	+26	29	000	+245
			57	100	+253
			99	100	+300
0504	0.5	+25	43	111	+211
0511	0.4	+25	94	000	+91
0518	0.2	+24	54	120	*+13*
			4	000	+110
- Ganymede Reappearances --					
1989					
0804	0.4	+41	103	200	-312
			49	210	*-26*
0819	0.7	+41	95	100	-306
			33a	001	-262
			92a	011	-217
0916	1.2	+39	83a	102	-324
1001	1.2	+38	27	000	-272
1008	1.2	+38	71a	000	-352
1015	1.2	+38	41a	111	-285
1022	1.1	+37	103	200	-340
			15	111	-273
1029	0.9	+37	15	00-	-268
1105	0.7	+36	36b	010	-308
			96	000	-305

UT Date mmdd	Geom-etry r	°	Ob. No.	Con. stb	Res. sec.
1105	0.7	+36	62a	110	-214
1113	0.5	+36	11b	001	-351
			43	000	-303
1120	0.3	+36	102	100	-350
1990					
0102	0.3	+33	60	210	-314
			104a	001	-309
			104	101	*-146*
0109	0.6	+33	20	100	-272
			15	001	-223
			28	000	-186
			6	222	*-156*
			64	111	*+7*
0116	1.0	+32	34	110	-299
			67	011	-289
			6	201	-268
			1	200	-266
			15	100	-224
0123	1.4	+32	35a	211	-336
			72a	100	-312
0130	1.7	+31	35a	100	-373
			38	000	-334
			30	000	-264
			77	101	-258
			43	201	-218
			13	011	*-85*
			53	- - -	*+44*
0207	2.0	+31	43	111	-331
			17	001	-327
			41a	112	-270
			61	111	-224
0214	2.2	+30	104a	000	-266
			104	100	-246
0221	2.4	+30	74	100	-324
			42	010	-233
			20	110	-209
			28	000	-199
			5	011	*-90*
0307	2.7	+29	38	000	-340
			35a	000	-338
			36b	001	-325
			72a	100	-297
			77	001	-281
0314	2.7	+29	11b	100	-353
			96	000	-296
			33a	100	-273
			81	000	-262
			66a	011	-247
			36	100	-217
			30	000	-211
0322	2.8	+28	102	000	-326
			60	200	-315
			44	000	-304
			7a	000	-300
			61	100	-298
			41a	11 -	-253
			75	000	-217
			39	000	-213
			85	000	-200
			94	000	-186
			25	000	*-173*
0405	2.7	+27	67	011	-313

UT Date mmdd	Geom-etry r	°	Ob. No.	Con. stb	Res. sec.
0405	2.7	+27	106	001	-238
			42	111	-228
			6	121	-195
0419	2.5	+27	36	111	-174
			101	011	*-133*
0504	2.3	+26	41b	111	-246
0511	2.1	+25	59	011	-148
0518	1.9	+25	67	211	-226
--- Callisto Disappearances ---					
1989					
1126	2.1	+83	9	210	n.e.*
			15	11 -	n.e.*
			68a	000	n.e.*
			72a	100	n.e.*
			22	221	+48
			40a	- 2 -	+313
1213	0.9	+74	90	012	+82
			59a	021	+616
			104	102	+691
			104a	201	+811
			67	112	+994
			83b	022	*+1515*
			15	110	*+1590*
			103	022	*+1823*
1990					
0116	0.7	+64	36	100	+291
			75	000	+296
			30	000	+352
			81	000	+457
			41	110	+594
			39	000	+638
			7a	000	+651
			61	00 -	+876
			60	110	+979
			102	000	*+1166*
0201	2.0	+60	3	121	+347
			40a	- 2 -	+460
			100	011	+591
			2	011	+609
			32	011	+669
			11b	020	+676
			66a	011	+682
			76	210	+695
			87b	121	+790
			96	000	+836
			35a	122	+1149
0218	2.9	+57	42	000	+268
			47	100	+357
			67	010	+724
0307	3.4	+54	94a	000	+416
			103	202	+441
0324	3.6	+51	75	000	+339
			24	221	+376
			25	000	+550
			7a	100	+566
			60	201	+625
0409	3.3	+48	36	100	+194
			101	001	+300
			8	000	+302
			77	101	+378
			11	001	+381
			66a	002	+398

Table 8. Galilean Satellite Eclipse Timings, 1989-90 Apparition—*Continued.*

UT Date	Geom- etry		Ob. No.	Con.	Res.
mmdd	r	°		stb	sec.
Callisto Disappear.—Cntd.					
1990					
0409	3.3	+48	45	001	+429
			86a	112	+505
			33a	110	+509
			105	000	+522
			96	000	+552
			95	100	+576
			11b	001	+608
0513	2.1	+43	54	020	*-68*
			42	002	-27
			20	100	+176
0530	1.3	+40	44	200	+272
			65	222	+367
---- Callisto Reappearances ---					
1989					
1126	1.9	+83	9	210	n.e.*
			15	00 -	n.e.*
			72a	100	n.e.*
1213	0.4	+74	67	211	*-1601*
			15	110	*-1572*
			87b	022	*-1562*
			90	102	-72
1230	0.1	+69	56a	200	-664
			70a	210	-624
			104a	102	-88
			104	001	*+135*
1990					
0116	1.5	+64	102	020	*-1137*
			94b	010	-942
			61	00 -	-697
			30	000	-659
			75	000	-533
			36	000	-527
			33a	100	-492
			39	000	-349
			81	000	-220
			64	101	-39
0201	2.9	+61	68a	000	n.e.*
			32	000	-779
			38	010	-756
			100	000	-749
			2	000	-699
			3	101	-694
			40a	- 2 -	-658
			22a	- - -	-629
			66a	011	-612
			77	111	-434
			13	001	-429
0218	3.9	+57	67	110	-466
0307	4.5	+54	103	022	-684
			6	101	-611
			52	020	-538
			15	100	-446
			49	101	-273
			42	002	-213
			28	001	-194
0324	4.7	+51	84	010	-630
			25	111	-413
			75	111	-245
0409	4.6	+48	11b	201	-512
			33a	110	-386
			45	002	-362
0409	4.6	+48	8	101	-288
			66a	112	-278
			11	201	-253
0513	3.5	+43	15	121	-27
0530	2.7	+41	59	120	+35

Participating Observers

1	Abrahams, W. (6.0; *5*)
1a	" (20.0; *1*)
2	Andreas, F. (8; *2*)
3	Arredondo, E. (10; *8*)
4	Bembrick, C. (7.5; *4*)
4a	" (25; *2*)
5	Benn, D. (8.9; *1*)
5a	" (11.4; *6*)
6	Blanksby, J. (15.0; *28*)
7	Bock, P. (7.5; *2*)
7a	" (12.7, 9)
8	Bosselaers, M. (12.5; *3*)
9	Bourgeois, J. (25; *6*)
10	Brás, J. (6, *1*)
10a	" (16; *2*)
11	Bulder, H. (7.5; *3*)
11a	" (20; *1*)
11b	" (30; *28*)
12	Büttner, D. (6.3; *8*)
13	Calderón, P. (6; *12*)
14	Casas, R. (51; *1*)
15	Chen, D. (11.4; *33*)
16	Corrêa, 0. (6; *5*)
17	Coucke, M. (20; *4*)
18	Crespo, M. (8; *1*)
19	Cristini, D. (12; *1*)
20	Daadler, P. (15.0; *12*)
20a	" (25.0; *4*)
21	Daniels, T. (10; *2*)
22	Darnell, P. (10; *5*)
22a	" (15.2; *8*)
23	da Silva, A. (11.4; *1*)
24	Davis, M. (6; *1*)
24a	" (20; *2*)
25	Dawson, D. (15; *8*)
26	De Pooter, W. (7.6; *2*)
26a	" (11.4; *2*)
26b	" (25; *1*)
27	Di Luca, R. (12; *6*)
27a	" (35; *5*)
28	Elsworth, G. (6.0; *14*)
29	Fernandes, J. (14; *1*)
29a	" (15; *6*)
30	Filho, A. (6; *12*)
31	Fowler, G. (35.0; *2*)
32	Fritsche, A. (15; *2*)
33	Garcia, J. (16; *4*)
33a	" (40; *29*)
34	George, M. (11.3; *3*)
35	Gomez, J. (13.5; *1*)
35a	" (41; *20*)
36	Gonçalves, R. (5; *12*)
36a	" (6; *1*)
36b	" (15; *15*)
37	Gracias, N. (13.8; *7*)
37a	Gracias, N. (40; *2*)
38	Grados, J. (20; *10*)
39	Grahm, T. (8; *7*)
40	Grunnet, C. (6.3; *1*)
40a	" (20; *17*)
41	Haas, W. (15.2; *4*)
41a	" (20.3; *7*)
41b	" (31.8; *6*)
42	Hanna, W. (7.7; *10*)
43	Harper, C. (12.5; *14*)
44	Hays, R. (15; *10*)
45	"I.B.C. Arenal" (8; *5*)
46	Jariod, E. (16; *1*)
47	Kearney, P. (20.0; *4*)
48	Kerber, F. (11.4; *11*)
49	Kerr, S. (5.0; *6*)
50	Klein, L. (35.0; *1*)
51	Klos, D. (13; *3*)
51a	" (33; *2*)
52	Kruijshoop, A. (20.0; *14*)
53	Lara, M. (4; *1*)
54	Larkin, P. (20.0; *6*)
55	Leitão, C. (11.4; 1)
56	Loader, B. (10.0; *2*)
56a	" (20.0; *4*)
57	Lopez, M. (20; *1*)
58	Lux, B. (15; *3*)
59	MacDonald, M. (7.6; *4*)
59a	" (20.0; *10*)
60	MacDougal, C. (15; *13*)
61	Mallama, A. (31.8; *8*)
62	Marques, R. (9; *1*)
62a	" (25; *3*)
62b	" (40; *1*)
63	Martinez, D. (8; *1*)
64	Means, D. (5.4; *6*)
65	Mofle, S. (33.2; *18*)
66	Molau, S. (2.5; *1*)
66a	" (5; *17*)
67	Moller, H. (20.3; *29*)
68	Olesen, J. (15; *2*)
68a	" (20; *11*)
69	Otten, C. (11.4; *7*)
70	Parker, S. (7.0; *9*)
70a	" (10.2; *6*)
71	Parmentier, R. (15; 3)
71a	" (75; *8*)
72	Pedretti, R. (15; *2*)
72a	" (30; *15*)
73	Poletti, M. (15; *1*)
74	Priestley, J. (20.0; *6*)
75	Rowley, D. (5.0; *22*)
76	Ruiz Fernández, J. (21; *6*)
77	Ruiz Ruiz, B. (11.5; *15*)
78	Sampedro, T. (8; *4*)
78a	" (22; *1*)
79	Sanchez, J. (20.7; *2*)
80	Shankar, A. (6; *2*)
81	Silvestre, R. (11.4; *9*)
82	Simon, V. (8; *6*)
82a	" (12.5; *1*)
83	Smith, C. (6.3; *1*)
83a	" (7.5; *6*)
83b	" (25.0; *6*)
84	Stamm, J. (20; *5*)

Participating Observers-Cntd.

85 Stark, E. (8.0; *3*)
85a Stark, E. (20.0; *1*)
86 Sterzinger, P. (10.2; *1*)
86a " (12.5; *3*)
86b " (20; *2*)
87 Szabó, S. (7; *3*)
87a " (15; *1*)
87b " (20; *4*)
88 Szoroszlay, E.
& Székely, I. (10; *2*)
89 Tamburini, F. (12; *1*)
90 Tembrey, U. (9; *9*)
91 Temprano González, J. (21; *2*)
92 Torrell, S. (4; *1*)
92a " (6; *2*)
92b " (26; *2*)
93 Troiani, D. (25; *2*)
94 Underhay, E. (6; *2*)
94a " (10; *4*)
95 Van den Bulcke, G. (25; *6*)
96 Van Gestel, J. (20; *15*)
97 Van Mechelen, P. (25; *2*)
98 Verhaegen, W. (15.0; *1*)
99 Vidal, J. (41; *10*)
100 Viertel, A. (8; *2*)
101 Vingerhoets, M. (20; *16*)
102 Walker, G. (20.0; *20*)
103 Ward, C. (20.5; *9*)
103a Ward, C. (33.3; *1*)
104 Westfall, J. (10.2; *25*)
104a " (25.4; *27*)
105 Wils, P. (25; *1*)
106 Yang, H. (8; *3*)

Key:

A. *UT Date:* the Universal Time year, month number, and day of the event.

B. *Geometry:* The apparent distance of the satellite from the nearest Jovian limb in units of the Jovian equatorial semidiameter (r), followed by the jovicentric latitude in degrees of the center of the satellite in relation to the shadow center.

C. *Ob.No.:* Observer (or team) number as listed above. In that list, the first figure in parentheses represents the aperture of the telescope used in centimeters; the second (in italics) the number of timings submitted using that telescope.

D. *Con.:* Conditions of observation; in order, seeing, transparency, and field brightness. The numerical code is: 0 = condition not perceptible with no effect on timing; 1 = condition perceptible with possible minor effect on timing; 2 = condition serious with definite effect on the accuracy of the timing. A dash indicates that the observer did not report that particular condition.

E. *Res.* (residual): The time difference in seconds, found by subtracting the predicted eclipse UT from the observed eclipse UT. The former, originally given in Ephemeris Time, was converted to UT using an assumed ΔT correction of +57 seconds. Italicized residuals denote timings that were not used in the regression analysis. Those marked "n.e.*" indicated that no total eclipse was reported by that observer.

NEW BOOK RECEIVED

Notes by José Olivarez

The Lord of Uraniborg,
A Biography of Tycho Brahe.
By Victor E. Thoren.
Cambridge University Press,
40 West 20th Street,
New York, NY 10011. 1990.
523 pages. Price $59.50 cloth
(ISBN 0-521-35158-38.

The Lord of Uraniborg is a new and comprehensive biography of Tycho Brahe, father of modern astronomy and a famed alchemist of the 16th-Century Danish Renaissance. Born into a prominent noble family, he was trained for a career in power politics, but instead devoted his life to a pursuit of knowledge. On his island-fief of Hven, Tycho created a world-famous astronomical observatory, chemical laboratory, and general research institute under the patronage of the King of Denmark. In this Uraniborg, he constructed astronomical instruments, cast horoscopes, concocted medicines, composed Latin verse, and almost completely renovated the science of astronomy. Also, with his observations of the "new star" (supernova) of 1572 and the Comet of 1577, he mounted the first serious challenge to the then-existing Aristotelian world-view. [Aristotle taught that the stars did not change. He also taught that comets occurred in our own atmosphere; Tycho's attempt to determine the parallax of the Comet of 1577 proved that it was in reality farther away than our Moon. Ed.] Indeed, Tycho Brahe's scientific life was full of unprecedented achievement and his work of such accuracy that it virtually revolutionized astronomy and late-16th-17th-Century science as a whole. Written in an engaging style, *The Lord of Uraniborg* offers these and other perspectives on Tycho's life, and presents new analyses of virtually every aspect of his scientific work.

This work is the third published comprehensive biography of Tycho Brahe. The first was published by Pierre Gassendi in 1654, and the second by J.L.E. Dreyer in 1890. Dr. Thoren, Tycho's current biographer, was a Professor of History and Philosophy of Science at Indiana University. Those readers interested in astronomy and the history of science will find that this book is engaging reading.

OUR READERS SPEAK: TELESCOPE SELECTION—PART II

Mr. Harry Jamieson's article on telescope choice two issues ago ("Getting Started: Telescope Selection," Vol. 35, No. 4, December, 1991, pp.181-183) continues to generate letters from our readers, which appear below. (They have been slightly edited for style; but for content only in terms of deleting comments about particular brands of instrument; this means that the letter writers are responsible for their opinions, not the A.L.P.O.) Please note that following these letters is a reply by Mr. Jamieson to the letters that appeared in our immediately previous issue.

Dear John:

I would like to respond to the article by Harry Jamieson in Vol. 35, Number 4, *J.A.L.P.O.*, "Getting Started: Telescope Selection." Harry has done an excellent job of summarizing the relative advantages of the various optical designs. Each observer is an individual and each observer must take many things into consideration when he or she decides on a particular optical design. I started out using Newtonian reflectors because they were so inexpensive. I still feel that there is nothing on the market that compares with an optically sound Newtonian reflector; inch-for-inch, when cost is a major consideration. Amateur observers are lucky that the Newtonian exists. My "final" planetary telescope is a 9-inch f/15 apochromatic refractor with a folded optical design. I decided to purchase the largest telescope I could afford, with the highest optical quality per inch of aperture. I realize, however, that in choosing a 9-inch refractor I have limited the total aperture available; but I still feel that this telescope, capable of one-half arc-second resolution with superb image quality in a relatively compact design, was my best choice.

