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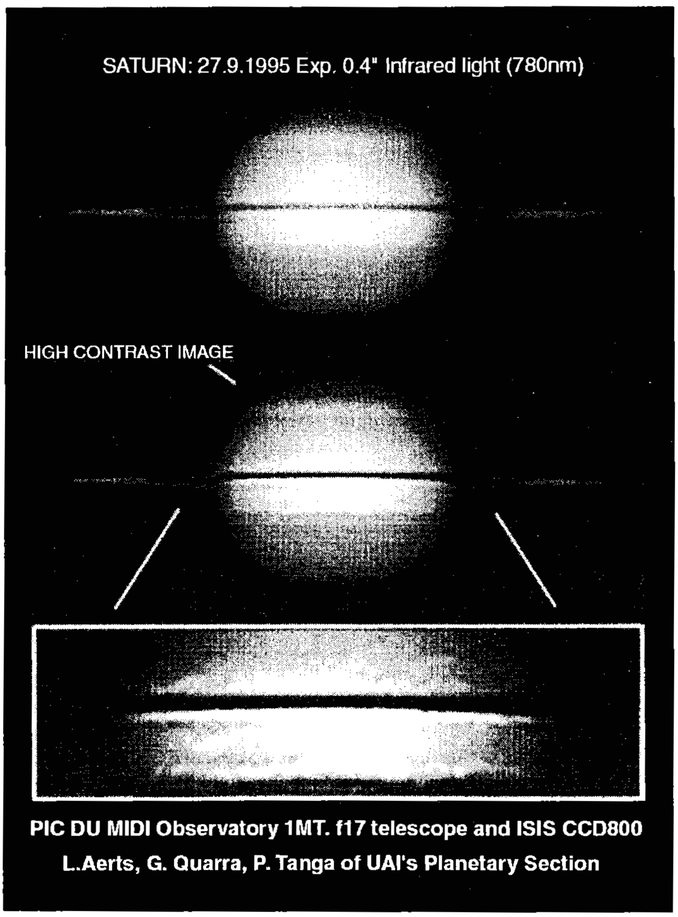

Saturn and its Ring System on 1995 Sep. 27, when the Earth was just 1°.7 north of the ring plane, and the Sun only 0°.8 north. CCD image by L. Aerts, G. Quarra, and P. Tanga, using the 1-meter reflector of Pic du Midi Observatory at f/17. 0.4-second exposure in infrared light (780 nm). Note bright EZn and extended white spot (see inset). South at top.

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The 1995-96 Apparition of Saturn and Edgewise Presentation of the Rings: Visual and Other Observations

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Abstract

Visual observations and drawings, photographs, CCD images, and photoelectric measurements of the planet Saturn and its Ring System were contributed by A.L.P.O. Saturn Section members during the 1995-96 Apparition, in a continuing highly successful international program. Observations made with telescopes ranging in aperture from 6.0 cm (2.4 in) to 100 cm (39.4 in) were received for the period 1995 Apr 20 - 1996 Feb 17. The highlight of the 1995-96 Apparition was the edgewise presentation of Saturn's Rings, when the Earth passed through the plane of the Rings three times, presenting unique observational opportunities, in addition to interactions of the Ring System with several of the brighter satellites. For the range of observations submitted, the inclination of the plane of the Rings to our line of sight, B, reached maximum values of +2°.67 on 1995 Nov 20 and -0°.62 on 1995 Jul 02, while the minimum value of 0°.00, when the Rings were theoretically edge-on to our line of sight, occurred on 1995 May 21, 1995 Aug 11, and 1996 Feb 11. With the Earth moving north and south of the ring plane during 1995-96, alternating limited views were possible of the north and south faces of Saturn's Rings, while essentially equal regions of the northern and Southern Hemispheres of the Globe could be studied during the observing season. White spots, chiefly confined to Saturn's bright Equatorial Zone (EZ), were detected visually and captured on CCD images during the apparition; also, intermittent sightings of ill-defined dark spots and wispy festoons among the belts and zones of the planet occurred. An insufficient quantity of recurring central-meridian (CM) transits arrived for analysis to permit reliable rotation rates. Accompanying this report are references, drawings, photographs, CCD images, graphs, and tables.

Introduction

Excellent observer participation during the 1995-96 Apparition generated a valuable collection of visual, photographic, and CCD observations of the planet Saturn and its Ring System. This analytical summary, with drawings, photographs, and CCD images, is based upon these data which were obtained for the period 1995 Apr 20 - 1996 Feb 17. (All dates and times in this report are in Universal Time (UT), and all directions are in the IAU sense.) Within these limits, the numerical value of B, the Saturnicentric latitude of the Earth referred to the ring plane (when north), ranged between the extremes of -0°.62 (1995 Jul 02) and +2°.67 (1995 Nov 20). The value of B′, the saturnicentric latitude of the Sun, ranged from +3°.10 (1995 Apr 20) to -1°.33 (1996 Feb 17). Of special consideration during the 1995-96 Apparition were the circumstances of the geometry of the Ring System and the interactions of the Earth and Sun with the ring plane.

During the 29.5-year sidereal revolution period of Saturn, the intersection of the Earth's orbit and the plane of the Rings takes place at alternating intervals of 13.75 and 15.75 years, the inequality of the two periods due to the ellipticity of Saturn's orbit. From an astronomical perspective, such events are considered quite rare and remarkable. In the 13.75-year period, the south face of the Rings and the Southern Hemisphere of the Globe of the planet are inclined toward Earth, and Saturn passes through perihelion during this time. In the longer 15.75-year interval, Saturn passes through the aphelion point of its orbit, and the north face of the Rings and Northern Hemisphere of the Globe are exposed to Earth-based observers.

The last apparition in which the Rings of Saturn were edgewise toward Earth was 1979-80. Since that observing season, the planet's northern regions could be effectively studied by astronomers. The numerical value of B varied from 0°.00 in 1979-80 to a maximum of +26°.94 on 1988 Sep 26.

Since the 1987-88 Apparition, the Rings have been progressively closing back up and returning to 0°.00 during the 1995-96 observing season. Also, Saturn passed through aphelion on 1988 Sep 11.

During the 1995-96 Apparition of Saturn, the Earth passed through the Ring System three times. The first passage occurred on 1995 May 21^d $22^h.8$, with the Earth going southward. The northern face of the Rings remained illuminated by the Sun, but the Earth, having passed through the ring plane southward, was on the opposite, darkened south side of the ring plane. Theoretically, the Rings should have been invisible from 1995 May 21 up until the time the Earth and Sun were again located on the same side of the Rings. During this period, the absolute value of B reached a maximum of -0°.62 on 1995 Jul 02.

The second ring passage by the Earth, headed again to the north side of the ring plane, occurred on 1995 Aug 11^d $03^h.6$, only about a month before Saturn, located in the constellation of Aquarius, reached opposition to the Sun on 1995 Sep 14^d 15^h. The Earth and Sun were, therefore, again on the same side of the ring plane, and the illuminated north face of the Rings should have been visible. The maximum value of B during this period reached +2°.67.

The Sun passed through the plane of the Rings on 1995 Nov 18^d $23^h.8$, going southward, but the Earth remained on the opposite north side of the ring plane. The northern face of the Rings, therefore, was no longer illuminated by the Sun, and consequently, the Rings should have been theoretically invisible from Earth after Nov 18 until the Earth joined the Sun south of the ring plane later in the 1995-96 Apparition.

Finally, the third ring passage by the Earth, now headed southward for the last time during the apparition, took place on 1996 Feb 11^d $20^h.4$. The Earth joined the Sun to the south of the ring plane, and the illuminated south face of the Rings should have become visible to terrestrial observers. This final passage of the Earth through the plane of the Ring System was expected to be the most troublesome to observe because Saturn was only a little more than a month away from conjunction with the Sun and very near the horizon for most observers.

In summary, the intervals when the Rings of Saturn should have been theoretically invisible to observers on Earth were:

1995 May 21^d 22h.8 - 1995 Aug 11^d 03h.6 UT
1995 Nov 18^d 23h.8 - 1996 Feb 11^d 20h.4 UT

It should be noted that any apparent disappearance of the Ring System, which can occur a number of times during a short interval, can be ascribed to one or more of the following geometric circumstances:

1. The Earth may be in the plane of the Rings so that only their edge is presented to viewers, and since the Rings are quite thin, they may be temporarily lost to even the largest apertures.