When I was trying to decide upon which telescope design, I narrowed the choices early in the game between a 9-inch triplet refractor and a large aperture (12-1/2-inch) Newtonian reflector. Many friends for whom I have great respect and admiration recommend the larger aperture Newtonian. It was not an easy decision; but, using Harry's article and his *Table 1*, one can see how I came to my conclusion. First of all, I agree that inch-for-inch of aperture, an unobstructed refractor offers the best image quality. At any observing site the amount of detail visible depends not only on the aperture of the telescope that is used, but also on the Seeing conditions at that site. The more frequently that one observes, the more likely that the observer will be able to observe during nights of excellent Seeing. If you observe 200 nights a year, you are likely to hit those nights of Seeing when large aperture will excel. I, for example, during a good observing year will observe on approximately 70 nights. During those nights, detail is usually limited by atmospheric Seeing conditions and not by aperture. I do have a small portion of nights where my 9-inch telescope can be used to its maximum, but those nights are rare. If I observed on more nights per year, the number of nights where 9 inches or greater aperture could be used to advantage would increase. So, for my particular observing site, while I realize that on nights of excellent Seeing the 12-1/2-inch Newtonian, if optically excellent, might very well out-perform the 9-inch refractor, on most nights of observing the atmosphere would limit the amount of detail visible, not the aperture. Note that a 9-inch telescope has the ability to resolve to approximately 0.5 arc-seconds, and 0.5 or better arc-second Seeing is anything but commonplace.

As you can see from *Table 1* in Harry's article, the Newtonian has the worst rating for ease of use. I agree with this. I like to draw while I am observing through the telescope, which requires the use of both hands. In a Newtonian reflector, especially one of 12-1/2 inches aperture or more, the eyepiece is located high in the air; and one must use some type of platform or ladder to get to the eyepiece. In addition, at my observing location there are street lights which I can dodge using a telescope with an eyepiece near the ground, whereas with the eyepiece high in the air, as would be the case with the Newtonian reflector, the observer would be totally out in the open in the glare of the street lights. I have long concluded that the telescopes that are used most are the telescopes which are easiest to use. Unfortunately, in planetary observing a certain amount of aperture is required. I am sure that this differs for everyone, but for me at about 6 inches aperture I start seeing fine detail on Jupiter. Above 6 inches of aperture, for me in my location, there is a game between increasing aperture showing increasing detail, but at the same time with a rapid decrease in the number of nights when the full aperture is usable. And, while I would agree that the simplest optical design is the best, making a straight-through refractor more desirable than a folded design, the fact is that a straight-through 9-inch f/15 refractor would be such a physically large telescope that a massive mount would be required and the telescope would be difficult to use. A *folded* 9-inch f/15 refractor, however, has a tube assembly about the same size as a a 12-1/2 inch f/4 Newtonian reflector. Placing the eyepiece at the bottom of the refractor, and particularly using a right-angle diagonal, makes a telescope which otherwise might be unwieldy easy to use with the eyepiece at a convenient height and location. I do use a right-angle diagonal when observing with my refractor. I have tried observing straight-through with a refractor, but have to admit that, after a long day at work and chasing the kids around, going outside and bending back over without the convenience of the diagonal is too difficult on my back. It would also be impossible for me to lie on my back, looking up at an object near the zenith, and then try to make a drawing. So, while I understand the comments of the editor on diagonals, I would just have to say that for me they are a necessity.

As pointed out in Harry's article, the one major difference between the Newtonian and the refractor is expense. A custom-made Newtonian, as compared with one commercially made, would be nearly as expensive as a large refractor. I have been observing for 25 years, and now for a final planetary telescope which I believe is capable of doing all that I wish a telescope could do for me, I had to spend basically the cost of a new domestic automobile. I decided, however, that 9 inches of aperture, given the Seeing conditions at my location, would take advantage of the vast majority of nights during which I observed. I felt that a triplet objective would provide the best image quality available, and that a folded optical path would keep the eyepiece low, making observing easy, particularly when using a star diagonal. The apochromatic refractor would have a degree of ease of maintenance and mechanical stability unmatched by the Newtonian, and for me portability was not a consideration.

Not everyone, I am sure, would reach the same conclusion that I have. Each observer is an individual and must take each point in *Table 1* of Harry's article into consideration before making a decision.

Jim Phillips, M.D.
April 14, 1992

Letter to the Editor:

I enjoyed Harry Jamieson's article on telescope selection a couple of issues ago and, even more so, the letters it engendered in the following issue. I echo Klaus Brasch's sentiments that this subject matter is of great relevance *and* great interest to our members and should be considered on a more regular basis, particularly when new optical designs hit the market. For example, the new low-dispersion "ED" refractors are currently being given a big play by Meade and, to a lesser extent, by Astro-Physics. They are significantly cheaper than 3-element apochromats or fluorites, but how do they stack up against them? Not many of us will rush to buy new telescopes when they hit the market, but I venture to speculate that we are all curious about their performance characteristics. It would be nice to hear from colleagues who do rush out to buy them, or at least have an opportunity to use them; and a "letters section" would be an appropriate format for that purpose.

I can better Klaus Brasch's (shudder) 35 year-long amateur career by about (double shudder) 10 years and have used telescopes of all major types and sizes during that long interval, ranging from a postwar 40-power folding refractor and a 3.5-inch "Skyscope" Newtonian reflector to the 36-inch Lick refractor, which I had "hands on" use of for observing the occultation of a star by Saturn's Rings in 1962 (when I was the A.L.P.O. Saturn Recorder). I used the 12-inch Clark refractor at Lick, the first telescope installed there in 1875, on a more-or-less regular basis during the '60s, and I currently own a 3-inch refractor, a 6-inch Newtonian with a superb mirror by Alika Herring, an 8-inch Schmidt-Cassegrain, and a fine 10-inch Newtonian manufactured by Cave Optical Company in the early '60s. While all telescope types have their pluses and minuses, my "bottom line" is that, inch for inch, Isaac Newton's telescope is tough to beat for planetary observing and easily provides the biggest bang for the buck. And, I might add, the resolution of low-contrast planetary detail is the sternest test of optical quality. Much is made of double-star resolution, but even mediocre instruments will pass the Dawes' Limit test. What separates the men from the boys is their performance on the planets.

My initial serious encounter with reflector-refractor comparisons came in the early 1950's when I was a college student in Brooklyn, New York. I had recently purchased my first "real" telescope, an 8-inch Newtonian, from Cave Optical Company and was thrilled with the crisp, detailed planetary images it rendered and its diffraction-limited performance on double stars. I was taking an astronomy course at Brooklyn College at the time and was permitted use of the college observatory, which housed a 7-inch refractor manufactured by the well-known J.W. Fecker Company. Although I never had the two telescopes side-by-side for comparison purposes, repeated use of both instruments on different nights convinced me that the 8-inch Cave outperformed the 7-inch Fecker in all major respects: image brightness, rendition of planetary detail, double-star resolution and, of course, color correction. It goes without saying that the cost of the reflector was a small fraction of the refractor's price tag. This experience convinced me that the Newtonian reflector is an incredible bargain and a telescope for the ages. Therefore, I was scarcely surprised by an article in the February [1992] issue of *Sky & Telescope* in which the writer found little difference in optical performance between a good 6-inch Newtonian and a 7-inch apochromatic refractor. I can only reiterate that Isaac Newton came up with a real winner more than three centuries ago.

Joel W. Goodman
April 15, 1992

Dear John:

After reading the letters in the Vol. 36, No. 1 *J.A.L.P.O.* regarding telescopes, I think it was an *excellent* "round robin" discussion of instrumentation; and no doubt the readers and the letter writers all will profit from it. Perhaps we should have one issue per year devoted to this topic or similar subjects. Dissemination of information is important, and it's far cheaper to write a letter and have it published in the *Journal* for all to see than to attempt to 'phone or write to dozens of observers. Even my fingers get numb after a while, and I write a lot of letters!

After reading all the letters, though, I was struck with one obvious fact that none of us broached, including myself. Here it is.

When choosing a telescope specifically for lunar and planetary observing we should tailor the aperture for the locale at which it is used. By that I mean the best aperture size for the usual Seeing conditions in that area.

Don Parker has told me in private correspondence that he frequently gets Seeing that allows him to reach the diffraction limit 8-10 times per month at his site. He has steady Trade Winds and a nearby ocean which tends to produce very calm skies, so no doubt a 16-inch telescope is fine for him. Most of us don't have nearly as good conditions; and using Parker as an example is a *best-case* scenario, not a typical one. Most of us would like to reach the diffraction limit 8-10 times per *year* in 8-10 inch 'scopes, let alone 8-10 times every month with twice the aperture! Most owners of 12-inch or larger Newtonians in the 40° N - 45 ° N latitude range that I know of diaphragm their 'scopes off-axis to 5 - 8 inches when observing the Moon or planets; using full apertures on deep-sky objects or on the *very infrequent* very good-Seeing nights. I can assure you that Don Parker would get little satisfaction with a 16-inch in our area of the country.

Here in the East, or in New England, 4-8 inches aperture or so is the most efficient. Ten and 12-inch 'scopes seldom show any more than a 6-inch or 8-inch as Seeing is seldom good enough. One 12-inch f/8 owner whom I know disassembled his instrument some years ago and now uses it as a collimator at an optical shop where he works. Instead, he now uses mostly a 6-inch f/15 refractor. Another observer who observes with me on Saturday nights and has done so for the past 27 years no longer brings his optically superb 8-inch f/9 reflector, but relies on a 5-1/2 inch f/10.5 refractor instead. We have noticed a deterioration not only in the number of clear nights here over this time span, but a decreasing frequency of good-Seeing ones too. Of my 8 or 9 telescopes, my largest is now a 4-1/4-inch Bausch and Lomb refractor (lens made in 1944).

I have not joined the bandwagon to get a larger instrument (although I could well afford to) for myself, as anything larger than the apertures I use or have access to would simply not be effective on the vast majority of nights and would be more likely to lead to frustration rather than satisfaction. I recall years in the 1950's and 1960's when we got over 200 clear nights per year here. That has not occurred here in the last 20-25 years. We are lucky to get 90-120 clear nights a year, and one with 140 clear nights is now a rarity. It is nearly impossible to do any long-term *systematic* work any more. It takes 2-3 days after the passage of a cold front for skies to settle down and by then the next front is coming through. We pray for "Bermuda Highs" when skies get very hazy and calm. If this high settles in for a week or two (sometimes longer), then things are much better. These occur in Summer or early Autumn. The rest of the year is usually *zilch.* So you tailor the aperture to your site conditions and do the best you can.

As a result of this situation, I now devote more time to other astro-pursuits like checking and evaluating telescopes and eyepieces or collecting and observing with binoculars of which I now own over 20 pairs. (I have over 80 eyepieces!) As the result of this experimentation and evaluation, I have resisted the temptation to purchase "modern junk" and go out of my way to look for the *best* in the older stuff. Also, my wife and I devote considerable time to nature pursuits like birdwatching—at least that doesn't require steady skies!

I evaluate all eyepieces on a nearby miniature golf course that has mercury vapor floodlights. My trees block most of them and the lights go out after midnight. This test soon shows up eyepiece faults better than any other test including the most severe astro tests. For *lunar and planetary* work you can take all the [*firm names deleted*] wide-angle eyepieces and trash-can them. They are OK for what they were designed for, faint deep-sky objects, and that's it.

Tom Dobbins recently told me that he has taken *microscope objectives* (obtained through Rolyn Optics) and has been using them as eyepieces. They work great for "eyepiece projection" photography, too.

Don Parker evaluated eyepieces [*firm name deleted*] sent him a few years back. In a letter to me Don said they were "high-priced junk." I fully concur.

Schmidt-Cassegrain optics vary so much in quality that one person gets a good one and ten people get mediocre ones. I never recommend a S-C to anyone for lunar and planetary observing, despite Klaus Brasch's comments. The Japanese magazine *Skywatcher* evaluated [three commercial 8- and 9-inch S-C's] some years ago. All were compared to a [*firm name deleted*] 4-inch apochromat. A test chart of variable contrast was placed near a light source and photos were made. [Two of the S-C's] had so much scattered light due to "rough optics" and *improper baffling* that all the low-contrast details were washed out. The [remaining S-C] did better, but the [apochromat] trashed them all. It showed the faintest contrasts superbly—*you get what you pay for!* I have that issue of *Skywatcher* here and get it out for everyone to see when the talk veers toward S-C's. Neither *Sky & Telescope* nor *Astronomy* performed any tests like that when they evaluated S-C's almost two years ago. In Japan, these tests are performed routinely and are published. I've yet to see an S-C I'd want to own.

Rodger W. Gordon
April 17, 1992

I have very much enjoyed the recent article (and letters in response) concerning telescopes. This seems to be a never-ending area of debate and opinion, and I am a true Telescope Nut and read each word with eagerness! It would be nice, however, if we could somehow "normalize" all of these divergent points of view. I suspect that there are too many variables floating around uncontrolled in these individual opinions. A case in point would be Rodger W. Gordon's letter in Vol. 36, No. 1, comparing a 6-inch f/5 Newtonian to a 6-inch f/15 refractor. He reached the conclusion that the shallow depth of focus caused the less steady Seeing in the f/5, without ever accounting for "open tube vs. closed tube," "reflective system vs. refractive system," or "obstructed vs. unobstructed system." In my opinion, this comparison would only be truly telling if an f/5 Newtonian were compared to an f/15 Newtonian with an equal-size obstruction and tube diameter.

Garry S. Nichols
(no date)

Our Writers Respond: More Telescope Selection

Response by Harry D. Jamieson

Dear John:

I would like to begin by thanking all the people who wrote in to comment on my article "Getting Started: Telescope Selection" [*J.A.L.P.O.*, Vol. 35, No. 4, Dec., 1991, pp. 181-183; here Mr. Jamieson naturally addresses the letters that appeared in *J.A.L.P.O.*, Vol. 36, No. 1, March, 1992, pp. 26-29, and not the letters that appear immediately above]. Though of course I do not agree with all of the points made by all of the authors, the important thing is that this discussion is taking place where it can benefit our novice members even more, perhaps, than my original article did.

In general, I thought that all of the letters were very helpful, and their authors obviously put a lot of thought into them. One point that I would like to stress, though, was that I had only one very modest goal in mind when I wrote my article. This goal was to present the pros and cons of the three major telescope types in a non-technical way to novices who were interested in becoming serious lunar and planetary observers. Discussions of eyepieces or exotic telescope types would have been beyond what I was trying to accomplish.

----- Bob Grant -----

Taking the letters in the order in which they appeared, Bob Grant made a very good point when he stressed the worth of a large-aperture Newtonian on an equatorial platform. Such platforms can allow a Newtonian to be both cheaper and more portable, and I fully endorse this idea. An f/6 mirror can still be ground accurately without too much trouble.

I differ with Bob on the importance of ease of use and maintenance. A telescope that is difficult to use or one that demands constant "tweaking" will become a telescope that is not used often, and it is certain that such a telescope will not *enhance* an observer's effectiveness. It is true that most of today's modern telescopes are convenient and virtually maintenance-free, but there are still many older ones in use that people have kept for various reasons.

My reservations about Tri-Shiefspieglers are that they give reversed images and do not appear to be that commercially available. I also felt, as stated above, that a novice should try to stay in the mainstream with his or her first telescope purchase. Novices often depend heavily on the advice and support of older hands in the local clubs; who might be hardpressed, say, to help them align their Tri-Schiefspieglers!

----- Rodger W. Gordon -----

Mr. Gordon's long letter contained a great deal of food for thought. Remembering my goal of trying to help novices select a telescope, I could not bring myself to recommend Maksutov-Cassegrains to them because of their high price per inch of aperture and small sizes available (up to 7 inches). Also, these telescopes are not "mainstream," as discussed above. However, Mr. Gordon is very correct when he says that these telescopes can give images approaching those produced by premium refractors of slightly smaller size, and a wealthy novice seeking portability and quality and willing to sacrifice aperture would do better purchasing a Maksutov than a SCT.

Mr. Gordon is also correct when he says that refractors up to 4 inches are portable, and I should have been more specific when I listed non-portability as a drawback for this type of telescope. It is probably safe to say that refractors up to 7 inches are portable if their f-ratio is kept below about 10. Certainly, our local club's 6-inch f/15 [refractor] is not something that I would want to drag around; but what is and is not portable can depend upon a large number of variables, not the least of which includes whether you look like Danny DeVito or Arnold Schwarzenegger. It is obvious, though, that among telescopes of equal aperture and f-ratio, Newtonians and SCTs are more portable than refractors—especially as these factors increase.

Mr. Gordon makes a very compelling point when he mentions that longer f-ratios have a greater depth of focus, and are thus less sensitive to the effects of bad Seeing. This is probably one of the most important reasons to choose a longer f-ratio that I have ever seen, and unfortunately one of the least discussed. One wonders if this benefit can be had by using a Barlow lens on a short f-ratio telescope, and my guess is that it probably cannot be. We would still have the original short depth of focus going to the Barlow.

Though I didn't want to get into eyepieces, which deserve an entire article of their own, I strongly endorse everything that Mr. Gordon said about them. I cannot stress strongly enough the importance of cutting back whenever possible on the number of optical surfaces between you and what you are looking at. With a good mounting, clock drive, and corrector, it is not necessary to have a lunar feature or planet centered within a 60-degree field.

----- Karl Fabian -----

Mr. Fabian has pointed out an obvious shortcoming in my article. When I wrote it, I had the intention of comparing telescopes of equal aperture and f-ratio, but never transmitted this thought to the reader. I should also have stressed the importance of aperture much more than I did. In fact, it might even be appropriate to tell novices as a sort of First Law that, everything else being equal, "There is no substitute for aperture." I also found Mr. Fabian's comparisons between obstructed and unobstructed systems to be a reasonable and useful rule of thumb.

----- Paul H. Bock -----

Mr. Bock's letter, like the rest, contained a number of valuable points. I feel that we disagree about the value of small-aperture Maksutovs in all but a few specialized areas of lunar and planetary research. Their nearly refractor -like images do not compensate for their expense and limited resolving power, and I can recommend them only to people of means who really must have table-top portability. Again, there is no substitute for aperture.

I have already admitted to Paul in private correspondence that I was too general in my remark that an f/7 is the shortest focal ratio that should be considered. For any aperture, the table below shows what ratios are needed to achieve various commonly used powers-per-inch with 6-mm and 7-mm eyepieces, which are the shortest recommended.

Power-per-inch	f-ratio with 6 mm	f-ratio with 7 mm
20	4.72	5.51
30	7.08	8.27
40	9.45	11.02
50	11.81	13.78

My main reason for recommending the f/7 as the shortest suitable f-ratio was that optics get progressively harder to make accurately as the ratio gets shorter, and optical quality is vital. However, longer f-ratios are needed to obtain powers above 30X per inch with a 6-mm or 7-mm eyepiece if a Barlow is to be avoided. This is particularly important if you have a telescope smaller than about 12 inches in aperture, which can often use 40-50X per inch to advantage. Larger telescopes are often confined to 20-30X per inch because of the seeing conditions, and so might only rarely need a Barlow at all. If a Barlow is to be employed, it is suggested that the eyepiece be a Hastings or Steinheil triplet, as recommended by Mr. Gordon in order to reduce the number of optical surfaces involved.

I would like to have used more quantitative terms than "best," "medium," and "worst," but my purpose was to write a non-technical article for novices, deliberately on the *Astronomy* level. Also, I had to concern myself with the article's length. Probably, an entire article could be written about a rigorous quantitative analysis for each of the categories. I promise not the use those terms in my Lunar Dome Survey reports, Paul.

I am not as familiar as I should be with the disadvantages of apochromatic lenses, and I'm glad that Paul has pointed them out to us. All too often, we allow our excitement about a new technology to make us forget to check to see what's been swept under the rug.

----- Klaus R. Brasch -----

I agree with most of Klaus Brasch's points. Like Mr. Fabian, he reminds us that there is no substitute for aperture when everything else is equal. I also have to agree strongly with him that a well-made classical Newtonian in the 8- to 12-inch, f/6 - f/8 range is the ideal inexpensive photo-visual telescope. However, Klaus and I come to a severe parting of the ways in our views of the SCT. The image deterioration caused by a 30-percent (never mind a 35-percent) obstruction is as much as that generated by a smooth 1/4-wave figure error (See "Build Your Own Telescope," by Richard Berry , p. 231). I have also had this figure quoted to me by Jean Dragesco. There is nothing bogus about the very provable fact that obstructions in the light path remove light from your central Airy Disk and distribute it among the rings, and tiny lunar and planetary details act as Airy Disks. This is one reason why SCT images are "softer" than those provided by a refractor or Newtonian with a small "planetary" diagonal (20-percent obstruction or less). The other reason has to be optical quality, which Klaus admits was bad during the "heady Halley" days. Production-line optics are never going to have the quality of hand-crafted work, and buyers of these telescopes should be especially careful to test them upon receipt.

I was very happy to "suffer the slings and arrows" of those who cared enough to take the time to write about this important topic. This can be a very controversial subject, as shown by the diversity of opinions among the writers, but I feel that all of this has been of great service to our novice members. To the letter writers, my sincere thanks. To our novice members who have yet to settle on what to buy, my advice is to join a local astronomy club if you haven't already. You will doubtless hear these same arguments repeated there, but you will also have an opportunity to look at the Moon and planets through a selection of the three major telescope types and after that judge for yourself. Try to compare like apertures and magnifications where possible, using Karl Fabian's rule of thumb. Your final decision about what to buy (or make!) will have to be your own; but whatever it is, try to go for optical quality and aperture.

GETTING STARTED:
THE FUNDAMENTALS OF METEOR OBSERVING

By: Mark A. Davis

ABSTRACT

This article discusses basic meteor observing methods which A.L.P.O. members can use to contribute to our knowledge of meteors and discusses the information that needs to be recorded in order for such observations to be of scientific value.

Meteor astronomy is usually neglected by amateurs, which is unfortunate because this field offers an excellent opportunity to contribute observations of scientific value, as well as to provide many enjoyable hours of observing. There are only a few professional astronomers active in meteor research today, and therefore this field relies on amateurs for data. These amateur-collected data can provide astronomers with information on the origin and evolution of meteoroids, which in turn sheds light on the origin and evolution of our Solar System. With minimal equipment, and a knowledge of a few basic concepts, you can begin a lifelong pursuit of meteor observing.

Meteors typically are small particles, normally no larger than a grain of sand, that enter our atmosphere at speeds of up to 70 kilometers per second. They become visible at an altitude of about 100 kilometers due to their impact with the atmosphere. Most such particles will evaporate from the effects of heat well before reaching the surface of the Earth.

Although you can see meteors on any clear night, your chances of seeing greater numbers will increase if you keep a few points in mind. Moonlight and light-polluted skies wreak havoc upon meteor observation. Therefore, it is always best to observe around the date of New Moon, as well as from the darkest skies possible.

Another important consideration is the time of night when your meteor watch is held. Due to the rotation of the Earth, it is best to observe in the early morning hours. At this time, you are facing the direction in which the Earth is traveling in its orbit and more meteors will collide with our atmosphere, and will tend to collide at a higher speed. At other times, the meteors observed must travel at speeds that allow them to overtake the Earth. This situation is similar to the view from a car traveling through a snowstorm, where more snowflakes will strike the front windshield than strike the back.

There are two broad groups of meteors. Those that arrive from random locations in the sky are termed *sporadic*, while others that appear to radiate from a particular region of the sky come from *meteor showers*, such as the Perseids of August. [In most cases, showers are named after the constellation that contains their *radiant*, or point from which they appear to radiate. The fact that meteors appear to radiate at all is a perspective effect, because they actually follow parallel courses in space. Also, note that one needs to observe several meteors radiating from the same area before one can be sure that that area constitutes a radiant. Ed.]

Sporadic meteors, also known as the sporadic background, usually produce only about 5 to 10 meteors per hour for a single naked-eye observer, although they actually make up the bulk of the objects that enter our atmosphere. The object that produces a meteor is called a *meteoroid*, and it is believed that most sporadics derive from meteoroids that belong to unknown minor showers; or may once have belonged to showers, but have left their original orbits. (Roggemans, 1989) To increase your chances of observing such meteors, you should remember that they show a diurnal variation in frequency, with more occurring before dawn than after sunset. There is also an annual variation, with more meteors occurring in the second half of the year.

The highlights for meteor observers during any year are the nights when meteor showers are active. Although each shower differs somewhat from other showers, they normally last for several nights with a peak of activity occurring on a specific date. The number of meteors one can observe increases greatly on those nights when a shower is active, with rates ranging up to 100 or more per hour, depending on the shower. Shower meteors can be distinguished from the sporadic background by the fact that the former radiate from one particular region of the sky, which is called the *radiant*. The Geminids of December, for example, appear to come from a point near the star Castor. *Table 1* (p. 81) lists the major showers that occur each year.

After you have located a dark site for your meteor observing, the next point to consider is in which direction to watch. To increase the chance of observing a meteor, center your field of view to the south or southeast; or preferably 20-45° away from the radiant of an active shower, if one is occurring. In addition, the center of your field of view should be 45° above the horizon. With this elevation, you are able to see the area of sky from the horizon to the zenith, maximizing your chances of seeing meteors. Using a lawn chair make this choice a convenient viewing elevation.

To insure the usefulness of your meteor watch, you need to record certain information. As a minimum, record the date and time of the watch, as well as the classification and brightness of the meteors seen. Record your obser-

Table 1. Major Annual Meteor Showers.

	Radiant Position (1950.0)*			Maximum	Maximum
Shower Name	Right Ascension	Declination	Dates Active	Date	Rate†
Quadrantids	15 h 20 m	+48°.5	January 1 - 5	January 3	110
Lyrids	18 h 06 m	+33°.6	April 16 - 25	April 22	90
Eta Aquarids	22 h 22 m	-1°.9	April 19 - May 28	May 4	50
Delta Aquarids	22 h 12 m	-16°.5	July 8 - August 19	July 29	30
Perseids	03 h 05 m	+57°.4	July 17 - August 24	August 12	95
Orionids	06 h 18 m	+15°.8	Oct. 2 - Nov. 7	October 21	25
Leonids	10 h 09 m	+22°.2	November 14 - 21	Nov. 18	(varies)
Geminids	07 h 29 m	+32°.5	December 7 - 17	Dec. 14	110

* At maximum date; from Levy and Edberg (1986), pp. 44-45.

† This is the maximum *zenithal hourly rate (ZHR)*; the rate at shower maximum, in the predawn hours, for a dark-sky site and with the radiant at the zenith. It is highly variable from year to year.

vations with a double date (e.g., July 3-4 for the night of July 3rd-4th) and give the beginning and ending times of your watch in Universal Time (UT). Any breaks you take from your observing should also be accurately recorded. [It is also essential to note the limiting stellar magnitude of the faintest star visible in the area of the sky you are watching. Ed.]

Although somewhat difficult to do at first, the classification of a meteor becomes easier with practice. By knowing where a meteor's possible radiant lies, you can project its path backward to see whether it crosses the radiant. If you determine that the path does, then the meteor should be classified as a member of that particular shower. [Note also that paths should be short near the radiant and longer further away. Ed.] Otherwise, the meteor should be considered as a sporadic meteor. Take care on nights when more than one meteor shower is active. In such a case, prior to the watch, you should identify all active radiants.

You should determine the magnitude of a meteor by comparing its brightness to the brightness of a star whose visual magnitude is known. This requires some knowledge of the locations and magnitudes of suitable comparison stars, which can be planned for prior to the observing session. In order to make such comparisons accurate, you will need to identify at least one star of each whole-number magnitude between first and sixth, inclusive. Also, note the location and brightness of any brighter stars or planets that happen to be above the horizon. [Note also that the comparison star should be at approximately the same altitude as the meteor observed. Ed.]

Two publications that are especially useful to meteor observers are *Observe Meteors* by David Levy and Stephen Edberg, which is available from the Astronomical League, and *Handbook for Visual Meteor Observations*, edited by Paul Roggemans and available from Sky Publishing Corporation. The A.L.P.O. Meteors Section welcomes new observers and encourages everyone, regardless of experience, to help in contributing to the body of knowledge related to meteors. Interested persons should contact the A.L.P.O. Meteors Recorder, Robert D. Lunsford, whose address is given on the inside back cover, for additional information and observing forms.

REFERENCES

Levy, David; and Edberg, Stephen. (1986) *Observe Meteors: The Association of Lunar and Planetary Observers Meteor Observer's Guide*. Washington, DC: Astronomical League.

Roggemans, Paul. (1989) *Handbook for Visual Meteor Observations*. Cambridge, MA, Sky Publishing Corporation.

Comments by Editor

This article describes how to visually count and classify meteors. The following report (pp. 82-83) by our Meteors Recorder summarizes such observations. When grouped in this manner, they illustrate the progress of meteor showers, particularly when the records of several observers are combined. Note that these observations were made without any optical aid. Also, several observers may occupy the same site, dividing the sky among them for better coverage. The more experienced visual observer can plot meteor paths on a star chart; this allows suspected radiants to be confirmed and sometimes new radiants to be discovered.

Going beyond the naked eye, meteor photography is easy to do, with just a simple camera, a fast lens, fast film, and a conventional camera tripod. This technique demands patience because meteors bright enough to photograph are infrequent. Gratings or prisms can be used for meteor spectroscopy; or image intensifiers for recording fainter meteors,. Alternatively, *telescopic meteors* may be counted through the eyepiece, perhaps in the course of observing other objects.

METEORS SECTION NEWS

By: Robert D. Lunsford, A.L.P.O. Meteors Recorder

As predicted in the December, 1991, issue of *J.A.L.P.O.* (p. 186), the Quadrantid meteor shower produced a strong display over Western Europe on the morning of January 4, 1992. The intense maximum occurred at 04h 30m UT, only one-half hour earlier than expected. The zenithal hourly rates (*ZHR*; see *Table 1* on p. 81 for an explanation) obtained from five observers in the French Alps was 174 at the time of maximum. [Koschak, Ralf. *WGN*, Vol. 20-1, p. 31]

Two observers on the East Coast of the United States, Mark Davis and Roger Venable, were able to see the Quadrantids while their rate was declining when the radiant appeared in the sky over North America, as shown in *Table 1* (below) for JAN 04. Even though these observers' rates appear much lower than those of their European counterparts, their actual ZHRs are comparable, although not reliably so due to the low elevation of the radiant as seen from North America. Dr. Venable's ZHR calculations for his four different time periods, shown in *Table 1*, gave 204, 113, 92, and 84 respectively (Venable, Roger. Personal communication.)

From my vantage point on the West Coast of the United States, only a small fraction of the display remained to be seen, reaffirming the brief observing window available for this and several other showers. [The editor has graphed the *raw* rates for the Quadrantid shower in *Figure 22* on p. 83.]

It is encouraging that we are now better able to predict the exact hour of maximum for many showers, due to better world-wide coverage. This bodes well for the predicted 1999 Leonid storm when many observers will be relying on such predictions in order to travel to the best possible locations to witness this anticipated spectacle.

Table 1. Recent A.L.P.O. Meteor Observations.