2. The Sun may be in the plane of the Rings so that only their edge is illuminated.

3. The Sun and Earth may be opposite one another on either side of the Ring plane, so that what observers see on Earth are regions that are only indirectly illuminated.

Following 1996 Feb 11, the Earth and the Sun were both located south of the plane of Saturn's Rings, where they will remain together until the next edgewise presentation commences on 2009 Aug 10^d 13^h UT. Meanwhile, observers will be able to conduct increasingly favorable investigations of the southern face of the Rings and Southern Hemisphere of the Globe for more than a decade.

Table 1 (below) gives geocentric data in Universal Time (UT) for the 1995-96 Apparition of Saturn.

Table 1. Geocentric Phenomena for the 1995-96 Edgewise Apparition of Saturn

Conjunction	1995	Mar	06^d	02^h UT
Opposition		Sep	14	15
Conjunction	1996	Mar	17	19

<u>Opposition Data:</u>

Constellation		Aquarius
Stellar Magnitude		+0.7
Globe:		
Equatorial Diameter	19″.23	
Polar Diameter	17″.16	
Ring System		
Major Axis	43″.84	
Minor Axis	00″.91	
B		+1°.19
B′		+0°.97
Declination of Saturn		-5°.59

For Saturn, B is the planetocentric latitude of the Earth referred to the plane of the Rings, positive (+) when north (when B is positive, the visible surface of the Rings is the northern face); B′ is the planetocentric latitude of the Sun referred to the ring plane, positive (+) when north (when B′ is positive, the north face of the Rings is illuminated).

Table 2 (below) lists the 33 individuals who submitted a total of 326 observations to the A.L.P.O. Saturn Section for the 1995-96 Apparition, along with their observing sites, number of dates of observations, and descriptions of their telescopes.

Table 2. Contributing Observers, 1995-96 Apparition of Saturn

Observer & Location	No. of Obser.	Telescope Data*
Aerts, Leo	1	100.0 cm (39.4 in) N
Pic-du-Midi, France		
Benton, Julius L., Jr.	1	8.3 cm (3.3 in) RR
Wilmington I., GA	2	15.2 cm (6.0 in) RR
Carroll, Jesse F.	1	15.2 cm (6.0 in) N
Chicago, IL		
Cicognani, Massimo	1	10.2 cm (4.0 in) RR
Collina, Italy	2	40.6 cm (16.0 in) SC
Colombo, E	1	20.3 cm (8.0 in) N
Brugherio, Italy		
Cole-Arnal, Oscar	9	12.7 cm (5.0 in) RR
Belwood, Ont., Canada	9	25.4 cm (10.0in) SC
Crotty, Russell	1	15.2 cm (6.0 in) N
Malibu, CA	6	25.4 cm (10.0 in) N
Dan, Andras	4	25.4 cm (10.0 in) N
Alsohegy, Hungary		
Enrico, Mariani	1	20.3 cm (8.0 in) CS
Marzio, Italy		
Graham, David L	8	15.2 cm (6.0 in) RR
North Yorkshire, UK	1	20.3 cm (8.0 in) RR
	3	40.6 cm (16.0 in) N
Mount Hamilton, CA	6	91.4 cm (36.0 in) RR
Haas, Walter H	5	20.3 cm (8.0 in) N
Las Cruces, NM	27	31.8 cm (12.5 in) N
Heath, Alan W.	1	7.5 cm (3.0 in) RR
Nottingham, UK	19	30.5 cm (12.0 in) N
	1	41.5 cm (16.3 in) DK
Hernandez, Carlos	1	50.8 cm (20.0 in) CS
Miami, FL		
Lehman, David J.	4	22.9 cm (9.0 in) N
Fresno, CA	11	25.4 cm (10.0 in) N
McAnally, John W.	12	20.3 cm (8.0 in) SC
Waco, TX		
Melillo, Frank J.	25	20.3 cm (8.0 in) SC
Holtsville, NY		
Morrison, Neil	3	20.3 cm (8.0 in) SC
Crawley, UK		
Niechoy, Detlev	1	10.2 cm (4.0 in) RR
Gottingen, Germany	62	20.3 cm (8.0 in) SC
	1	30.5 cm (12.0 in) N
Nowak, Gary	1	15.2 cm (6.0 in) N
Hinesburg, VT	3	25.4 cm (10.0 in) SS
Parker, Donald C.	3	40.6 cm (16.0 in) N
Coral Gables, FL		
Plante, Phil	2	15.2 cm (6.0 in) N
Braceville, OH	6	20.3 cm (8.0 in) RR
	3	20.3 cm (8.0 in) SC
	5	40.6 cm (16.0 in) N
Post, Cecil	1	20.3 cm (8.0 in) N
Las Cruces, NM		

Table 2—Continued.

Observer & Location	No. of Obser.	Telescope Data*
Quarra, G.	1	100.0 cm (39.4 in) N
Pic-du-Midi, France		
Raffaello, Lena	1	11.4 cm (4.5 in) RR
Rieti, Italy		
Rummler, Jens A.	3	20.3 cm (8.0 in) N
Oscar, LA		
Schmude, Richard W.	2	9.0 cm (3.5 in) RR
Barnesville, GA	3	35.6 cm (14.0 in) SC
Skjelnes, Sigmund	5	6.0 cm (2.4 in) RR
Varaldsoy, Norway		
Tanga, Paolo		
Torino, Italy	1	15.4 cm (6.1 in) N
Pic-du-Midi, France	1	100.0 cm (39.4 in) N
Teichert, Gerard	4	28.0 cm (11.0 in) SC
Hattstatt, France		
Testa, Luigi	1	20.3 cm (8.0 in) CS
Parma, Italy		
Viladrich, Christian	1	20.3 cm (8.0 in) SC
Cahors, France		
Westfall, John E.		
San Francisco, CA	29	27.9-cm (11.0 in) SC
Sierra Brooks, CA	8	35.6 cm (14.0 in) SC
Will, Matthew	6	15.2 cm (6.0 in) N
Springfield, IL	6	20.3 cm (8.0 in) N
Total Observations		326
Total Observers		33

* DK = Dall-Kirkham, RR = Refractor, N = Newtonian, SC = Schmidt-Cassegrain, CS = Cassegrain, SS = Schiefspiegler

Figure 1 (p. 4), a histogram, gives the distribution of observations by month, showing that most of the data accumulated for the months of 1995 July through 1996 January (90.5 percent), with a decline in the number of observations on either side of this rather wide peak. Of the submitted observations, 39.6 percent were made before opposition (1995 Sep 14), 0.3 percent actually on that date, and 60.1 percent were made after opposition. While an intense scrutiny of Saturn in the months nearest, and inclusive of, the date of opposition is very gratifying, it remains our objective to achieve, as much as possible, an uninterrupted coverage of the planet throughout any given apparition. Therefore, we urge observers to begin following the planet when it first appears in the eastern sky before dawn and to continue their investigations until Saturn nears conjunction with the Sun.

Figure 2 (p. 4) depicts the international distribution of the 33 observers and 326 observations of the A.L.P.O. Saturn Section for 1995-96. The United States was responsible for 56.1 percent of the submitted observations and a little less than half of the participating observers (45.5 percent).

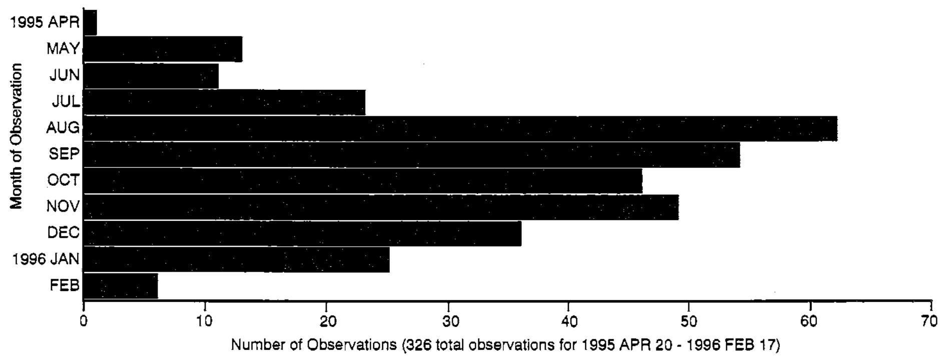

Figure 1. Distribution of observations by month, 1995-96 Apparition of Saturn.

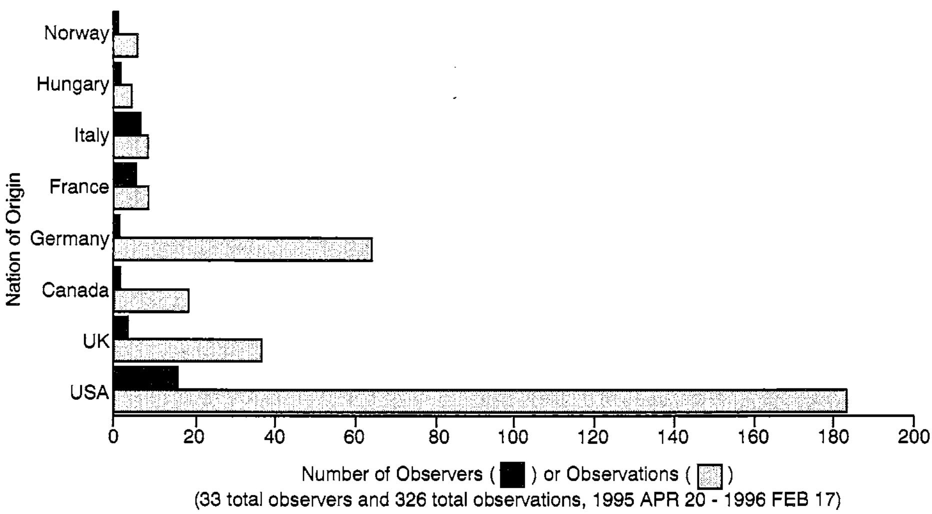

Figure 2. Distribution of observers and observations by nation of origin, 1995-96 Apparition of Saturn.

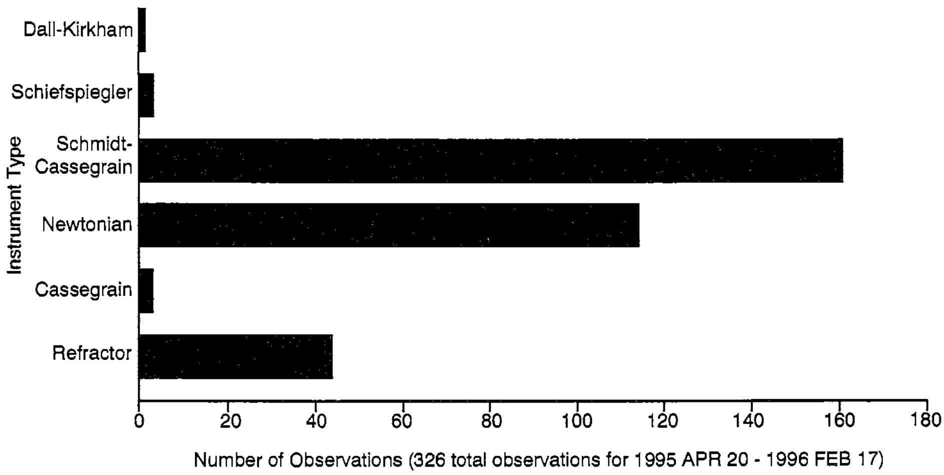

Figure 3. Distribution of observations by instrument type, 1995-96 Apparition of Saturn.

With the remaining half of the observations and observers coming from outside the United States, it is obvious that international participation in our programs continued during 1995-96. A major goal of the A.L.P.O. Saturn Section is to enlist as many dedicated observers as possible throughout the world.

Figure 3 (p. 4) graphs the number of observations by instrument type, where it can be seen that telescopes of classical design (i.e., refractors, Newtonians, and Cassegrains) were responsible for about half (49.4 percent) of the 326 total observations in 1995-96. The use of Schmidt-Cassegrains accounted for the majority of the other half, with a few reports made with Schiefspieglers and one with a vintage Dall-Kirkham. Also, 93.6 percent of the total observations were made with instruments equal to or greater than 15.2 cm (6.0 in) in aperture.

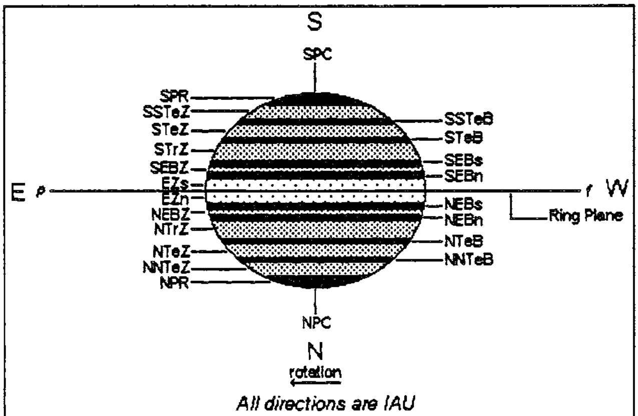

Figure 4. General nomenclature for Saturn during the 1995-96 Edgewise Apparition.

The appearance of Saturn above is as it would be seen in a normal inverting telescope when near the meridian in the Earth's Northern Hemisphere. Features then appear to move across the Globe of Saturn from right to left. Saturn, like Jupiter, has two regions of rotation defined as System I and System II, where:

System I ($10^h\ 14^m\ 00^s$)—Equatorial portions of Globe (e.g., EZ, SEB, NEB)

System II ($10^h\ 38^m\ 25^s$)—Portions of Globe north or south of System I.

Because the Rings were nearly edgewise to our line of sight during most of the 1995-96 Apparition, the diagram shows no Ring components. Abbreviations are as follows: B = Belt, C = Cap, E = Equatorial, f = following, N = North, n = North Component, P = Polar, p = preceding, R = Region, S = South, s = South Component, Te = Temperate, Tr = Tropical, Z = Zone.

Seeing conditions during the 1995-96 Apparition averaged 5.1 on the A.L.P.O. Seeing Scale (where 0.0 is the worst possible seeing and 10.0 denotes perfect seeing). Atmospheric transparency (usually the faintest star just barely visible to the unaided, dark-adapted eye near the object being observed) averaged about +3.8 during the 1995-96 observing season.

The writer expresses his gratitude to all of the A.L.P.O. Saturn observers mentioned in Table 2 who faithfully contributed data to our programs during 1995-96. Observers in the United States and elsewhere are invited to join us in future apparitions as we strive to maintain a comprehensive international surveillance of Saturn.

The Globe of Saturn

This discussion is based on the 323 observational reports that were submitted to the A.L.P.O. Saturn Section during the 1995-96 Apparition. Three of the 326 total observations for the apparition were omitted from this analysis because they studied Saturn's satellite Titan only. To be as concise as possible, the names of observers are not included in the text except when the identity of a specific individual is relevant to the discussion. Tables, graphs, drawings, photographs, and CCD images accompany this report (see *Figures 6-31*, pp. 18-23, and the front cover illustration), and readers should refer to them as well as the text. Features on the Globe of Saturn are described in north-to-south order and can be identified by the nomenclature diagram in *Figure 4* (above).

In the following discussion of Saturn's global atmospheric features, data comparisons are made between apparitions, as has been traditional in earlier Saturn observing reports. This practice should help the reader recognize delicate variations that may be taking place on the planet both seasonally and over a considerably longer period.