1992 UT Date	Observer and Location	Universal Time	Number and Type of Meteors Seen*	Comments* (+N = Limiting Magnitude)
JAN 01	John Gallagher, NJ	08:05-10:12	1 QUA, 8 SPO	+6.4
03	Mark Davis, VA	04:54-07:00	4 QUA, 9 SPO	+5.9
	Han-Sub Jung, S. Korea	15:00-15:50	2 QUA, 1 COM, 2 SPO	+4.6
	" " "	16:00-16:50	4 QUA, 3 SPO	+4.8
	" " "	17:00-17:50	2 QUA, 1 COM, 8 SPO	+5.2
	" " "	18:20-19:10	15 QUA, 1 COM, 5 SPO	+4.8
04	Roger Venable, GA	05:28-06:28	15 QUA, 3 SPO	+5.7
	Mark Davis, VA	06:10-07:10	30 QUA, 3 SPO	+5.8
	" " "	07:10-08:10	21 QUA, 3 SPO	+5.6
	Roger Venable, GA	07:29-08:29	37 QUA, 11 SPO	+6.2
	Mark Davis, VA	08:10-09:50	39 QUA, 6 SPO	+5.7; 5% cloudy
	George Zay, CA	08:15-09:27	9 QUA, 4 SPO	+5.4
	Roger Venable, GA	08:47-09:47	52 QUA, 9 SPO	+6.5; 5% cloudy
	Harry Jamieson,Pete Rasmussen, & Rocky Togni, AR	09:20-10:50	36 QUA, 4 SPO	+4.3
	Roger Venable, GA	09:48-10:05	11 QUA, 2 SPO	+6.4; 30% cloudy
	Robert Lunsford, CA	10:32-11:32	15 QUA, 2 SPO	+5.7; 10% cloudy
	" " "	11:32-12:32	28 QUA; 11 SPO	+5.9
	George Zay, CA	12:04-13:43	32 QUA, 7 SPO	+5.4
	Robert Lunsford, CA	12:32-13:47	16 QUA, 6 SPO	+6.0
06	John Gallagher, NJ	05:15-07:51	3 DCA, 5 SPO	+5.6
08	" " "	06:00-08:06	2 DCA, 6 SPO	+6.6
15	" " "	05:00-08:37	2 DCA, 6 SPO	+6.4
17	" " "	04:35-07:20	4 DCA, 6 SPO	+5.8; 10% cloudy
20	" " "	05:25-06:26	*None Seen*	+4.5; 50% cloudy
22	" " "	06:05-08:07	2 SPO	+6.1
27	" " "	05:00-07:05	2 DCA, 1 DLE, 1 SPO	+6.1
28	George Zay, CA	06:45-08:59	8 SPO	+5.6
	" " "	09:00-10:32	16 SPO	+5.9
30	John Gallagher, NJ	05:32-08:08	1 VIR, 1 DLE, 6 SPO	+5.6

Table 1 continued on p. 83 with notes

Table 1—*Continued.*

1992 UT Date	Observer and Location	Universal Time	Number and Type of Meteors Seen*	Comments* (+N = Limiting Magnitude)
FEB 02	John Gallagher, NJ	06:00-08:35	1 DLE, 1 VIR	+6.9
04	" " "	00:20-01:51	2 SPO	+6.5
	" " "	05:00-08:05	2 DLE, 2 VIR, 1 SPO	+7.0
06	" " "	05:20-08:32	2 VIR, 1 DLE, 12 SPO	+7.2
07	" " "	02:20-03:20	*None Seen*	+6.4
08	Mark Davis, VA	07:00-10:00	2 VIR, 19 SPO	+5.8
	George Zay, CA	08:34-11:15	3 DLE, 10 SPO	+6.0
	" " "	11:16-13:10	1 VIR, 12 SPO	+5.9
09	Mark Davis, VA	06:00-10:00	2 VIR, 1 DLE, 21 SPO	+5.8
	George Zay, CA	06:22-08:15	10 SPO	+6.0
10	John Gallagher, NJ	05:20-07:27	3 VIR, 1 DLE, 5 SPO	+7.4
	Mark Davis, VA	08:00-10:00	1 VIR, 10 SPO	+5.7
11	John Gallagher, NJ	00:30-02:10	*None Seen*	+6.6
21	" " "	05:30-07:37	1 DLE, 1 SPO	+5.9; 45% cloudy
22	George Zay, CA	02:54-04:24	6 SPO	+5.1
	" " "	04:25-05:54	1 DLE, 6 SPO	+5.2
	John Gallagher, NJ	05:40-07:46	2 VIR, 2 SPO	+5.5
MAR 01	" " "	06:00-09:09	11 SPO	+7.1
05	" " "	05:00-07:05	1 DLE, 4 SPO	+5.8
10	" " "	00:40-02:45	1 SPO	+6.3
	" " "	06:15-07:19	1 DLE	+6.5; 50 % cloudy
12	" " "	05:45-08:23	1 DLE, 5 SPO	+6.8, 25 % cloudy
15	George Zay, CA	11:45-12:54	9 SPO	+5.7
16	John Gallagher, NJ	00:40-01:44	3 SPO	+6.1
	" " "	01:45-02:47	1 CAM, 2 SPO	+5.1
21	" " "	06:00-08:08	8 SPO	+6.2
24	" " "	00:40-02:42	2 SPO	+6.7
25	" " "	05:50-08:30	2 KSE, 10 SPO	+6.1
29	" " "	06:30-09:14	1 CAM, 12 SPO	+6.6

Key To Abbreviations: **CAM** = Camelopardalids, **COM** = Coma Berenicids, **DCA** = Delta Cancrids, **DLE** = Delta Leonids, **KSE** = Kappa Serpentids, **QUA** = Quadrantids, **SPO** = Sporadics, **VIR** = Virginids.

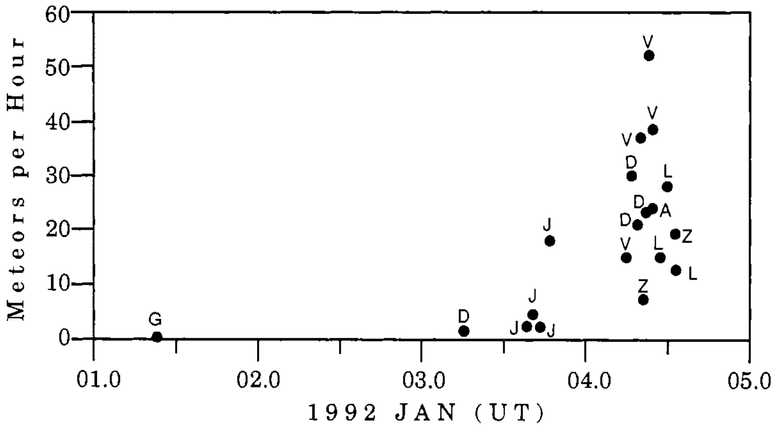


Figure 22. "Raw" rates of Quadrantid meteors based on counts by Mark Davis (D), John Gallagher (G); Harry Jamieson, Pete Rasmussen, and Rocky Togni (A); Han-Sub Jung (J), Robert Lunsford (L), Roger Venable (V), and George Zay (Z) for 1992 JAN 01-04. Symbols are centered at the mid-time of each observing session.

COMET CORNER

By: Don E. Machholz, A.L.P.O. Comets Recorder

PRESENT COMET ACTIVITY

These Summer and Autumn nights offer few comets. However, please continue to make observations and send them to the Comets Recorder (address on inside back cover).

Periodic Comet Schwassmann-Wachmann 1.—This comet will occasionally outburst by several magnitudes, as it did last year, reaching magnitude +12. It follows a near-circular 15-year orbit more than 5 AU [*Astronomical Unit*; the mean distance of the Earth from the Sun] from the Sun. Please report all positive *and negative* observations to this Recorder. [*Table 1*, below and right column]

Comet Shoemaker-Levy (1991a₁).—The team of Carolyn and Eugene Shoemaker and David Levy discovered this comet on plates exposed at Palomar Mountain Observatory on 1991 OCT 06. It will be closest to the Sun on 1992 JUL 24 at 0.84 AU and should be one of the brightest comets of the year. [Recent reports made this comet slightly fainter than predicted. Ed.] [*Table 2*, to right]

Comet Tanaka-Machholz (1992d).—Discovered in late March, 1992, this comet was closest to the Sun on 1992 APR 22 at 1.26 AU. It is now pulling away from both the Sun and the Earth, and thus getting dimmer rather rapidly. [*Table 3*, to right]

EPHEMERIDES

Notes: In the "Elongation. from Sun" column, **E** refers to visibility in the evening sky, and **M** to morning visibility. "Total Mag." values are forecasts of visual total magnitudes and are subject to considerable uncertainty.

Table 1. Ephemeris of Periodic Comet Schwassmann-Wachmann 1.

1992	2000.0 Coörd.				Elongation		Total
UT Date	R.A.		Decl.		from Sun		Mag.
(0h UT)	h	m	°	'	°		
JUL 17	05	11.9	+30	06	036	M	+17.9
22	05	16.0	+30	12	040	M	+17.9
27	05	19.9	+30	18	044	M	+17.9
AUG 01	05	23.6	+30	23	047	M	+17.8
06	05	27.2	+30	28	051	M	+17.8
11	05	30.7	+30	33	055	M	+17.8
16	05	34.0	+30	38	059	M	+17.8
21	05	37.1	+30	43	064	M	+17.8
26	05	40.0	+30	48	068	M	+17.7
31	05	42.7	+30	52	072	M	+17.7
SEP 05	05	45.2	+30	57	076	M	+17.7
10	05	47.4	+31	02	081	M	+17.7
15	05	49.4	+31	06	085	M	+17.6
SEP 20	05	51.1	+31	11	089	M	+17.6
25	05	52.5	+31	16	094	M	+17.6
30	05	53.6	+31	20	099	M	+17.5

(Continued in right column)

Table 1—*Continued.*

Table 2. Ephemeris of Comet Shoemaker-Levy (1991a₁).

1992	2000.0 Coörd.				Elongation		Total
UT Date	R.A.		Decl.		from Sun		Mag.
(0h UT)	h	m	°	'	°		
JUL 17	11	32.7	+47	34	052	E	+6.6
22	11	47.9	+35	38	051	E	+6.6
27	11	56.9	+24	58	049	E	+6.8
AUG 01	12	02.5	+15	53	047	E	+7.0
06	12	06.1	+08	21	045	E	+7.3
11	12	08.4	+02	06	043	E	+7.7
16	12	10.1	-03	07	040	E	+8.0
21	12	11.4	-07	33	038	E	+8.4
26	12	12.4	-11	22	035	E	+8.7
31	12	13.4	-14	43	033	E	+9.1
SEP 05	12	14.3	-17	44	031	E	+9.4
10	12	15.3	-20	27	029	E	+9.8
15	12	16.3	-22	59	028	E	+10.1
20	12	17.4	-25	22	027	E	+10.4
25	12	18.5	-27	37	027	E	+10.7
30	12	19.5	-29	47	027	E	+10.9

Table 3. Ephemeris of Comet Tanaka-Machholz (1992d).

1992	2000.0 Coörd.				Elongation		Total
UT Date	R.A.		Decl.		from Sun		Mag.
(0h UT)	h	m	°	'	°		
JUL 17	08	02.2	+52	10	031	E	+11.1
22	08	13.9	+50	31	030	E	+11.2
27	08	24.4	+48	56	030	M	+11.4
AUG 01	08	33.8	+47	25	030	M	+11.6
06	08	42.3	+46	00	030	M	+11.7
11	08	50.1	+44	38	030	M	+11.9

For those who may wish to compute their own ephemerides for these three comets, here are their orbital elements.

Value	Comet S-W 1	Comet 1991a1	Comet 1992d
T	1991 OCT 26.7	1992 JUL 23.8	1992 APR 22.6
q (AU)	5.7718	0.8367	1.2624
ϖ	049°.90	145°.22	065°.41
☊	312°.12	048°.35	300°.51
i	009°.37	113°.51	079°.26
e	0.0447	1.0000	1.0000
Epoch	1950.0	2000.0	2000.0

JUPITER UPDATE

By: José Olivarez and Phillip W. Budine, A.L.P.O. Jupiter Recorders, and Isao Miyazaki

I. JANUARY, 1992, SYNOPSIS

(Prepared March 31, 1992. Based on observations by Benninghoven, Budine, McDougal, Miyazaki, Olivarez, Robinson, and Whitby)

THE GREAT RED SPOT

As of 1992 JAN 31, the Red Spot's center was at System II longitude (λII) 031°, with a rotation period of 9h 55m 41s.

LONG-ENDURING SOUTH TEMPERATE BELT OVALS

Data on the three STB ovals for January, 1992, follow:

	Oval BC	Oval DE	Oval FA
λ II (JAN 31)	173°	188°	299°
Drift during 30 days	-12°	-15°	-12°
Rotation Period (JAN)	9:55:24	9:55:20	9:55:24

OLIVAREZ BLUE FEATURES

Olivarez Blue Features are dark projections from the south edge of the North Equatorial Belt (NEBs-EZn). Their System-I longitudes (λI), rotation periods, and 30-day drift rates as of 1992 JAN 31 were:

Feature	λI	Rot. Period	Drift Rate
OL-8 (90)	010°	9:50:30	0°
OL-1 (83)	060	9:50:30	0
OL-23 (89)	095	9:50:30	0
OL-1 (89)	184	9:50:29	-1
OL-4 (86)	242	9:50:29	-1
OL-5 (88)	318	9:50:27	-2

OTHER TRANSIT FEATURES BEING FOLLOWED BY THE A.L.P.O. JUPITER SECTION

NEBn-NTrZ Area.—Dark Feature λII longitudes as of 1992 JAN 31 were: Dc No. 5, 215°; Dc No. 1, 340°; Dc No. 7, 280°.

NTBs Area.—Data on longitudes and rotational periods and rates for the North Temperate Belt South rapidly-moving dark spots (Dc) as of 1992 JAN 31 were:

Feature	λI	Rot. Period	Drift Rate
Dc No. 1	208°	9:49:09	-60°
Dc No. 2	291	9:49:11	-59
Dc No. 3	310	9:49:09	-60
Dc No. 4	108	9:49:00	-67

NTBn Area.—Similar data for the white spots (Wc) on the north edge of the North Temperate Belt as of 1992 JAN 31 were:

Feature	λII	Rot. Period	Drift Rate
Wc No. 1	030°	9:55:37	-3°
Wc No. 2	040	9:55:37	-3

NOTES ON SPECIAL FEATURES

- A long-lived white spot in the STrZ-SEBs region continued to exist near λII 240° during January. Its position on 1992 JAN 30 was λII 243°, latitude -21°.
- A persistent tiny dark spot in the SEBs was seen approaching the preceding end of the Great Red Spot Region during January, and was expected to reach the GRS Bay Area at the end of February, 1992.

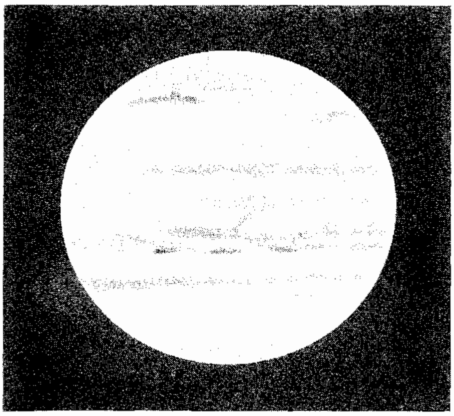


Figure 23. Drawing of Jupiter by Samuel R. Whitby on 1992 JAN 12, 09h 55m UT. 15.2-cm (6.0-in) Newtonian reflector, 155X. Seeing = 9 on the A.L.P.O. 0 (worst) - 10 (best) System; Transparency = 5 on the A.L.P.O.'s similar 0-5 Scale. CM longitudes: λI = 054°, λII = 282°. South at top.

II. FEBRUARY, 1992, SYNOPSIS OF DRIFT AND ROTATION RATES

(Prepared March 12, 1992, by Phillip W. Budine)

Feature and Long. Sys.	Time Span (1991-1992)	Long. Range	Drift Rate	Rot. Period
SSTB (λII):				
Wc No. 3	DEC 12-FEB 29	245-179°	-25°.4	9:55:06
STB (λII):				
Oval BC	DEC 04-FEB 29	198-163°	-12°.1	9:55:24
Oval DE	DEC 04-FEB 29	215-182°	-11°.4	9:55:25
Oval FA	NOV 06-FEB 29	334-286°	-12°.6	9:55:23
Dc No. 1	OCT 10-FEB 29	359-305°	-11°.5	9:55:25
STRZ (λII):				
RSc	OCT 06-FEB 29	029-033°	+0°.82	9:55:42
Wc No. 1	OCT 22-FEB 29	223-249°	+6°.1	9:55:49

(OVER)

Jovian Drift and Rotation Rates—*Continued.*

Feature and Long. Sys.	Time Span (1991-1992)	Long. Range	Drift Rate	Rot. Period
SEBs (λII):				
Dc No. 1	DEC 04-FEB 09	356-012°	+7°.3	9:55:51
NEBs-EZN (λI) *(Note: OL-features are all Dc's)*:				
OL-7 (91)	JAN 26-FEB 29	023-020°	-2°.7	9:50:26
OL-1 (83)	OCT 08-FEB 29	061-060°	-0°.2	9:50:30
Wc No. 1	NOV 09-FEB 29	068-065°	-0°.8	9:50:29
OL-23 (89)	OCT 22-FEB 29	095-095°	0°.0	9:50:30
OL-4 (91)	NOV 25-FEB 29	112-106°	-1°.9	9:50:27
OL-1 (91)	OCT 06-FEB 29	139-154°	+3°.1	9:50:34
Wc No. 6	DEC 25-FEB 29	164-166°	+0°.9	9:50:31
OL-1 (89)	OCT 09-FEB 29	188-192°	+0°.8	9:50:31
OL-6 (91)	JAN 07-FEB 29	217-212°	-2°.8	9:50:26
Wc No. 7	FEB 01-FEB 29	270-270°	0°.0	9:50:30
OL-4 (86)	Oct 23-Feb 29	244-243°	-0°.2	9:50:30
Wc No. 3	JAN 28-FEB 29	253-250°	-2°.8	9:50:26
OL-8 (91)	JAN 28-FEB 29	277-277°	0.0	9:50:30
OL-5 (91)	DEC 10-FEB 29	307-306°	-0°.4	9:50:29
OL-5 (88)	OCT 12-FEB 29	320-315°	-1°.1	9:50:29
Wc No. 4	JAN 28-FEB 29	318-318°	0.0	9:50:30
NEBn-NTrZ (λII):				
Dc No. 1	OCT 20-FEB 29	352-342°	-2°.3	9:55:37
Dc No. 2	NOV 09-FEB 29	047-060°	+3°.5	9:55:45
Wc No. 3	NOV 09-FEB 29	059-074°	+4°.1	9:55:46
Dc No. 5	OCT 10-FEB 29	227-217°	-2°.1	9:55:38
Dc No. 7	NOV 11-FEB 29	245-242°	-0°.8	9:55:40
Wc No. 8	DEC 25-FEB 29	162-161°	-0°.5	9:55:40
Wc No. 11	MAR 30'91-FEB 29	336-336°	0°.0	9:55:41
Wc No. 13	MAR 30'91-FEB 29	016-016°	0°.0	9:55:41
Wc No. 15	JAN 26-FEB 29	233-230°	-2°.7	9:55:37
NTBs (λI):				
Dc No. 1	NOV 30-FEB 29	327-143°	-59°.4	9:49:10
Dc No. 2	NOV 18-FEB 29	078-228°	-61°.8	9:49:07

NOTES (as of 1992 FEB 29)

- **SEBs:** Dc No. 1 was last observed on 1992 FEB 09 at λII = 012°.
- **NEBs-EZn:** Dc OL-8 (90) was last observed on 1992 JAN 31 at λI = 010°.
- **NTBs:** Dc No. 3 was last observed on 1992 JAN 31 at λI = 310°. Dc No. 4 was last observed on 1992 JAN 31 at λI = 108°.
- **NTBn:** Wc No. 1 was last observed on 1992 JAN 31 at λII = 030°. Wc No. 2 was last observed on 1992 JAN 31 at λII = 040°.

III. OUTSTANDING FEATURES OBSERVED ON JUPITER IN MARCH, 1992.

(Prepared April 7, 1992, by José Olivarez)

There were four outstanding features or types of features in March, 1992:

- **The Great Red Spot:** After being faint during January and February, the RS appeared to intensify in March and became a well-defined light-orange ellipse about 22° long in longitude, centered at about λII = 032°.
- **Blue Festoons in the Equatorial Zone:** The Olivarez Blue Features in the NEBs-EZn region were very active in March and appeared especially well-defined and *very bluish* as seen in 8- and 12-1/2-inch telescopes by José Olivarez. These dark projections were each usually followed by an adjacent white region or oval. See the column to the left for the recent longitudes.
- **Brilliant White Ovals in the Equatorial Zone:** Several brilliant white ovals were observed in the Equatorial Zone. An especially bright one was recorded by Olivarez on 1992 MAR 14. This oval was the brightest feature on the planet and attracted wide attention. It was seen again on 1992 MAR 21 by Olivarez, when it was still the brightest feature on the planet.
- **The False Red Spot:** A very dark segment of the STB-SSTmB combination that was following the long-enduring Oval FA attracted wide attention in February and was mistaken for the Great Red Spot by a number of novice Jupiter observers. The center of this dark segment lay at λII = 320° on 1992 FEB 27 and had moved to λII = 278° by 1992 MAR 21, according to transit timings by Olivarez.

INTENSITIES OF THE BELTS AND ZONES

The darkest belt on Jupiter in March was the NEB. After it, in descending order of intensity, were the NTB, SEBn, the "EZs Belt," and the SSTB.

The brightest zone on Jupiter was the NTrZ, which appeared bright white.

NEW ACTIVITY NEAR THE GREAT RED SPOT

The development of a new STB segment preceding the Great Red Spot was noted by Olivarez on 1992 MAR 31. This new dark segment looked bluish in a 12-1/2-inch reflector. Also, an inclined streak appeared to project from the SSTB toward the GRS at the latter's following end. This appearance is shown in *Figure 24* (below).

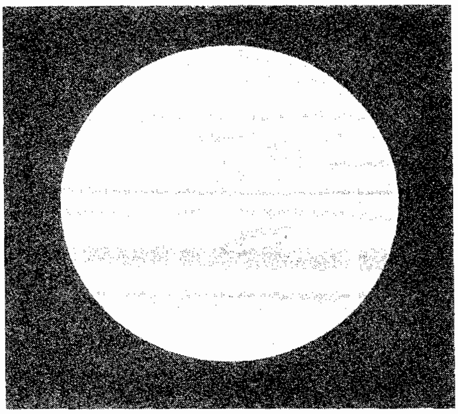


Figure 24. Drawing of Jupiter by José Olivarez on 1992 MAR 31, 02h 30m UT. 20-cm (8-in) reflector, 195X. Seeing = 7 (0-10 scale); Transparency = 4 (0-5 scale). λI = 026°, λII = 014°. South at top.

IV. MARCH, 1992, SYNOPSIS OF DRIFT AND ROTATION RATES

(Prepared March 31 1992, by Phillip W. Budine)

Feature and Long. Sys.	Time Span (1991-1992)	Long. Range	Drift Rate	Rot. Period
STB (λII):				
Oval BC	Dec 04-Mar 31	198-150°	-12°.3	9:55:24
Oval DE	Dec 04-Mar 31	215-170°	-11°.5	9:55:25
Oval FA	Nov 06-Mar 31	334-272°	-12°.7	9:55:23
Dc No. 1	Oct 10-Mar 31	359-289°	-12°.1	9:55:24
STrZ (λII):				
RSc	Oct 06-Mar 31	029-035°	+1°.02	9:55:42
Wc No. 1	Oct 22-Mar 31	223-255°	+5°.9	9:55:49
Dc No. 1	Feb 07-Mar 31	348-000°	+6°.7	9:55:50
NEBs-EZn (λI) *(Note: OL-features are all Dc's)*:				
Wc No. 5	Jan` 26-Mar 31	038-037°	-0°.5	9:50:29
OL-3 (91)	Nov 25-Mar 31	041-048°	+1°.7	9:50:32
OL-1 (83)	Oct 08-Mar 31	061-060°	-0°.2	9:50:30
OL-2 (91)	Nov 09-Mar 31	075-073°	-0°.4	9:50:29
OL-23 (89)	Oct 22-Mar 31	095-093°	-0°.4	9:50:29
OL-4 (91)	Nov 25-Mar 31	112-105°	-1°.7	9:50:28
Wc No. 2	Nov 25-Mar 31	120-108°	-2°.9	9:50:26
Wc No. 11	Mar 04-Mar 31	140-137°	-3°.3	9:50:26
Dc No. 12	Mar 04-Mar 31	148-146°	-2°.2	9:50:27
OL-1 (91)	Oct 06-Mar 31	139-153°	+2°.4	9:50:33
Wc No. 6	Dec 25-Mar 31	164-164°	+0°.0	9:50:30
OL-1 (89)	Oct 09-Mar 31	188-189°	+0°.2	9:50:30
OL-6 (91)	Jan 07-Mar 31	217-212°	-1°.8	9:50:28
Wc No. 7	Feb 01-Mar 31	270-270°	0°.0	9:50:30
OL-4 (86)	Oct 23-Mar 31	244-244°	-0°.0	9:50:30
Wc No. 3	Jan 28-Mar 31	253-252°	-0°.5	9:50:29
OL-8 (91)	Jan 28-Mar 31	277-275°	-0°.9	9:50:29
OL-5 (88)	Oct 12-Mar 31	320-312°	-1°.4	9:50:28
Dc No. 8	Feb 02-Mar 31	343-345°	+1°.1	9:50:31
Wc No. 13	Feb 02-Mar 31	352-352°	0°.0	9:50:30
NEBn-NTrZ (λII):				
Dc No. 1	Oct 20-Mar 31	352-339°	-2°.4	9:55:37
Dc No. 2	Nov 09-Mar 31	047-060°	+2°.8	9:55:44
Wc No. 3	Nov 09-Mar 31	059-073°	+2°.9	9:55:45
Dc No. 5	Oct 10-Mar 31	227-219°	-1°.4	9:55:39
Dc No. 7	Nov 11-Mar 31	245-243°	-0°.4	9:55:40
Wc No. 8	Dec 25-Mar 31	162-165°	+0°.9	9:55:42
Wc No. 11	Jan 30-Mar 31	336-335°	-0°.5	9:55:40
Wc No. 12	Jan 30-Mar 31	352-348°	-2°.0	9:55:38
Wc No. 13	Jan 30-Mar 31	016-015°	-0°.5	9:55:40
Wc No. 15	Jan 26-Mar 31	233-229°	-1°.8	9:55:38
Dc No. 10	Nov 21-Mar 31	087-087°	0°.0	9:55:41
Dc No. 14	Nov 13-Mar 31	136-135°	-0°.2	9:55:40
Dc No. 9	Dec 06-Mar 31	167-173°	+1°.5	9:55:43
Wc No. 16	Feb 29-Mar 31	198-199°	+0°.9	9:55:42
Dc No. 18	Feb 01-Mar 31	299-292°	-3°.5	9:55:36
NTBs (λI):				
Dc No. 1	Nov 30-Mar 31	327-087°	-58°.5	9:49:11
Dc No. 2	Nov 18-Mar 31	078-166°	-60°.4	9:49:09

NOTES

This report is based on March observations as of 1992 MAR 31. The following observers contributed transit timings and strip sketches or photographs: Claus Benninghoven, Mark Bosselaers, Phillip Budine, Frank Daerden, Walter Haas, Craig MacDougal, Isao Miyazaki, Michael Morrow, Dietmar Niechoy, Donald Parker, Robert Robinson, Randy Tatum, and Samuel Whitby. Sample drawings by Robinson and Budine are shown in *Figures 25-26* (right column).

Observations by José Olivarez on 1992 MAY 13 showed that the center of the Great Red Spot then lay at λII = 038°, an increase in longitude of 3° from March.

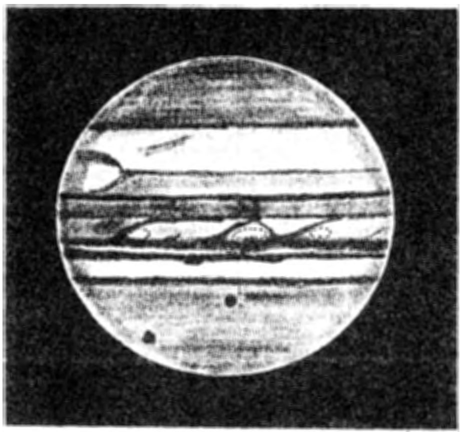


Figure 25. Drawing of Jupiter by Robert L. Robinson. 1992 MAR 05 (UT inferred as 02h20m). 25-cm (10-in) reflector, 164-246X. Seeing 7-8 (0-10 scale). λI = 233°, λII = 058°. South at top.

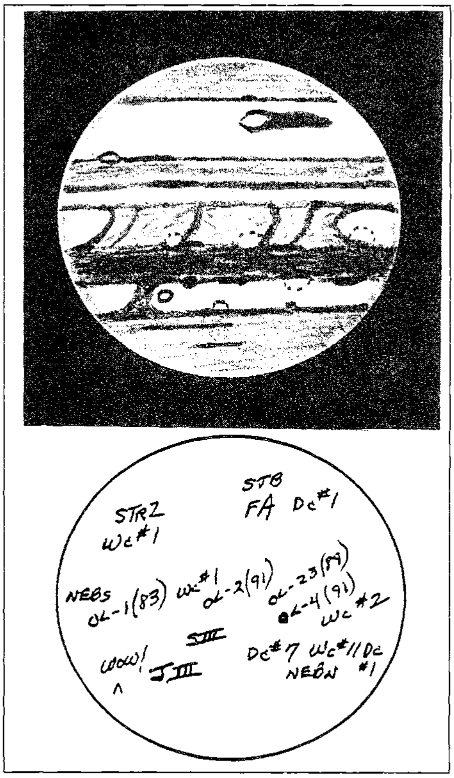


Figure 26. Drawing of Jupiter by Phillip W. Budine on 1992 MAR 04, 02h 45m UT. 10-cm (4-in) refractor, 150X and 167X; also observed with 20-cm (8-in) reflector, 205X.. Seeing = 8 (0-10), Transparency = 5 (0-5). λI = 090°, λII = 283°. Below the drawing is a diagram that identifies some of the transit features listed in the text. South at top.

COMING SOLAR-SYSTEM EVENTS: JULY-SEPTEMBER, 1992

WHAT TO LOOK FOR

This column is intended to alert our readers about upcoming events in the Solar System; giving visibility conditions for major and minor planets, the Moon, comets, and meteors. You can find more detailed information in the 1992 edition of the *A.L.P.O. Solar System Ephemeris.* (See p. 96 to find out how to obtain this publication.) Celestial directions are abbreviated. All dates and times are in Universal Time (UT). For the time zones in the United States, UT is found by adding 10 hours to HST (Hawaii Standard Time), 9 hours to AST (Alaska Standard Time), 8 hours to PST, 7 hours to MST, 6 hours to CST, and 5 hours to EST. Note that this addition may well put you into the next UT day!

PLANETS: COMING AND GOING

Saturn lies in Capricornus and reaches opposition on 1992 AUG 07, when its disk will measure 19 by 17 arc-seconds. The Saturn System, including its 42-by-12 arc-second Rings, will then be at magnitude +0.2. The Rings remain well-presented, with the Earth 16° above their N face. Also, its "variable moon," **Iapetus**, passes close to Saturn on 1992 JUL 26 and SEP 04, when the 11th-magnitude satellite will be relatively easy to identify. In the E Sky in the evening, the Ringed Planet will be visible almost all night.

The Remote Planets **Uranus** and **Neptune** are both in Sagittarius, about 25-30° W of Saturn, and are thus also well placed in the evening S sky. Indeed, Uranus is in opposition on 1992 JUL 07, at magnitude +5.6, and should be visible to the naked eye at a dark site. Near the date of opposition, its disk subtends 3.8 arc-seconds. At magnitude +7.8, Neptune requires binoculars to locate. However, finding it should be easier when it passes just 0.4 arc-minutes N of the +6.42-magnitude star BS 7276 on 1992 AUG 13, 01h. While on the subject of the Remote Planets, note that 14th-magnitude **Pluto** remains visible in the evening near the Serpens-Libra border.

Jupiter remains in Leo and is visible as a -1.7-magnitude star, a little brighter than Sirius, low in the west after sunset in July and August. On 1992 JUL 28, 21h UT, the Giant Planet passes 17 arc-minutes S of the +4.63-magnitude star χ Leonis; a good opportunity to compare the star's brightness with that of the each Galilean satellite in a low-power field. Then, on 1992 AUG 23, 05h UT, Venus (magnitude -3.9, 19° E of the Sun) passes just 17 arc-minutes N of Jupiter, so the brightnesses and colors of the two brightest planets can be compared directly in a low-power telescopic view. Thereafter Jupiter is essentially unobservable until late October, being in conjunction with the Sun on 1992 SEP 17.

Mars continues to pull slowly away from the Sun in the morning eastern sky and is visible as a reddish star as it moves from Aries to Taurus to Gemini. It will brighten slightly from visual magnitude +0.8 on July 1st, when 58° W of the Sun, to magnitude +0.3 on October 1st, when 88° W of the Sun. Its disk diameter grows only from 5.7 to 8.2 arc-seconds during the same period, when larger amateur instruments should show some detail. In the early part of our period, Mars' Southern Hemisphere is tilted toward us; but the Earth is moving N, crossing Mars' equator on 1992 AUG 30, after which the Martian Nouth Pole is tilted toward us. The phase defect (on the W or preceding limb) will become gradually more evident, with the fraction illuminated dropping from 89 percent on July 1st to 87 percent on October 1st. Helping Northern-Hemisphere observers, the Red Planet moves northward 9° during these three months, ending at declination 23° N on October 1st.