Evidence has implied in the past that the constantly changing inclination of Saturn's rotational axis relative to the Sun and Earth may influence recorded variations in belt and zone intensities, which are given in *Table 3* (p. 6). Photoelectric photometry of Saturn in the last few years has raised the possibility that the planet may

Table 3. Visual Numerical Relative Intensity Estimates and Colors for the 1995-96 Apparition of Saturn

Globe/Ring Feature	Number of Estimates	Mean & Standard Error	Change Since 1994-95	"Mean" Derived Color in 1995-96
		1995-96 Relative Intensities		
ZONES, HEMISPHERES, REGIONS, AND CAPS:				
NPR	69	4.93 ±0.12	-0.63	Dull Yellowish-Grey
NNTeZ	3	5.93 ±0.45	——	Dull Yellowish-White
NTeZ	19	5.99 ±0.13	-0.59	Dull Yellowish-White
NTrZ	21	5.57 ±0.17	-1.22	Yellowish-Grey
NEBZ	1	5.80 ----	——	Yellowish-Grey
EZn	113	6.89 ±0.05	-0.70	Light Yellowish-White
Globe N of Rings (entire)	47	4.45 ±0.14	-0.88	Dusky Yellowish-Grey
Globe S of Rings (entire)	50	4.92 ±0.15	-0.73	Dusky Yellowish-Grey
EZs	107	6.56 ±0.06	-0.03	Dull Yellowish-White
SEBZ	1	4.00 ----	——	Dull Grey
STrZ	29	5.80 ±0.14	-0.91	Yellowish-Grey
STeZ	17	6.31 ±0.23	-0.41	Dull Yellowish-White
SSTeZ	4	5.95 ±0.38	——	Yellowish-Grey
SPR	63	5.26 ±0.11	- 0.71	Dusky Yellow-Grey
SPC	14	4.06 ±0.40	-1.44	Dull Grey
BELTS:				
NNTeB	3	5.17 ±0.17	——	Greyish
NTeB	11	5.14 ±0.40	-1.11	Greyish
NEB (entire)	101	3.89 ±0.09	-0.75	Dark Grey
NEBn	9	4.56 ±0.37	——	Dull Greyish
NEBs	8	4.00 ±0.40	——	Dark Grey
EB	7	4.09 ±0.08	+0.39	Dark Grey
SEB (entire)	86	4.31 ±0.11	-0.33	Greyish-Brown
SEBn	4	5.18 ±0.50	——	Greyish
SEBs	4	4.88 ±0.42	——	Greyish
STeB	13	4.90 ±0.23	-0.13	Greyish
SSTeB	5	5.12 ±0.35	——	Greyish
SPB	3	3.43 ±0.87	——	Very Dark Grey
RINGS:				
A (entire)*	16	4.69 ±0.28	——	Dull Greyish
Cassini's Division (A0 or B10)*	2	5.00 ±1.00	——	Dull Greyish
B (entire)*	17	5.01 ±0.23	——	Dull Greyish
C (ansae)*	2	3.75 ±1.25	+1.43	Dark Greyish
Crape Band	20	2.93 ±0.29	+0.73	Dark Grey
Shadow Globe on Ring	2	1.40 ±0.40	+0.78	Dark Greyish-Black
Shadow Ring on Globe	50	1.21 ±0.09	+0.21	Dark Greyish-Black

* Because of the changing inclination of Saturn's Rings, these major ring components were not seen to advantage, and the estimated intensities were impressions of their relative brightness when they were very close to edge-on orientation. Descriptive reports by the majority of observers did not support the intensity values given above (see discussion under "The Visibility of the Rings" on pp. 11-15). Because of such limited views of the north and south face of the Rings, and because there was often confusion as to exactly what region was being estimated, little credibility is given to these intensity values and no comparison has been made to their intensities at greater ring inclinations in previous apparitions.

Notes: For nomenclature see text and Figure 4 (p. 5). A letter with a digit (e.g. A0 or B10) refers to a location on the ring component 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 and suffices as a suitable reference when B remains greater than about ±5°. With the Rings being near or at edgewise orientation during 1995-96, this normal reference point could not be effectively used. Observers were asked to utilize, as an alternative, the Equatorial Zone (EZ). Although this region has exhibited some brightness variations in recent years, it is usually the most stable of the zones in overall intensity. The EZ, for 1995-96, was to have an assigned numerical intensity of 7.0 (averaged over several apparitions). All other features on the Globe or in the Rings are compared systematically using this scale, described in the *Saturn Handbook*, which is available from the A.L.P.O. Saturn Section. The "Change Since 1994-95" is in the same sense of the 1994-95 value subtracted from the 1995-96 value, "+" denoting an increase in brightness and "-" indicating a decrease (darkening). When the apparent change is less than about three times the standard error, it is probably not statistically significant.

exhibit oscillations of about 0.10 visual magnitude with time, even after geometric changes affecting viewing angle and illumination have been allowed for. It is thought that transient and long-lived atmospheric features in the belts and zones of Saturn may contribute to such brightness fluctuations. Regular, long-term photoelectric photometry of Saturn, combined with simultaneous visual intensity estimates, is needed to gain a better understanding of such phenomena.

The intensity scale used is the A.L.P.O. Standard Numerical Relative Intensity Scale, where 0.0 represents totally black and 10.0 is the brightest possible condition. This scale is usually normalized by setting the outer third of Ring B at a standard brightness of 8.0. The arithmetic sign of an intensity change is found by subtracting a feature's 1994-95 intensity from its 1995-96 intensity. A change of only 0.1 mean intensity points is not considered to be of any real importance, nor is a variation really significant until it exceeds about 3 times its standard error.

Latitudes of Global Features.—In considering estimated latitudes of Saturn's global features, observers have been routinely using the visual method developed and introduced by Haas during the 1960s. Employing this method, the fraction is estimated of the polar semidiameter of the planet's disk that is subtended on the central meridian (CM) between the limb and the feature whose latitude is sought. There is no doubt that Haas' procedure is convenient and easy to use, and latitudes derived from this method have compared quite favorably with values determined with a bifilar micrometer or from measurement of accurate drawings. After mathematical reduction, the resulting latitudes of Saturn's global features appear in *Table 4* (below). Because these estimates were made by only a few observers, one must not place too much confidence in the comparative data. Even so, Haas has been using this procedure for many years with exceptionally reliable results, and his technique continues to grow in popularity among visual observers. We suggest that Saturn observers regularly employ this very simple procedure; yet, whenever possible, attempt to measure latitudes on drawings and CCD images; and without question, use bifilar micrometers if they are available. It is always worthwhile and instructive to compare results from all methods. A complete discussion about determining latitudes and using Haas' visual method can be found in *The Saturn Handbook*.

Table 4. Saturnian Belt Latitudes in the 1995-96 Apparition.

Saturnian Belt	Form of Latitude: Planetocentric	Eccentric	Planetographic
	° ° °	° ° °	° ° °
N edge NEB	+22.8 ±3.2 (+2.4)	+25.2 ±3.5 (+2.6)	+27.8 ±3.7 (+2.8)
S edge NEB	+15.6 ±2.9 (-1.3)	+17.3 ±3.2 (-1.5)	+19.3 ±3.5 (-1.6)
Center EB	+4.4 ±0.5 (——)	+5.0 ±0.5 (——)	+5.5 ±0.6 (——)
N edge SEB	-8.3 ±2.8 (-8.4)	-9.3 ±3.1 (-9.2)	-10.4 ±3.4 (-10.0)
S edge SEB	-13.8 ±3.0 (-6.4)	-15.3 ±3.4 (-7.0)	-17.1 ±3.7 (-7.4)

Notes: For nomenclature see Figure 4 (p. 5). 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 1994-95 latitude value from the 1995-96 latitude value.

Northern Portions of the Globe

With the possible exception of the Equatorial Band (EB), the 1995-96 observations suggested that all the belts and zones of the Northern Hemisphere of Saturn appeared to be slightly darker than in the 1994-95 Apparition. Of course, intensity estimates during the 1995-96 Edgewise Apparition were hampered by the virtual invisibility of the outer third of Ring B, the customary reference standard for making relative numerical intensity estimates. Observers had to rely on the EZn (northern half of the Equatorial Zone between where the Rings cross the Globe and the Northern Equatorial Belt) as the reference standard; but the EZn showed several fluctuations in intensity throughout the observing season. Consequently, it may be that any perceived darkening had more to do with inherent systematic errors rather than with actual brightness variations of Saturn's global features. Even so, comparing the mean intensity of the Globe North of the Rings (see Table 3, p. 6) in 1995-96 with that in 1994-95, the discernable mean brightness variation was -0.88 intensity points. Furthermore, comparing the estimated brightness of the Globe North of the Rings versus that of the Globe South of the Rings, the former was the darker of the two hemispheres by -0.47 mean intensity points. Results from photoelectric photometry of Saturn's Globe were entirely inconclusive because of the lack of data from previous apparitions, and even if such data were available, complications would arise because of the presence of the Rings.