In August and September, Mars is passing through the Milky Way, so do not be surprised to see a star in the same field as the Red Planet. Some such conjunctions are:

AUG 04, 19h. Mars 1 arc-min. N of ω Tau (Mag. +4.96), 67° W of the Sun.
AUG 06, 15h. Mars 1 arc-min. N of BS 1370 (Mag. +6.04), 67° W of the Sun.
SEP 05, 16h. Mars 2 arc-min. S of BS 1961 (Mag. +6.09), 77° W of the Sun.
SEP 12, 16h. Mars 4 arc-min. N of open star cluster NGC 2129, 80° W of the Sun.
SEP 13, 22h. Mars 8 arc-min. N of 1 Gem (Mag. +4.16), 80° W of the Sun.

As is its wont after superior conjunction, **Venus** is creeping up into the western sky in the early evening. Throughout our period it remains at magnitude -3.9, but its elongation east of the Sun increases from only 5° on 1992 JUL 01 to 29° on OCT 01. During the same interval, its diameter grows from 9.7 to 11.8 arc-seconds, and its phase decreases from 100 to 87 percent. (Venus' AUG 23 conjunction with Jupiter is described under that planet.)

For once, observers in the Earth's Northern Hemisphere have two favorable apparitions of **Mercury** in a row. In late June-early July, Mercury was well-placed in the west after sunset, reaching a Greatest Eastern Elongation of 26° on 1992 JUL 06. The next apparition is a morning one, centered on its Greatest Western Elongation of 18° on 1992 AUG 21. Observe Mercury for a few days on either side of this date in order to estimate the time of its apparent *dichotomy* (half-phase). For the latter apparition, the innermost planet remains over 15° from the Sun between 1992 AUG 13 and AUG 29. There's a nice conjunction of Mercury with Jupiter on 1992 SEP 16, with just one problem—the two planets are only 2° E of the Sun at the time!

MINOR PLANETS

Three of the brightest of the **minor planets** reach opposition during 1992 JUL-SEP. Their 10-day ephemerides are given in the 1992 edition of the *A.L.P.O. Solar System Ephemeris*, and their opposition data are given below:

	Opposition Data		
Minor Planet	1992 Date	Stellar Magnitude	Declination& Constellation
21 Lutetia	JUL 05	+9.4	25°S Sag
1 Ceres	JUL 29	+7.5	30°S Mic
68 Leto	SEP 08	+9.6	19°S Aqr

Besides the objects above, the remaining three of the "Big Four" minor planets, **2 Pallas**, **3 Juno**, and **4 Vesta** will be brighter than Mag. +10 during at least part of the current period, along with **532 Herculina**.

THE MOON

During the current period, the schedule for the Moon's **phases** is:

New Moon	First Quarter	Full Moon	Last Quarter
JUN 30.5	JUL 07.1	JUL 14.8	JUL 22.9
JUL 29.8	AUG 05.5	AUG 13.4	AUG 21.4
AUG 28.1	SEP 03.9	SEP 12.1	SEP 19.8
SEP 26.4	OCT 03.6	OCT 11.8	OCT 19.2

The three lunations listed above constitute Numbers 860-863 in Brown's series.

The other significant lunar visibility condition is the Moon's **librations**, or E-W and N-S tilts in relation to the Earth. Extreme librations occur on the following dates:

North	East	South	West
JUL 06	JUL 09	JUL 20	JUL 24
AUG 02	AUG 06	AUG 17	AUG 22
AUG 30	SEP 03	SEP 13	SEP 19
SEP 26	OCT 01	OCT 10	OCT 16

Lunar E and W directions here follow the usage of the International Astronomical Union, with Mare Crisium near the *east* limb. Favorable libration-lighting conditions for viewing the NE limb occur on JUL 05-10, AUG 02-06, AUG 30-SEP 02, and SEP 29. Likewise, the SW limb will be well-presented on JUL 20-24, AUG 17-20, and SEP 15-16. Worthwhile dates for viewing the lunar N polar area are JUL 04-09, AUG 01-05, AUG 30-SEP 01, and SEP 24-25.

PLANETARY AND LUNAR OCCULTATIONS

Eleven minor planets will occult stars in 1992 JUL-SEP. See *Table 1* (p. 90) which lists the date, occulting object, visual magnitude of planet followed by that of the star, and *possible* zone of visibility for each occultation.

The Moon passes in front of Mars on 1992 SEP 20, 09h when both are 83° W of the Sun. This event will be visible in southern South America, with Mars disappearing at the sunlit limb of the 45-percent illuminated last-quarter Moon, and reappearing at the dark limb. Many places will be able to see this event in a dark sky, and the table below gives information for some selected locations.

	Disappearance			Reappearance		
Site	UT h	Alt.☽	Alt.☉	UT h	Alt.☽	Alt.☉
Buenos Aires	07.5	+20°	-28°	09.0	+29°	-10°
Cerro Tololo	07.2	+13°	-43°	08.4	+24°	-28°
Rio de Janeiro	08.0	+40°	-11°	09.4	+44°	+ 9°
Santiago	07.3	+12°	-40°	08.5	+22°	-26°
Saõ Paulo	07.9	+37°	-16°	09.3	+43°	+ 3°

More information about these and other occultations can be had from the International Occultation Timing Association (IOTA), 1177 Collins Ave., SW, Topeka, KS 66604, U.S.A.

COMETS

The column by Don E. Machholz, "Comet Corner," on p. 84, and the *A.L.P.O. Solar System Ephemeris: 1992* list thirteen known comets that will be visible during at least part of this period. Of these, **Comets Shoemaker-Levy (1991d)**, **Helin-Lawrence (1991L)**, **Shoemaker-Levy (1991a1)**, **P/Ciffréo**, and **Tanaka-Machholz (1992d)** should be visible in amateur instruments under dark skies.

METEOR SHOWERS

(Contributed by Robert D. Lunsford, A.L.P.O. Meteors Recorder)

The last week of July offers no less than seven active meteor radiants visible at once. The main attraction is the **South Delta Aquarids**, which reach maximum strength on July 28th this year, with their radiant located at right ascension 22h 13m, declination -17°. Observers in the southern United States [better yet, in the Southern Hemisphere] will see more members of this shower, due to the radiant's higher altitude. This shower's maximum rates can approach 30 meteors per hour. Other active showers during this period include the **Piscid Austrinids**, **Alpha Capricornids**, **South Iota Aquarids**, **North Delta Aquarids**, **Perseids**, and the controversial **Upsilon Pegasids**. The Moon is new on July 29th, so it will not interfere during this period; get out and watch the show!

The **Perseid** maximum coincides exactly with Full Moon this year. Normally only 20-30 shower members per hour are visible under these conditions. With the display that occurred over Japan in 1991, this shower may again be strong despite the lunar interference. The predicted maximum should occur near 0 hours UT on AUG 12, promising great circumstances for Europe and Western Asia; but it is too early for North America. Should the maxi-

Table 1. Occultations of Stars by Planets, 1992 JUL-SEP.
(For further information, consult the A.L.P.O. Solar System Ephemeris: 1992 or Sky & Telescope, January, 1992, p. 76.)

1992		Occulting	Visual Mag.		
	UT Date	Object	Occulter	Star	Predicted Visibility Zone
JUL	01.39	**54 Alexandra**	+11.5	+9.4	N South America
	03.56	**498 Tokio**	+11.6	+9.1	Taiwan, Japan
	10.65	**690 Wratislavia**	+12.0	+9.0	SE Asia
	20.68	**165 Loreley**	+11.7	+9.2	Mongolia, N China, South Korea, Japan
AUG	09.26	**490 Veritas**	+12.9	+9.3	SE Canada, NW U.S.A., Hawaii?
	28.27	**37 Fides**	+11.3	+9.4	South America
SEP	12.30	**344 Desiderata**	+11.1	+8.6	N Canada; SE Canada, NW U.S.A.?
	14.48	**58 Concordia**	+14.2	+6.6	W U.S.A.
	17.02	**2 Pallas**	+10.9	+9.0	Central South America; Central America?
	19.06	**2 Pallas**	+10.9	+8.9	Greenland, E Canada, Bermuda?
	25.33	**6 Hebe**	+10.8	+8.3	NE Canada; NE U.S.A., SE Canada?
	27.39	**21 Lutetia**	+11.3	+9.0	E Australia

mum occur later, North America, especially its east coast, could see an impressive display. Be sure to observe on the morning of the 12th, facing toward the northeast with the Full Moon at your back.

An often-neglected shower than merits observing time is the **Aurigids**. This shower peaks in 1992 on the morning of August 31st, with its radiant located at right ascension 05h 38m, declination +42°. Its shower members are very swift and are best seen during the last few hours before morning twilight. The brighter members tend to leave persistent trains. The hourly rates for this shower are usually low, but as recently as 1986 the zenithal hourly rate reached 40.

SCHRÖTER'S EFFECT ON VENUS: TWO LETTERS

"Schröter's Effect" refers to the discrepancy between the predicted and observed times of Venus' half-phase or *dichotomy*. First noted by the German astronomer Johann Schröter almost 200 years ago, this phenomenon has never been explained. I have developed a theory to account for the discrepancy, but it requires testing against good-quality CCD imagery to determine whether it is correct. The next favorable time to investigate the Schröter Effect will occur in January, 1993, when Venus reaches dichotomy again. I am organizing a project to make slow-scan CCD observations of this event to determine the shape of Venus' terminator. The minimum requirements are a 4-inch telescope (without a spider support) that provides an image of Venus spanning at least 40 pixels on your CCD, a visible-light filter, and calibration of the images for flat field and bias. Observations will be collected before and after dichotomy also. Interested observers are invited to contact me for more information. My e-mail address is tmallama@stx.com.

Anthony Mallama
Galileo Observatory
14012 Lancaster Lane
Bowie, MD 20715

In his note on "Dichotomy and Venus" on page 365 of *Sky & Telescope* for April, 1992, Mr. Ken Ramsley reminds us that the Sun is not a point source as seen from Venus and hence illuminates more than half of that planet. Thus half of the visible whole disc of Venus will be sunlit when the planet is on the crescentic side of dichotomy, whereas the famous Schröter Effect places *observed* half-phase on the gibbous side of dichotomy.

However, we should remember that what has been observed over the centuries is *not* what portion of the disc is sunlit but rather when the terminator is exactly straight. In evening apparitions the terminator is convex before dichotomy and concave afterwards; the reverse is true for morning apparitions. The terminator can obviously be straight when more than half of the disc is lit because the Sun is not a point and also when less than half is seen as lit because the dimly lit terminator regions are invisible.

Mr. Ramsley does well to question whether the observed terminator coincides with geometric reality. Over decades of observing Venus I have repeatedly found that Wratten Filter 47 (deep blue), which transmits about 3 percent of the light in the visual range, causes the disc to look smaller and more concave when compared to filters of greater total transmission, clearly because the dimly lit terminator regions vanish. Whether we have here a complete *quantitative* explanation of the Schröter Effect, sometimes regarded as a discrepancy of many days from geometric dichotomy, must still be, I think, an open question.

Walter Haas
Director Emeritus, A.L.P.O.
2225 Thomas Drive
Las Cruces, NM 88001

THE 1991 APPARITION OF NEPTUNE

By: Richard W. Schmude, Jr., A.L.P.O. Remote Planets Recorder

ABSTRACT

Four persons submitted photoelectric measurements, visual observations, or both of Neptune during 1991. A total of 55 photometric measures were made, resulting in adopted magnitudes (blue, visual, red, and infrared; adjusted to unit distance from the Earth and Sun) of: B(1,0) = -6.55±.03, V(1,0) = -6.91±.02, R(1,0) = -6.56, and I(1,0) = -5.82±.11. The visual- and blue-band values suggest that Neptune may have been slightly brighter in 1991 than in previous years. Visual studies indicated that Neptune had a greenish hue in 1991, in contrast with the bluish hue that it had in the late 1980's.

INTRODUCTION

Neptune reached opposition on 1991 JUL 08, having a declination of 22°S and an angular diameter of 2.3 arc-seconds [7]. Four persons, listed with their location, form of observation, and instrument in *Table 1* below, contributed observations of this planet in 1991. The observations consisted of photoelectric photometry and visual studies.

Table 1. Participating Observers, 1991 Apparition of Neptune.

Observer and Location	Type of Observation*	Type of Telescope†
David L. Graham, England	V	15-cm (6-in) Ref
Frank J. Melillo, NY, USA	PP, V, C	20-cm (8 -in) S-C
Richard W. Schmude, Jr., NM, USA	PP, V, C	25-cm (10-in) New
John E. Westfall, CA, USA	PP	36-cm (14-in) S-C

* C = color, PP = photoelectric photometry, V = visual.
† New = Newtonian, Ref = refractor, S-C = Schmidt-Cassegrain.

PHOTOMETRY

A total of 13 B-filter (blue), 36 V-filter (visual), 1 R-filter (red), and 5 I-filter (infrared) photometric measurements of Neptune were made by three persons in 1991. All used SSP-3 solid-state photometers, described previously. **[1, 2]** All filters used closely matched the Johnson BVRI System. [The most widely-used set of wavelength ranges. Ed.]

As with our previous Uranus report **[1]**, the visual magnitude, V(1,0), set to a distance of 1.0 Astronomical Unit from the Sun and the Earth, was found from equation (1):

$$V(1,0) = V_{meas} - 5\log(r\Delta) - 2.5\log k - (m\alpha) \quad (1)$$

where $\mathbf{V_{meas}}$ is the measured stellar magnitude, **r** is the Neptune-Sun distance, Δ is the Neptune-Earth distance [both distances in AU], **k** is the fraction of Neptune's disk which is illuminated by the Sun as seen from the Earth; **m** is the solar phase-angle coefficient for the Johnson V filter, which is estimated to be 0.007 magnitudes/degree; and α is the phase angle in degrees, or angle between the Earth and the Sun as seen from Neptune. **[1, 3]**

The third term, **2.5 log k**, never exceeds 0.0004 magnitudes for Neptune and is ignored here. The fourth term, **(mα)**, can amount to as much as 0.013 magnitudes for the V(1,0) value but was also neglected because **m** is unknown for the Johnson B, R, and I filters. The **2.5 log k** and the **(mα)** terms were also neglected for the B(1,0), R(1,0) and I(1,0) calculations. One of the goals of the A.L.P.O. Remote Planets Section is to measure the solar phase coefficient, **m** of Neptune for the Johnson B, R, and I filters.

The names, positions, and multicolor magnitudes of the comparison stars used in the 1991 measurements are summarized in *Table 2* (p. 92), along with the names of the observers who used those stars. The magnitudes for o Sgr and π Sgr are from source **[4]**, while those of SAO 187634 are from source **[5]**. One problem with some of the measurements is that π Sgr was used as a comparison star, and source **[6]** lists this as a "suspected variable." Because of this possible source of error, the final magnitudes for 1991 are separated into two categories: (1) all data and (2) the data excluding measures that used π Sgr as the comparison star.

All 55 photometric measurements of Neptune are arranged in chronological order in *Table 3* (p. 93), and are all based on the stellar magnitudes listed in *Table 2*. In those cases where the observer used a stellar magnitude that was different than the one listed in *Table 2*, the Neptune magnitude measurement was changed to reflect a comparison-star magnitude consistent with *Table 2*. For example, the V-magnitude of π Sgr was reported to be +2.87 in source **[4}** but as +2.89 in source **[5]**; and all measures using it were converted, if necessary, to be consistent with the value of +2.87.

Table 4 (p. 93) gives the mean multicolor magnitudes of Neptune for 1991 along with those listed in sources **[7]** and **[8]** for comparison. There were no significant differences among the observations made using π Sgr, o Sgr, or SAO 187634 as comparison stars, which suggests that the comparison-star mag-

Table 2. Comparison Stars Used for the Photometry of Neptune in 1991. (2000.0 Coordinates)

Star Name	R. A.	Dec.	B	V	R	I	Observers Using Star	Source
SAO 187634	19h 04.3m	-21°32'	7.70	7.18	--	--	Schmude†	[5]
o Sgr	19h 04.7m	-21°44'	4.78	3.77	3.13	2.59	Melillo, Schmude	[4]
π Sgr	19h 09.8m	-21°01'	3.20	2.87	2.53	2.28	Schmude*†, Westfall	[4]

*Used only in June. †o Sgr used as check star.

nitudes given in *Table 2* are accurate. Also, on 1991 JUL 06 the writer made 10 measurements of Neptune using SAO 187634 as the comparison star and o Sgr as the check star. The V magnitude of o Sgr was measured as +3.78, only 0.01 magnitude different from its value in *Table 2*.