In terms of atmospheric activity, the EZn showed sporadic white-spot activity and bright patches during the second half of the 1995-96 Apparition during the months of 1995 September and October. These features will be discussed in the later section dealing with the Equatorial Zone. Observers also detected variations in the appearance, brightness, or both of different belts and zones in the Northern Hemisphere of Saturn during 1995-96. For example, a number of transient wispy festoons, subtle dusky mottlings, and amorphous light areas characterized several of the planet's northern-hemisphere belts or zones during the apparition.

North Polar Region (NPR).-The dull yellowish-grey NPR was usually uniform in appearance in 1995-96, exhibiting what may be interpreted as a slight decrease in brightness (-0.63 in mean intensity) since 1994-95. With the NPR appearing undifferentiated, the North Polar Cap (NPC) and the encircling North Polar Belt (NPB) were not reported during the apparition.

North North Temperate Zone (NNTeZ).—One or two observers thought they could see a dull yellowish-white NNTeZ during 1995-96, describing it as having about the same mean intensity as the North Temperate Zone (NTeZ).

North North Temperate Belt (NNTeB).—A few isolated sightings of a narrow, greyish NNTeB occurred throughout the 1995-96 Apparition. Comparatively speaking, the NNTeB looked almost identical to its southern-hemisphere counterpart, the South South Temperate Belt (SSTeB). The NNTeB was also about the same intensity as the nearby North Temperate Belt (NTeB).

North Temperate Zone (NTeZ).—Among the Saturnian northern-hemisphere zones, the NTeZ was surpassed in brilliance only by the EZn in 1995-96. The dull yellowish-white NTeZ appeared to undergo a very small decrease in brightness since the immediately preceding apparition (the change in mean intensity amounted to -0.59). The NTeZ was sporadically reported during the apparition; but when it was seen, observers suspected ill-defined diffuse light and dark features. Intensity data in 1995-96 suggested that the NTeZ was just marginally darker than the STeZ (by -0.32 mean intensity points) and was reported with about the same frequency.

North Temperate Belt (NTeB).—The greyish NTeB was poorly defined during most of 1995-96, but in good seeing the diffuse belt could be distinguished from its surroundings fairly easily. Since the 1994-95 Apparition, intensity data hint that a small darkening trend occurred in the NTeB (amounting to -1.11 in mean intensity). When seen, the NTeB was uninterrupted as it crossed the Globe from limb to limb. In comparison to the South Temperate Belt (STeB), the southern counterpart might have been slightly the darker (by -0.24 mean intensity points).

North Tropical Zone (NTrZ).—The NTrZ was the dullest zone in Saturn's Northern Hemisphere in 1995-96, darker by -1.22 mean intensity points since 1994-95. Observers described the NTrZ as a uniform yellowish-grey zone, mostly devoid of activity, as it extended across the Globe from limb to limb. Compared with the STrZ in the opposite hemisphere of Saturn, the NTrZ was marginally the darker (by -0.23 in mean intensity).

North Equatorial Belt (NEB).—The overwhelming aspect of the dark-grey NEB during 1995-96 was as a single feature, only rarely suspected of being differentiated into an NEBn and NEBs, where n refers to the North Component and s to the South Component, separated by an NEBZ (North Equatorial Belt Zone). Intensity estimates in 1995-96 revealed that the NEB, taken as a whole, was the darkest belt in Saturn's Northern Hemisphere and second in darkness only to the South Polar Belt (SPB) for Saturn's entire Globe. The NEB appeared a little darker than it had been in 1994-95 (by -0.75 mean intensity points), and it was a mere -0.42 in mean intensity darker than its southern counterpart, the South Equatorial Belt (SEB). Based on latitude data presented in Table 4 (p. 7), the NEB was somewhat wider than the SEB during 1995-96. When the dull-greyish NEBn and dark-grey NEBs were both reported, the NEBs always appeared to be the darker of the two components (by -0.56 mean intensity points). The yellowish-grey NEBZ was glimpsed only once during 1995-96, with a mean intensity that approached that of the NNTeZ and NTeZ. A few small dark spots and associated dusky projections, occasionally extending into the adjacent EZn, were reported in good seeing during the apparition. Consequently, reduction of a small number of central-meridian transit timings of dark festoons projecting from the NEBs gave very tentative rotation rates (in System I) ranging from $10^h 14^m 17^s$ to $10^h 16^m 57^s$.

Equatorial Zone (EZ).—With Saturn's Rings at or very near edgewise orientation during the 1995-96 Apparition, the EZ was divided by the ring plane into the EZn (the region of the EZ between where the Rings cross the Globe and the NEB) and the EZs (the portion of the EZ between where the Rings cross the Globe and the SEB). The light yellowish-white EZn was very slightly darker during 1995-

96 than it was in 1994-95 (a mean intensity difference of -0.70), and the EZn was consistently the most brilliant zone on Saturn during the observing season. Observers described the EZn as developing greater prominence after 1995 August and remaining comparatively bright for the rest of the apparition. This impression was presumably due to the emergence of several extremely diffuse and elongated white patches or ovals in the EZn, initially sighted on 1995 SEP 18, just four days after opposition. These brilliant white features, with a mean intensity of 7.8, apparently endured until 1995 SEP 27, but a series of CM transits was difficult to obtain because of the diffuse morphology of these features. Using apertures ranging from 15.2 cm (6.0 in) up to 100.0 cm (39.4 in), they were detected visually, recorded on CCD images, and photographed in integrated light. An additional, albeit minor, outburst of whitish ovals in the EZn occurred during the period lasting from 1995 OCT 13 to OCT 19; and as mentioned before, the EZn thereafter maintained its elevated brightness until at least 1996 FEB 17, the end of the observing season. It is enticing to conclude that at least some of the observed and very diffuse white areas ultimately merged and expanded longitudinally along the EZn by the end of 1995 October. White spots were also sighted during the 1994-95 Apparition, but none have been as striking or long-lasting as the Great White Spot of 1990.

Transient and ill-defined festoons, projecting from the NEB into the EZn, were recorded during 1995-96; the few CM transits of these rather amorphous have already been discussed.

The Equatorial Band (EB) was seldom seen during the 1994-95 Apparition, and then as a dark-grey, very poorly-defined linear feature extending across Saturn's Globe. The EB was the only feature on Saturn's Globe during 1995-96 that was suspected of exhibiting a slight increase in brightness since the immediately preceding apparition. Unfortunately, only one intensity estimate was made of the EB in 1994-95, and therefore, one must place little or no confidence in this mean intensity variation for the EB from 1994-95 to 1995-96.

The dull yellowish-white southern half of the Equatorial Zone (EZs) was barely (-0.33 mean intensity points) dimmer than the EZn. Observers reported possible dispersed whitish patches in the EZs on 1995 SEP 26 and OCT 19, both probably extended regions of diffuse white areas seen in the EZn separated in our view from Earth by Saturn's ring plane.

For those periods when the Rings were not exactly edgewise during 1995-96, it is quite conceivable that observers may have seen the EZn or EZs through portions of the very tenuous Ring E where it crossed in front of Saturn's Globe.

Shadow of the Globe on the Rings (Sh G on R).—This feature was rarely reported in 1995-96; but when suspected, it appeared as a dark greyish-black feature on either side of opposition, regular in form, with any deviation from the actual black (0.0) intensity due to scattered light and bad seeing.

Shadow of the Rings on the Globe (Sh R on G).—This feature was sometimes very troublesome to identify because of the varying inclination of the Rings, which occurred within such a small range during 1995-96. When observed either to the north or south of the ring plane, this shadow was dark greyish-black in hue as it extended across the Globe. Of course, any variation from the true black (0.0) intensity occurs for the same reasons as noted in the preceding paragraph.

SOUTHERN PORTIONS OF THE GLOBE

With the Rings of Saturn reaching edgewise orientation to our line of sight in 1995-96, it has already been remarked that nearly equal portions of the Northern and Southern Hemispheres of the planet could be seen during the apparition. With the Rings edge-on, the opportunity for comparing analogous features in either hemisphere of Saturn's Globe was at an optimum. The mean intensity of the Globe south of the Rings (as shown in Table 3, p. 6) in 1995-96 was darker (by -0.73 intensity points) than in 1994-95. Also, as indicated earlier in this report, the estimated brightness of the Globe north of the Rings was darker (by -0.47 mean intensity points) than the Globe south of the Rings.

In the Southern Hemisphere of Saturn during 1995-96, the EZs exhibited a few bright and very diffuse whitish spots in 1995 September and October (these EZs features were discussed in the previous section dealing with Saturn's EZ). Observers also found that fluctuations occurred in the appearance and intensity of various belts and zones in the Southern Hemisphere of Saturn during the apparition. As with the Northern Hemisphere, festoons and other dusky regions, as well as whitish patches, characterized some of the planet's southern-hemisphere belts or zones in 1995-96.

South Equatorial Belt (SEB).—The SEB was usually reported as a solitary, greyish-brown feature during 1995-96; yet in a very few instances it was seen differentiated into SEBn or SEBs components with an intervening SEBZ. The mean intensity of the SEB averaged -0.33 darker than it was in 1994-95; and other than the SPB, the SEB was the darkest and most prominent belt in the Southern Hemisphere of Saturn. It was noted earlier in this report that the NEB was darker (by -0.42 in mean intensity) than the SEB in 1995-96. A few dark spots were glimpsed on the SEB periodically during the observing season, but their longevity was too brief for long-term central-meridian transit timings. On those rare occasions when the SEBn and SEBs were thought to be present, both looked greyish in color, and the SEBs was considered to be the darker of the two components (by -0.30 mean intensity points). Like the NEBZ, the dull grey SEBZ was suspected only once during 1995-96

South Tropical Zone (STrZ).—The yellowish-grey STrZ was rather dull during 1995-96, with a change in overall intensity of -0.91 since 1994-95. When compared with the NTrZ in Saturn's opposite hemisphere, the STrZ appeared the brighter by +0.23. The STrZ appeared stable in brightness, and there was no discrete atmospheric activity in this region throughout the apparition.

South Temperate Belt (STeB).—The STeB was described in 1995-96 as greyish in color, extending with no discontinuity as it crossed the Globe from limb to limb. When compared with 1994-95, the STeB was duskier by a virtually negligible value of -0.13; and with respect to the NTeB, as was noted before, the STeB was the dimmer by -0.24 intensity points. No activity was reported in the STeB in 1995-96.

South Temperate Zone (STeZ).—Aside from the EZs, the dull yellowish-white STeZ was the brightest zone in Saturn's Southern Hemisphere during 1995-96, but it looked darker by a rather subtle -0.41 mean intensity points than it had been in 1994-95. The STeZ displayed steadiness in intensity throughout the apparition, with no distinct activity, and comparative analysis revealed that the NTeZ was -0.32 mean intensity points darker than the STeZ.

South Polar Region (SPR).—The SPR was a dusky yellowish-grey during the 1995-96 observing season, with practically no discernable activity, with a diminution in brightness since 1994-95 of -0.71 mean intensity points. The NPR was marginally duller than the SPR, by a mean intensity difference of -0.33. There were several sightings in 1995-96 of the South Polar Cap (SPC), usually well-defined when present but slightly darker than it had been in 1994-95 (by -1.44 mean intensity points). Bordering the SPR, the South Polar Belt (SPB) was detected on three occasions during the 1995-96 Apparition. When visible, this curvilinear feature had the distinction of being the darkest belt on Saturn.

Saturn's Ring System

A wealth of supporting information has appeared in this Journal and elsewhere describing the specific theoretical events that were anticipated during the 1995-96 Apparition as Saturn gradually moved from an approximate heliocentric longitude of 346°.5 to 356°.5 during the 1995 Apr 20 - 1996 Feb 17 observing season. Of course, Saturn was then under close scrutiny by amateur and professional astronomers all over the world, but of particular note were the truly spectacular images of the planet and its Rings by the Hubble Space Telescope.

Earlier in this report, the phenomena concerning the three passages of the Earth, plus the single crossing of the Sun, through the ring plane during 1995-96 were discussed. Readers interested, however, in a comprehensive explanation of the prerequisite geometric conditions for edgewise presentation of the Rings to our line of sight should consult the appropriate literature in the list of references at the end of this report.

The following analysis of observations of Saturn's Ring System throughout 1995-96 has been arranged in such a way as to present the submitted data as clearly and as briefly as possible, in order to improve the reader's understanding of the collective observational sample.

The Visibility of Saturn's Rings.— Due to the extremely small angles of inclination of Saturn's Rings to our line of sight during 1995-96, observers could see neither the northern or southern ring face to any real advantage. Observers were sometimes confused as they tried to identify specific ring components and make dependable intensity estimates. Because of the uncertainties introduced by less-than-favorable views of either ring face, our ongoing comparative analysis of mean intensity data for these regions between apparitions was suspended for 1995-96.

Observers attempted, with varying degrees of success, to estimate the surface brightness (visual numerical intensity) of the sunlit and unilluminated ring surfaces throughout the 1995-96 Apparition at varying distances outward from the Globe of Saturn. For the most part, at times when the illuminated side of the Rings opened up a degree or so to our line of sight, observers confirmed the usual aspect: Ring B was the brightest of the ring components, followed by Ring A and Ring C in order of decreasing intensity. Several individuals could see nonuniformities in brightness along the sunlit side of the Rings as one progressed linearly outward from Saturn's Globe in the ring plane. Only a few isolated reports of Cassini's Division (A0 or B10) were submitted. The ring ansae were often described as being of unequal length on either side of the Globe or as exhibiting discontinuities longitudinally. The Crape Band (Ring C in front of the Globe) was by no means conspicuous, and observers frequently confused it with the shadow of the Rings on the Globe.

When the Sun and Earth were on opposite sides of the ring plane, several observers commented that light passing through various ring components from the illuminated surface made them appear complementary. Here, the intensity of the dark side of the component appeared to have an intensity roughly opposite to that of the sunlit side. For example, it was discovered that the outer third of Ring B (normally the brightest component on the illuminated face of the Rings) appeared quite dark, Ring A was somewhat brighter than B, and Ring C appeared to be the brightest of the three main components when so silhouetted. Such reversals in brightness or intensity at various positions have been seen during other edgewise apparitions, an effect that is related to particle density when the Rings are illuminated from the opposite side. Reflected light from Saturn's Globe onto the Rings definitely complicated matters; and although the intensity of this extraneous light approximately decreases with the inverse square of the distance from the planet and could be corrected for, observers were extremely reluctant to place much confidence in their intensity estimates. The dark face of the Rings repeatedly displayed asymmetry in overall brightness and linear extent at both ansae. In 1995-96, as in previous edgewise apparitions, when the unilluminated side of the Rings was edgewise to Earth, bright stellar-like points of light could be seen along the longitudinal extent of the Rings at each ansa. In 1995-96, any Saturnian satellites situated in the ring plane took on the appearance of "beads" of light, sometimes twinkling as fluctuations in seeing occurred. Also near the exact times of edgewise orientation of the Rings, non-uniformities in brightness not attributable to any known satellites of Saturn were reported, appearing as one or more "condensations" or "nodules" of light along the otherwise dark ring surface. These features were detected both visually as well as with CCD cameras, and they varied considerably in number, intensity, and conspicuousness. They were usually more prominent in larger instruments and when the seeing and transparency were better than average.

As mentioned elsewhere in this discussion, the Ring System should theoretically have been visible prior to 1995 May 21 (the first passage of the Earth through the ring plane), from 1995 Aug 11 (the date of the second passage of the Earth through the plane of the Rings) up through 1995 Nov 18 (when the Sun passed to the other side of the ring plane from the Earth), and henceforth after 1996 Feb 11 (the third and final passage of the Earth through the ring plane). More importantly, the periods during which the Rings of Saturn were theoretically invisible, regardless of the telescope aperture used, were from 1995 May 21 through 1995 Aug 10 and from 1995 Nov 19 through 1996 Feb 10. A detailed account of the visibility of the Ring System with respect to date and telescope aperture is presented chronologically in graphical form in *Figure 5* (pp. 12-14), covering the dates from 1995 Apr 20 - 1996 Feb 17. In this period, 323 observations were submitted (as mentioned earlier, three of the total observations for the 1995-96 Apparition

[text continued on p. 14]

Figure 5. The Visibility of Saturn's Rings in 1995-96 with Different Apertures.