The mean magnitudes derived for Neptune for 1991 are:

$$B(1,0) = -6.55 \pm .03,\ V(1,0) = -6.91 \pm .02,$$

$$R(1,0) = -6.56,\ \text{and}\ I(1,0) = -5.82 \pm .11.$$

[There is no uncertainty range for R(1,0), which is based on only one measurement. The uncertainty range for I(1,0) is high as there were only five measurements and because of their high scatter. The latter is perhaps due to the faintness of Neptune in this spectral range, which includes methane absorption bands. Ed.] Appleby reports a value of V(1,0) = -6.90±.03 for Neptune as based on measurements made between 1962 and 1964 **[9]**. The 1991 and 1962-1964 values are in close agreement but are slightly fainter than those reported elsewhere **[7, 8]**. The 1991 value is also brighter than the 1989 magnitude, but fainter than the 1990 A.L.P.O. measurements **[10]**. Also, Lockwood reported that Neptune became brighter in 1990, as compared with earlier years, rather than becoming fainter as was expected **[11]**. The values given in *Table 4* are consistent with Neptune having remained brighter than expected in 1991 as well.

VISUAL STUDIES OF NEPTUNE

Melillo and Schmude studied Neptune's disk during the 1991 Apparition with apertures of 20 and 25 cm (8 and 10 in) respectively. They observed no albedo features similar to those reported in sources **[12]** and **[13]**. These negative results agree with an observation made by Patrick Moore in September, 1991. He used the 152-cm (60-in) reflector at Palomar Mountain Observatory to study Neptune and found no markings on the disk **[14]**.

Neptune may have had an unusually strong green color during 1991. Moore reported that Neptune was greener than normal as seen through the 152-cm telescope mentioned above **[14]**. Melillo reported that Neptune had a blue-green color during July and August, 1991. These observations differ from the bluish color that the planet had in the late 1980's **[13, 15, 16]**. The bluish color of Neptune as observed by O'Meara in August, 1988, is especially significant because he used the same aperture of telescope as Moore did in 1991. Although no definite conclusions can be drawn from these visual studies, the results are interesting. This writer hopes that more people will report color observations of Neptune in 1992. [The (B-V) color index of Neptune in 1991 was +0.36 magnitudes, definitely less blue than reported in sources **[7]** and **[8]**. Ed.]

Finally, Graham submitted visual observations of Neptune that he had made in 1989. On 1989 JUL 04 he suspected that the planet had a blue-green color. His drawings also show limb darkening.

CONCLUSION

During the 1991 Apparition of Neptune, three individuals used SSP-3 solid-state photometers for a total of 55 multicolor measurements of the brightness of the planet. The mean reduced magnitudes that resulted are given in *Table 4* (p. 93), and all of them are based on measurements where either o Sgr or SAO 187634 was the comparison star. The V(1,0) magnitude of Neptune was 0.04 magnitudes or 4 percent brighter in 1991 than the value reported in the *Astronomical Almanac* **[7]**. Visual observations were made by three persons, two of whom reported that Neptune had an unusually greenish hue in 1991.

ACKNOWLEDGEMENTS

The writer wishes to express his gratitude to the observers who submitted data in 1991. Special thanks go to Aryan Hastings, Frank Melillo, John Westfall, and Bill Winkler for proofreading this manuscript before publication, as well as that of reference **[1]**.

REFERENCES

1. Schmude, R.W. Jr. "The 1991 Apparition of Uranus." *J.A.L.P.O.*, *36*, No. 1 (March, 1992), pp. 20-22.
2. Optec, Inc. *Model SSP-3 Solid-State Stellar Photometer Technical Manual for Theory of Operation and Operating Procedures.* Lowell, MI: Optec, Inc., 1988.
3. Lockwood, G.W. "Photometry of Planets and Satellites." Cpt. 2 in: Genet, R.M., ed. *Solar System Photometry Handbook.* Richmond, VA: Willmann-Bell, Inc., 1983.
4. *Arizona-Tonantzintla Catalog*. Sky Publishing Corp., Belmont, MA, 1965.
5. Hirshfeld, A. & Sinnott, R.W., Eds. *Sky Catalog 2000.0, Vol. 1, Stars to Magnitude 8.0.* Sky Publishing Corp., Cambridge, MA, 1982.

Table 3. Summary of Photometric Measurements Made of Neptune During the 1991 Apparition.

Note: "Meas." = measured magnitude; "Normal." = magnitude normalized to 1 AU from Earth and Sun

1991		Magnitude		Comparison
UT Date	Filter	Meas.	Normal.	Star
JUNE		+	-	
06.359	V	7.87	6.87	π Sgr
06.362	B	8.22	6.52	π Sgr
09.338	V	7.86	6.87	π Sgr
09.349	B	8.22	6.51	π Sgr
13.326	V	7.76	6.97	π Sgr
13.336	B	8.12	6.61	π Sgr
15.380	V	7.75	6.98	π Sgr
15.386	B	8.22	6.51	π Sgr
15.390	V	7.78	6.95	π Sgr
15.400	B	8.20	6.53	π Sgr
15.404	V	7.83	6.90	π Sgr
15.415	B	8.20	6.53	π Sgr
15.419	V	7.80	6.93	π Sgr
17.249	V	7.87	6.86	π Sgr
17.255	B	8.10	6.63	π Sgr
17.258	V	7.78	6.95	π Sgr
17.267	B	8.13	6.60	π Sgr
17.270	V	7.80	6.93	π Sgr
17.278	B	8.21	6.52	π Sgr
17.298	V	7.81	6.92	π Sgr
17.301	B	8.12	6.61	π Sgr
19.253	V	7.83	6.90	π Sgr
21.241	V	7.81	6.92	π Sgr
22.238	V	7.81	6.92	SAO 187634
22.259	V	7.74	6.99	π Sgr
22.274	V	7.84	6.89	π Sgr
22.291	V	7.75	6.98	π Sgr
22.298	B	8.14	6.59	π Sgr
22.315	V	7.76	6.97	π Sgr
JULY		+	-	
06.259	V	7.80	6.93	SAO 187634
06.265	V	7.86	6.86	SAO 187634
06.280	V	7.82	6.91	SAO 187634
06.284	V	7.80	6.92	SAO 187634
06.306	V	7.79	6.94	SAO 187634
06.311	V	7.82	6.91	SAO 187634
06.327	V	7.83	6.89	SAO 187634
06.332	V	7.82	6.91	SAO 187634
06.353	V	7.84	6.89	SAO 187634
06.357	V	7.84	6.88	SAO 187634
16.170	V	7.92	6.81	o Sgr
16.177	I	9.19	5.54	o Sgr
17.177	I	8.74	5.99	o Sgr
31.258	V	7.76	6.97	SAO 187634
31.265	B	8.16	6.57	SAO 187634
31.282	V	7.78	6.95	SAO 187634
AUGUST				
06.170	V	7.70	7.03	o Sgr
06.175	V	7.80	6.93	SAO 187634
06.177	I	8.72	6.04	o Sgr
06.185	B	8.21	6.52	SAO 187634
11.170	V	7.86	6.88	o Sgr
11.177	I	8.77	5.97	o Sgr
17.166	R	8.18	6.56	o Sgr
17.270	V	7.86	6.88	π Sgr
SEPTEMBER				
04.125	V	7.86	6.90	o Sgr
04.125	I	9.22	5.54	o Sgr

Table 4. Mean Normalized Magnitudes for Neptune During the 1991 Apparition.

Type of	Mean of 1991 Observations				Literature	
Magnitude	Without π Sgr	No. Meas.	With π Sgr	No. Meas.	Ref. [7]	Ref. [8]
B(1,0)	-6.55±.03	2	-6.56±.02	13	-6.46	-6.46
V(1,0)	-6.91±.02	18	-6.92±.02	36	-6.87	-6.87
R(1,0)	-6.56	1	-6.56	1	-----	-6.54
I(1,0)	-5.82±.11	5	-5.82±.11	5	-----	-5.74
B-V	+0.36±.04	-	+0.36±.03	-	+0.41	+0.41
V-R	-0.35	-	-0.35	-	-----	-0.33
R-I	-0.74	-	-0.74	-	-----	-0.80

6. Johnson, H.L.; Mitchell, R.I.; Iriarte, B.; & Wisniewski, W.Z. "UBVRIJKL Photometry of the Bright Stars." *Lunar and Planetary Laboratory Communication*, No. 63 (1966).
7. U.S. Naval Observatory. *Astronomical Almanac for the Year 1991*. Washington, DC: U.S. Govt. Printing Office, 1990.
8. Harris, D.L. "Photometry and Colorimetry of Planets and Satellites." Cpt. 8 in: Kuiper, G.P.; & Middlehurst, B.M., eds., *Planets and Satellites*. Chicago: University of Chicago Press, 1961.
9. Appleby, J.F. "Multicolor Photoelectric Photometry of Neptune." *A.J.*, *78*, No. 1 (Feb., 1973), pp. 110-112.
10. Schmude, R.W., Jr. "The Remote Planets: 1987-1990 Report." *J.A.L.P.O.*, *35*, No. 4 (Dec., 1991), pp. 153-156.
11. Lockwood, G.W. & Thompson, D.T. "Solar Cycle Relationship Clouded by Neptune's Sustained Brightness Maximum." *Nature*, *349*, No. 6310 (14 Feb. 1991), pp. 593-594.
12. Graham, F.G. "Prediscovery Images of Neptune's Great Dark Spot." *J.A.L.P.O.*, *35*, No. 2 (June, 1991), p. 69.
13. O'Meara, S.J. "Neptune Through the Eyepiece." *Sky & Telescope*, *77*, No. 5 (May, 1989), pp. 486-487.
14. Moore, P. "Sky Notes." *Newsletter No. 50* (Pub. by British Astronomical Association), (Oct., 1991), pp. 8-9.
15. Hodgson, R.G. "A Quinquennial Observational Report of the A.L.P.O. Remote Planets Section for the Years 1985-1989." *J.A.L.P.O.*, *35*, No. 3 (Sept., 1991), pp. 97-99.
16. Schmude, R.W., Jr. "A View of Uranus and Neptune." *National Newsletter, Royal Astronomical Society of Canada*, *82*, No. 5 (Dec., 1988), p. 86.

ANNOUNCEMENTS

A.L.P.O. BUSINESS: FIRST RETURNS FROM 1992 BUSINESS/BOARD MEETING

The 1992 A.L.P.O. Business/Board Meeting was held at our 42nd convention; in San Jose, California, on July 18. A full report will appear in our next issue; meanwhile, here is a brief summary of events.

1993 A.L.P.O. Convention.—We will hold our 1993 Convention in Las Cruces, New Mexico, most likely in the first half of August. We expect that this will be an *A.L.P.O.-only* convention; details will follow.

1995 A.L.P.O. Convention.—The 1995 A.L.P.O. Convention will be held at the Omnisphere/Science Center in Wichita, Kansas, at the kind invitation of José Olivarez, its Director and an A.L.P.O. Board Member. The exact date is to be decided, and we have invited the Astronomical League to join us.

Other Years.—Our 1994 meeting place is undecided, although we have a firm invitation from the Roper Mountain Science Center in Greenville, South Carolina, which will undoubtedly be discussed at our 1993 Business/Board Meeting. Another future possibility is a 1997 meeting in Philadelphia with the Astronomical League, when both the A.L.P.O. and and A.L. will celebrate their 50th anniversaries.

Instrument Section.—A provisional Instrument Section was formed, whose chief functions will be to provide information on telescopes and their selection, as well as to test and (when feasible) correct optics. The Acting Recorder of this new Section is: Michael Mattei, 11 Coughlin, Littleton, MA 01460. A description of plans for the new Section by Mr. Mattei should appear in the next issue.

Staff Changes.—Two staff changes have been made by the A.L.P.O. Board: (1) Dr. Paul K. Mackal has been relieved as Assistant Recorder of the Jupiter Section; (2) Harry D. Jamieson has been appointed permanent Recorder of the Lunar Dome Survey.

Discussion Items.—Several items were discussed without votes being taken, and will likely be voted on at the next Board Meeting.

An Aurora Section was proposed. We welcome the comments and suggestions of our readers regarding this proposal.

Cooperation with the Astronomical League was also discussed, with League President Jim Fox contributing. The value of the League's "Observe" publications was noted, along with the possibility that this series could be extended to cover the subjects of most of our observing Sections. Both the Astronomical League and the A.L.P.O. recognize the need for training programs, and perhaps our efforts could be combined.

OTHER A.L.P.O. BUSINESS

Address Change for Remote Planets Recorder.—Effective immediately, the new address of Richard W. Schmude, Jr., Remote Planets Recorder, is: 802 - 9th Street, Apt. 21, Los Alamos, New Mexico 87544.

A.L.P.O. Benefactors.—Once again we are honored to list those A.L.P.O. members who have generously contributed more than the minimum dues required for membership. Thanks to them, we are able to maintain our operations and publications. The persons listed below have made contributions since our previous listing in our September, 1991, issue.

A.L.P.O. **Sponsors** contribute at least $50 per year and are: Richard Baum; Julius L. Benton, Jr.; James R. Brunkella, Nancy J. Byrd; Darryl J. Davis; Phillip R. Glaser; Virginia Glaser, David McDavid, Patrick S. McIntosh, Michael Mattei; Paul C. Millikan; Brenton R. Ogle; José Olivarez; Arthur K. Parizek; Donald C. Parker; Thomas C. Peterson; James Phillips; Richard W Schmude; Berton and Janet Stevens; Richard J. Wessling; Matthew Will; and Thomas P. Williams.

Sustaining Members contribute at least $25. They are: George D. Bailey, III; W.D. Baldwin; Roger L. Ball, Sr.; Richard A. Bean; Claus Benninghoven; Klaus R. Brasch; Harper M. Bruce; Phillip W. Budine; Clark R. Chapman; Donald M. Clement; Thomas P. Davis; Stephen L. Davis; Thomas P. Davis; Kenneth J. Delano; Jose L. Diaz; Alexander Dutkewych; J. Kenneth Eakins; Alan French; Michael Granger; John W. Griesé, III; Charles Hance; Chris Harper; Richard E. Hill; Mike Hood; John T. Hopf; Harry D. Jamieson; Joe and Joann Kamichitis; H.W. Kelsey; Charles F. Lamb; Mark Lancaster; George F. Lenz; Major Kenneth D. Luedeke; John E. Lukens; Robert D. Lunsford; David D. Meisel; Jay H. Miller; Col. John W. Mohr, USMC; Woodie F. Morris; Lee Morrow; James P. Mulroy; Donald E. Neiman; New Mexico State University; Gary S. Nichols; William P. Pala; Walt Parker; F.W. Price; David J. Raden; Peter Rasmussen; Mark Raymond; Richmond Astronomical Society; Bob Riddle; Timothy J. Robertson; Sacramento Valley Astronomical Society; Fred Sammartino; John Sanford; Peter C. Scott; Lee M. Smojver; Don Spain; Harold J. Stelzer; Michael E. Sweetman; Richard A. Sweetsir; Ken Thomson; Brad Timerson; Daniel M. Troiani; Michael J. Vaclav; William A. Vance; Wynn K. Wacker; Gary K. Walker; Leo F. Wellner; Samuel R. Whitby; Jack Whorwood; and Alan P. Witzgall.

A special thanks goes to **Mr. Phillip R. Glaser**, of La Jolla, California, who has recently donated 100 dollars to the A.L.P.O. The donation is to continue a Sponsor Membership for himself and his wife Virginia. Mr. Glaser was a very active contributing member and observer in the 1950's and 1960's and served for a time as Jupiter Recorder. His generous support of our association is greatly appreciated. His gifts have been regular for many years. Indeed, it is doubtful that the A.L.P.O. could have survived without the financial assistance of Mr. Glaser and a number of other most helpful friends.

NON-A.L.P.O. BUT WORTHWHILE

Ninth Annual OKIE-TEX Star Party.-The Ninth OKIE-TEX Star Party will be at a new location; the Prude Ranch, near Fort Davis, Texas, the site of the Texas Star Party. However, the OKIE-TEX event will be held October 19th-24th, 1992, allowing you to see objects in the Fall and Winter skies from this dark-sky site. Besides deep-sky objects, note that the planets Mercury, Venus, and Saturn will be observable in the early evening; while Mars will rise in the late evening. The Orionid Meteor Shower is scheduled to peak on 1992 OCT 21.4 UT, or before dawn on October 21st as seen from Prude Ranch. The star party is limited to 700 registrations; registration is $25 per person ($5 each additional family member) until October 1, 1992, and $50 thereafter. Make your lodging reservations by calling the Prude Ranch directly at 915-426-3201. To register, or simply to find out more, write to: Beryl Cadle, Okie-Tex Registrar, Okla. City Astronomy Club, P.O. 21221, Oklahoma City, OK 73156 (telephone: 405-789-3742).