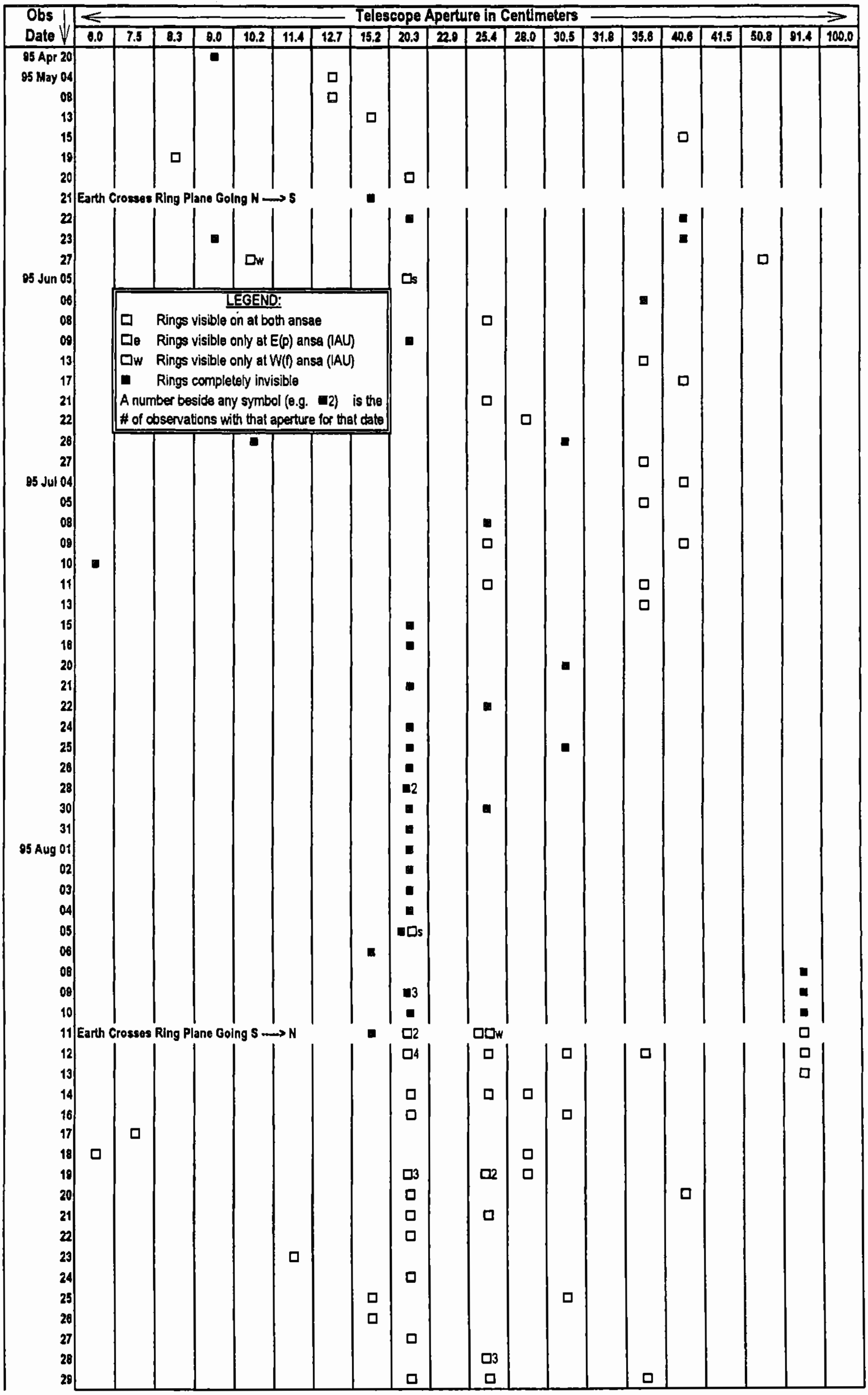

Figure 5.—Continued.

Obs Date	Telescope Aperture in Centimeters																		
	6.0	7.5	8.3	9.0	10.2	11.4	12.7	15.2	20.3	22.9	25.4	28.0	30.5	31.8	35.6	40.6	41.5	50.8	91.4	100.0
95 Aug 30									□		□									
95 Sep 01											□									
02									□		□				□					
03								□	□2				□							
04									□											
06									□2											
08											□									
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11									□2											
12									□											
14	Saturn at Opposition								□											
16															□		□			
17									□2											
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95 Nov 02								□												
03	□							□	□					□						
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16											□			□						
18	Sun Crosses Ring Plane Going N ----> S								□					□						
19								□												
20									□□w			□								
21									□											
22												□								
23											□e			■						

Figure 5.—Continued.

Telescope Aperture in Centimeters

Obs Date	6.0	7.5	8.3	9.0	10.2	11.4	12.7	15.2	20.3	22.9	25.4	28.0	30.5	31.8	35.6	40.6	41.5	50.8	91.4	100.0
95 Nov 24									■3											
25									■											
26									■					■						
27									■			□								
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29												■								
30														■						
95 Dec 01									■											
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31														□e						
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06							■		■											
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12												■								
13									■			■								
15									□											
22									□											
28									■				■							
31							■													
96 Feb 03							■													
07									□											
11	Earth Crosses Ring Plane Going N ——> S							■												
16							□						□							
17									□											
	5	1	1	2	2	1	9	21	131	4	34	33	20	24	11	13	1	1	6	3

Number of Observations (323 Total)

NOTE: *Three observations made with the 31.8 cm. instrument are omitted from the above tabulation because they were simply visual observations of the satellite Titan. All directions are in the IAU sense, not sky directions.*

have been omitted from the graph because they were solely studies of Titan). Figure 5 shows the dates when the Rings were edgewise to the Earth and Sun, the date of opposition, the total observations by date and by aperture, and an explanation of the symbolism utilized.

It is immediately apparent in Figure 5 that when the Rings were theoretically supposed to be visible from Earth, they were almost always seen by observers using instruments ranging from 6.0 cm (2.4 in) through 100.0 cm (39.4 in) unless poor seeing or transparency conditions interfered. For the periods when Saturn's Rings theoretically should not have been seen, regardless of the aperture employed, most visual observers described Saturn as being completely devoid of Rings. As one would expect, the invisibility of the Rings persisted for several days prior to and following the edgewise presentations. There were instances, however, when simultaneous visual observations yielded conflicting results. For example, one observer would report that he could see the Rings, while another individual using the same aperture on the same date (and under comparable seeing conditions) would report that he could not find them at all. In other simultaneous observations, when two substantially different apertures were used, the outcome was as expected; that is, observers using larger instruments could see the Rings, but smaller telescopes were unable to detect them. Those who employed CCD cameras, because of their greater sensitivity to faint illumination, afforded much better success in capturing short ring "appendages" at both ansae in various instruments. With regard to concurrent visual and CCD observations, there were a few occasions when observers reported they could not see the Rings in the eyepiece, but CCD images revealed them. In short, observational results during 1995-96 confirmed the expected asymmetries with respect to the extent, appearance, and brightness of the Rings of Saturn at edgewise presentations.

It should be stressed that a few factors other than aperture affected the data in Figure 5, many of which are virtually impossible to correct for. For instance, seeing varied from place to place, as well as atmospheric transparency, and the altitude of Saturn above the horizon at the time of observation also probably influenced how easily the Rings could be seen, as did moonlight and artificial illumination. One could cite differences among individuals in terms of experience at the telescope, psychophysical peculiarities of the eye, visual acuity, contrast sensitivity, as well as varying degrees of optical quality and overall light transmission of the telescopes employed. Finally, systematic errors are always apparent in such a compilation of observations. Even though all of these factors influenced our interpretation and evaluation of the data submitted, every attempt has been made to alleviate as much subjectivity as possible in order to increase the reliability of the results.