Lunar Geology Workshop.—The geology of the Apollo 17 Landing Site (Taurus-Littrow) will be the topic of a workshop at the Lunar and Planetary Institute, Houston, Texas, on December 2-4, 1992, one week before the 20th anniversary of the last Apollo mission. Indeed, Harrison Schmitt, the Apollo 17 Lunar Module Pilot, is one of the Co-conveners. To find out more, write to: LPI-LAPST Workshop on Apollo 17, Lunar and Planetary Institute, 3600 Bay Area Blvd., Houston, TX 77058-1113.

Pluto-Charon Meeting.—There will be a professional-level Pluto-Charon meeting next summer in Flagstaff, Arizona. The tentative date is July 6-9, 1993, which includes the 15th anniversary of Charon's discovery. Topics will include the first full results from the Pluto-Charon mutual event season (1985-1990) and possible spacecraft missions to the Pluto-Charon system. To be placed on the mailing list, write: Mary Guerrieri, Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721.

Undergraduate Astronomical Research Awards.—The American Astronomical Society announces the availability of National Science Foundation funds for undergraduate research in astronomy. Awards of up to $4750 are available for student support and travel to a national meeting to present the results of student research. The application should be completed by a person with an astronomy doctorate, and the student be an undergraduate, with small institutions given priority. The submission deadline for Summer 1993 funding is December 2, 1992. For further information, contact: American Astronomical Society Education Office, Astronomy Department, The University of Texas, Austin, TX 78712-1083.

International Astronomical Directories.- The Observatoire Astronomique de Strasbourg has recently published two unique directories of astronomy worldwide. The first is the third edition of the *International Directory of Professional Astronomical Institutions* (IDPAI 1990), with 660 pages, and over 3500 entries from about 90 countries. The other is the eighth edition of the *International Directory of Astronomical Associations and Societies* (IDAAS 1990), with 718 pages, and more than 3200 entries from about 90 countries. Each publication separately costs $US 38; the two together are $US 68; add 15 percent for airmail delivery. Orders should be placed with: Dr. A. Heck, Observatoire Astronomique, 11, rue de l'Université, F-67000 Strasbourg, France.

Astronomical Society of the Pacific Publications.—As usual, the A.S.P. has a number of new publications. (All prices include domestic handling and postage. California residents should add sales tax; foreign orders should include $3 for postage, or $4 for the Planet Flyby Videos.)

Cosmic Background Explorer Slide Set—a set of 16 slides of the findings of the Cosmic background Explorer (COBE) satellite. The final slide shows the "lumpy" temperature map of the Universe. The slide set is accompanied by a 16-page booklet. The price is $24.95; send orders to: A.S.P., COBE Set Orders, 390 Ashton Ave., San Francisco, CA 94112.

Video on Astronomical Observatories.—This half-hour 1982 film tours Kitt Peak in Arizona, the Very Large Array in New Mexico, Cerro Tololo in Chile, and the Arecibo radio telescope in Puerto Rico. The video is available in VHS or PAL format and is accompanied by a reading list. To order a copy, send $34.45 to: A.S.P., Video Order Department, 390 Ashton Ave., San Francisco, CA 94112.

Planet Flyby Videos.—This 35-minute VHS videotape shows dramatic computer-animated sequences from several spacecraft, including: (1) Three Magellan spacecraft films of the surface of Venus; (2) *Mars: The Movie*, flying over the planet's chasms, volcanoes, and cratered highlands; (3) Galileo spacecraft films of the Earth and the Moon, including coverage of previously poorly imaged regions of the lunar Farside; and (4) *Earth: The Movie*, a computer simulation of the climate and features of a rotating Earth. The tape is accompanied by a booklet of background information and a 4-page bibliography. To obtain a copy, send $33.95 to: A.S.P., Planet Video Orders, 390 Ashton Ave., San Francisco, CA, 94112.

■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■

PUBLICATIONS OF THE ASSOCIATION OF LUNAR AND PLANETARY OBSERVERS

(All Section Publications must be ordered directly from the appropriate Recorders.)
(Checks must be in U.S. funds, payable to an American bank with bank routing number.)

◆◆

Order from: Mark A. Davis, 130 Greenway Drive N.W., Christiansburg, VA 24073, U.S.A:

The A.L.P.O. Solar System Ephemeris: 1992. $6.00 in the United States, Canada, and Mexico; $8.50 elsewhere (airmail included). Over 120 pages of tables, graphs, and maps describing the positions and appearances of the Sun, Moon, each major planet, the major planetary satellites, Minor Planets, meteors, and comets. Make payment to "A.L.P.O."

◆◆

Order from: A.L.P.O., P.O. Box 16131, San Francisco, CA 94116, U.S.A:

An Introductory Bibliography for Solar System Observers. Free for a stamped, self-addressed envelope. A 4-page list of books and magazines about Solar System bodies and how to observe them. The current edition was updated in June, 1991.

◆◆

Order from: A.L.P.O. Membership Secretary, P.O. Box 143, Heber Springs, AR 72543, U.S.A:

① ***A.L.P.O. Section Directory--1992/93. Free***; just send a stamped, self-addressed envelope. An 8-page description of each Observing Section's personnel, projects, and publications.

② ***A.L.P.O. Membership Directory.*** $5.00 in the United States, Canada, and Mexico; $6.00 elsewhere. Continuously-updated list of members: alphabetically, by location, and by interest or interests. Make payment to "A.L.P.O."

◆◆

Order from: Walter H. Haas, 2225 Thomas Drive, Las Cruces, NM 88001, U.S.A:

Back issues of ***The Strolling Astronomer (J.A.L.P.O.).*** The following are still in stock but may not long remain so. In this list, volume numbers are in ***italics***, issue numbers are not, years are given in parentheses, and prices are $1.50 per issue unless otherwise stated. Discounts can be arranged for purchases over $20. Make payment to "Walter H. Haas."

1 (1947); 6. *8* (1954); 7-8. *11* (1957); 11-12.
21 (1968-69); 3-4 and 7-8. *23* (1971-72); 3-4, 7-8, 9-10, and 11-12.
25 (1974-76); 1-2, 3-4, 7-8, and 11-12.
26 (1976-77); 3-4, 5-6, and 11-12 [each $1.75].
27 (1977-79); 3-4, 5-6, 7-8, 9-10, and 11-12 [each $1.75].
28 (1979-81); 3-4 [each $1.75]. *31* (1985-86); 5-6 and 9-10 [each $2.50].
32 (1987-88); 1-2, 5-6, and 11-12 [each $2.50].
33 (1989); 1-3, 4-6, 7-9, and 10-12 [each $2.50]. *34* (1990); 1, 2, and 4 [each $2.50].
35 (1991); 1, 2, and 3 [each $2.50]. *36* (1992); 1 [$2.50]
Current Issue [*36*, 2]—$3.00.

KEEPING YOUR MEMBERSHIP CURRENT—

A.L.P.O. memberships include a subscription to the *Strolling Astronomer (J.A.L.P.O.),* the top line of your mailing label gives the volume and issue number for which your membership will expire (e.g., "36.2" means Vol. 36, No. 2). We include a *First Renewal Notice* in that issue, and a ***Final Notice*** in the next one.

Please also let the Membership Secretary know if your address changes.

CONTRIBUTING TO *THE STROLLING ASTRONOMER (J.A.L.P.O.)*—

We welcome reports and observations from our readers and our staff. Please submit typewritten, doubled-spaced copy. For articles longer than two pages, begin with a 75-150 word abstract (our Journal is abstracted). Cite pertinent references in full, including page numbers. Fully document observations with the name and address of the observer; the observing site if different from the observer's address; the date and time in Universal Time; the telescope type, aperture (cm. preferred), and magnification; filters used if any; atmospheric conditions (Seeing on the 0-10 A.L.P.O. scale; Transparency as the limiting stellar magnitude in the vicinity of the object); and other data as pertinent to the object observed. Illustrations are welcome but we cannot publish color. For low-contrast objects, contrasts should be exaggerated on drawings and photographs. Also, be sure to indicate celestial north or south, as well as celestial east or west if the image is laterally reversed.

With all communications with A.L.P.O. staff,
please furnish a stamped, self-addressed envelope.

THE ASSOCIATION OF LUNAR AND PLANETARY OBSERVERS

Founded in 1947, the A.L.P.O. now has over 600 members. Our dues include a subscription to the quarterly Journal, *The Strolling Astronomer*, and are $16.00 for one year ($26.00 for two years) for the United States, Canada, and Mexico; and $20.00 for one year ($33.00 for two years) for other countries. One-year Sustaining Memberships are $25.00; Sponsorships are $50.00. Associate Memberships, which do not include a Journal subscription, are $3.00 per year.

There is a 20-percent surcharge on all memberships obtained through subscription agencies or which require an invoice.

Our advertising rates are $85.00 for a full-page display Ad., $50.00 per half-page, and $35.00 per quarter-page. Classified Ads. are $10.00 per column-inch. There is a 10-percent discount for a 3-time insertion on all advertising.

All payments should be in U.S. funds, drawn on a U.S. bank with a bank routing number, and payable to "A.L.P.O." When writing our staff, please furnish stamped, self-addressed envelopes.

ASSOCIATION BOARD OF DIRECTORS

Phillip W. Budine
Walter H. Haas
Harry D. Jamieson
(Treasurer)
José Olivarez
Donald C. Parker
Elizabeth W. Westfall
(Secretary)
John E. Westfall
(Chair)

ASSOCIATION STAFF

Executive Director/Editor
John E. Westfall
P.O. Box 16131
San Francisco, California
94116
(CompuServe 73737,1102;
FAX 415-731-8242)

Founder/Director Emeritus
Walter H. Haas
2225 Thomas Drive
Las Cruces, New Mexico
88001

Membership Secretary
Harry D. Jamieson
P.O. Box 143
Heber Springs, Arkansas
72543

Book Review Editor
José Olivarez
1469 Valleyview Court
Wichita, Kansas 67212

Lunar and Planetary Training Program
José Olivarez
(Address immediately above)

International Solar System Observers' Fund
(Coordinator)
Paul H. Bock, Jr.
RR1, Box 347
Hamilton, Virginia 22068

—Solar Section—

Richard Hill
(Recorder, General)
4632 E. 14th Street
Tucson, Arizona 85711

Paul Maxson
(Recorder, White Light)
8839 N. 30th Avenue
Phoenix, Arizona 85051

Randy Tatum
(Recorder, Monochromatic)
1108 Ocala Road
Richmond, Virginia 23229

Francis G. Graham
(Recorder, Eclipses)
P.O. Box 209
East Pittsburgh,
Pennsylvania 15112

—Lunar Section—

John E. Westfall
(Recorder)
(Address under Executive Director/Editor)

Winifred S. Cameron
(Recorder, Lunar Transient Phenomena)
La Ranchita de la Luna
200 Rojo Drive
Sedona, Arizona 86336

Julius L. Benton, Jr.
(Recorder, Selected Areas Program)
(Address under Venus Section.)

Francis G. Graham
(Recorder, Eclipses and Photometry)
(Address under Solar Section)

Harry D. Jamieson
(Recorder, Lunar Dome Survey)
(Address under Membership Secretary)

—Mercury Section—

Richard M. Baum,
(Recorder)
25 Whitchurch Road
Chester CH3 5QA, England

—Venus Section—

Julius L. Benton, Jr.,
(Recorder)
Associates in Astronomy
305 Surrey Road
Savannah, Georgia 31410

—Mars Section—

Jeff D. Beish
(Recorder)
9460 Toni Drive
Miami, Florida 33157

Donald C. Parker, M.D.
(Recorder)
12911 Lerida Street
Coral Gables, Florida 33156

Carlos E. Hernandez
(Assistant Recorder)
8691 S.W. 32nd Terrace
Miami, Florida 33155

Daniel M. Troiani
(Assistant Recorder)
629 Verona Ct.
Schaumberg, Illinois 60193

Harry Cralle
(Assistant Recorder)
3902 E. 29th Street (J-4)
Bryan, Texas 77802

-Minor Planets Section-

Frederick Pilcher
(Recorder)
Illinois College
Jacksonville, Illinois 62650

—Jupiter Section—

Phillip W. Budine
(Recorder)
R.D. 3, Box 145C
Walton, New York 13856

José Olivarez *(Recorder)*
(Address under Book Review Editor)

John E. Westfall *(Assistant Recorder, Galilean Satellites)*
(Address under Executive Director/Editor)

—Saturn Section—

Julius L. Benton, Jr.
(Recorder)
(Address under Venus Section)

-Remote Planets Section

Richard W. Schmude, Jr.
(Recorder)
802 - 9th Street, Apt. 21
Los Alamos, New Mexico
87544

—Comets Section—

Don E. Machholz
(Recorder)
P.O. Box 1716
Colfax, California 95713

James V. Scotti
(Assistant Recorder)
Lunar and Planetary Laboratory
University of Arizona
Tucson, Arizona 85721

—Meteors Section—

Robert D. Lunsford
(Recorder)
161 Vance Street
Chula Vista, California 91910

David H. Levy
(Assistant Recorder)
(Address care of Recorder)

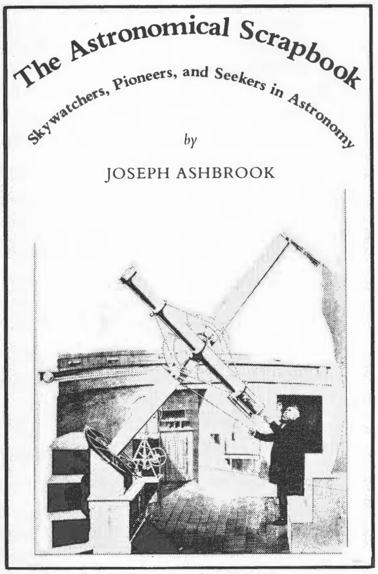
James V. Scotti
(Assistant Recorder)
(Address under Comets Section.)

-Instrument Section - *(provisional)*

Michael Mattei
(Acting Recorder)
11 Coughlin
Littleton, Massachusetts
01460

The Astronomical Scrapbook

Joseph Ashbrook



The Astronomical Scrapbook

Skywatchers, Pioneers, and Seekers in Astronomy

by

JOSEPH ASHBROOK

"A joy . . . a feast of information about controversial figures and landmarks in astronomy, accounts of nonexistent planets, and so on, all together in a relaxed style."

— Archie E. Roy,
New Scientist

"Underlying each story line is Ashbrook's scholarship, exactitude, and love of detail. . . . This is a gem of an anthology which can be savored time and again."

— David Hughes,
Nature

"Joseph Ashbrook had a very special talent in both astronomy and journalism. . . . He cast his net widely indeed, but with unerring aim upon carefully selected subjects. . . . A fascinating collection . . . not one dull page within its covers. I recommend it without reservation."

— Kenneth Glyn Jones,
Webb Society Quarterly Journal

For 23 years, Joseph Ashbrook's "Astronomical Scrapbook" column was the first thing thousands of *Sky & Telescope* readers turned to when their new issues arrived. Ashbrook was the magazine's editor until 1980. He had a special passion for little-known byways of astronomy and the geniuses, toilers, visionaries, and crackpots who traveled them. Now 91 of Joe's best articles have been brought together in the 83 chapters of this long-awaited volume.

Ashbrook's meticulous scholarship was matched only by his devotion to amateurs and their pivotal role in astronomy over the centuries. He detailed the lives and work of scores of intriguing personalities, their stumbles as well as their successes. The great Paris telescope fiasco, the alleged invisible moons of Earth, the astronomical hobbies of America's last king, the precomputer sweatshops full of slave-driven arithmetic workers, suspicious comet hoaxes, the city on the Moon, the inhabitants of the Sun, the thinnest lunar crescent ever seen, the biggest amateur telescope mirror ever made — these topics and many, many more make *The Astronomical Scrapbook* a book for everyone. Copublished with Cambridge University Press. *470 pages, hardbound.*

Order 46247 *SCRAPBOOK* . . . **$19.95**

Mass. residents add 5% sales tax. Foreign add 15% for postage. Payments from foreign countries must be in U. S. funds drawn on a U. S. bank, or by International Money Order.

SKY PUBLISHING CORPORATION
49 Bay State Road ★ P. O. Box 9102
Cambridge, Mass. 02238-9102