Figure 5 shows that, for the Earth's three passages through Saturn's ring plane, the Rings were detected visually or recorded on CCD images to within a day of each edgewise orientation, while visibility of the Rings before and after the Sun's passage through the ring plane varied considerably with aperture. As derived from Figure 5, the successes or failures of observers to detect the Rings with various instruments, using visual methods, photography, and CCD imaging during 1995-96, have been condensed into tabular form and presented in *Table 5* (p. 16). Table 5 divides the 1995-96 Edgewise Apparition into cumulative periods when the Rings should have been theoretically visible from Earth and when they were theoretically invisible, regardless of aperture. Under the category "Periods of Theoretical Visibility of Rings" in Table 5, three intervals of observing dates and number of attempted observations are shown. Each one of these is, in turn, subdivided into columns entitled "positive" and "negative" observations. In summary, for the 90 observing dates and 188 attempted observations for the three periods of theoretical ring visibility during 1995-96, 98.4 percent of the attempted observations were positive and only 1.6 percent were negative. Note also that within this range, the period of greatest observational emphasis occurred from 1995 Aug 11 - 1995 Nov 18. Likewise, the category "Periods of Theoretical Invisibility of the Rings" is presented, also broken down as described above into two intervals of observing dates and number of attempted observations. For the 95 observing dates and 135 attempted observations for the two periods of theoretical ring invisibility, 39.3 percent of the attempted observations were positive and 60.7 percent were negative. Next, using the first column in the table with the heading "Telescope Aperture" as a guide, it is easy to read across under each of the two main headings and five subsets of observing dates and attempted observations, and determine the number of times the Rings were seen or not seen with a given instrument. Cumulative totals and percentages for the main categories and constituent intervals are given at the bottom of the table.

Bicolored Aspect of the Rings.—The reported difference in color (and sometimes brightness) between the east and west ansae of the Rings when compared in red and blue filters (and in integrated light) was generally lacking during 1995-96, although a few observers noticed that there were some obvious differences in the extent and visibility of the ansae, as noted earlier in this report.

Table 5. Observations of Saturn's Rings by Period of Theoretical Visibility or Invisibility by Aperture
The 1995-96 Apparition of Saturn

Telescope Aperture (cm.)	← Periods of Theoretical Visibility of Rings →								← Periods of Theoretical Invisibility of Rings →						Total No. of Observations by Aperture for Apparition (Positive & Negative)
	No. of Attempted Observations: 1995 Apr 20 - 1995 May 20 (7 observing dates)		No. of Attempted Observations: 1995 Aug 11 - 1995 Nov 18 (80 observing dates)		No. of Attempted Observations: 1996 Feb 11 - 1996 Feb 17 (3 observing dates)		Total No. of Attempted Observations when Rings were Theoretically Visible (90 observing dates)		No. of Attempted Observations: 1995 May 21 - 1995 Aug 10 (41 observing dates)		No. of Attempted Observations: 1995 Nov 19 - 1996 Feb 10 (54 observing dates)		Total No. of Attempted Observations when Rings were Theoretically Invisible (95 observing dates)		
	Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative	
6.0			4				4	0		1			0	1	5
7.5			1				1	0					0	0	1
8.3	1						1	0					0	0	1
9.0		1					0	1		1			0	1	2
10.2							0	0	1	1			1	1	2
11.4			1				1	0					0	0	1
12.7	2		2		1		5	0				4	0	4	9
15.2	1		13	1		1	14	2		2	3		3	2	21
20.3	1		69		1		71	0	2	21	11	26	13	47	131
22.9			4				4	0					0	0	4
25.4			26				26	0	4	3	1		5	3	34
28.0			21				21	0	1		8	3	9	3	33
30.5			11		1		12	0		3	1	4	1	7	20
31.8			11				11	0			8	5	8	5	24
35.6			4				4	0	5	1		1	5	2	11
40.6	1		2				3	0	3	2	4	1	7	3	13
41.5			1				1	0					0	0	1
50.8							0	0	1				1	0	1
91.4			3				3	0		3			0	3	6
100.0			3				3	0					0	0	3
Totals with % by Period	6 85.7%	1 14.3%	176 99.4%	1 0.6%	3 75.0%	1 25.0%	185 98.4%	3 1.6%	17 30.9%	38 69.1%	36 45.0%	44 55.0%	53 39.3%	82 60.7%	323

NOTE: *Three observations made with the 31.8 cm instrument are omitted from the above tabulation because they were simply visual studies of the satellite Titan.*

SATURN'S SATELLITES

With the Ring System at or near edge-on orientation for much of 1995-96, interesting events involving the satellites of Saturn were expected. For example, near when the plane of the Ring System passed through the Sun, the best opportunity arose for observing shadow transits and eclipses of the satellites of Saturn that were near the equatorial plane. Likewise, when the Earth was near the ring plane was the best time to observe satellite transits and occultations. Such observations involved the precise timing of the specific events to the nearest whole second. In observing seasons leading up to, during, and following the 1995-96 Edgewise Apparition, the satellites Mimas (S1), Enceladus (S2), Tethys (S3), Dione (S4), Rhea (S5), Titan (S6), and Iapetus (S8) were predicted to participate in these events. Small apertures were insufficient to view these phenomena during 1995-96, although a few observers tried to record events involving Titan, and larger instruments definitely increased observational success. It has often been held that, even with moderate to large telescopes, the visibility of shadow transits of the Saturnian satellites other than Titan is somewhat questionable. It has been theoretically established that nearly all of the inner satellites of Saturn are far too small in diameter to cast umbral shadows onto the Globe of the planet. Nonetheless, trained observers with sufficiently large apertures have reported possible shadow transits of Tethys in past years.

Saturn's Rings were mostly absent from view during 1995-96, and with the orbits of the majority of Saturn's satellites lying within the same plane as the Rings, observational opportunities for the satellites were optimized. Also, these circumstances meant that much of the glare from the Rings was gone in 1995-96, and many observers were able to detect satellites that usually remain invisible for their aperture in other apparitions. A few observers utilized occulting bars in eyepieces to further enhance satellite visibility. Utilization of CCD imaging also helped reveal faint Saturnian satellites. Visually, observers regularly reported Titan, Tethys, Rhea, Dione, and Iapetus, while Enceladus was noted less often, and Mimas was only occasionally seen. Westfall used a CCD camera to record sequential images of the disappearance phase of Titan's eclipse by Saturn on 1995 JUL 13 (see *Figure 15*, p. 20), while Haas reported a transit of Titan across the Globe of Saturn on 1995 DEC 12 and again on 1995 DEC 20.

As in the immediately preceding apparition, no observers in 1995-96 contributed systematic visual magnitude estimates of Saturn's satellites using the methods outlined in *The Saturn Handbook.* Several photometric observations were attempted during the apparition, but a consistent program using photoelectric photometry as well as systematic visual magnitude estimates of Saturn's satellites is definitely needed in future apparitions.

Simultaneous Observations

A few simultaneous, or near-simultaneous, observations of Saturn were submitted during 1995-96 (simultaneous observations are those in which individuals work independently of one another but observe at the same time and on the same date). As in the 1994-95 Apparition, the occurrence of simultaneous observations appeared to be entirely coincidental, and the A.L.P.O. Saturn Section would like to receive reports from individuals who participate in a routine simultaneous observing effort. Simultaneous observations provide much-needed verification of ill-defined phenomena on Saturn's Globe and in the Ring System, greatly improving the overall confidence level in our data. Readers are urged to inquire about how to pursue simultaneous observations in future observing seasons.

Conclusions

Based on this analysis of the submitted observations of Saturn and its edgewise Rings during 1995-96, atmospheric activity remained moderate, somewhat consistent with the outcome of the immediately preceding observing season. Most observers remarked just how dim Saturn appeared during the apparition, no doubt as a result of the absence of the majestic Ring System during edgewise orientations during 1995-96. Whether the reported slight to almost-negligible diminution in brightness for most global features was related to any Saturnian seasonal effect is unclear, particularly because an assessment of such phenomena requires gathering and comparing data over at least entire one orbit of the planet around Sun, which spans a period of 29.5 terrestrial years. Now that the 1995-96 Edgewise Apparition of Saturn has passed, the A.L.P.O. Saturn Section has initiated a detailed comparative analysis of visual numerical relative intensity estimates going back to 1965-66 (one Saturnian year ago). Incorporating similar long-term data accumulated by other groups, such as the British Astronomical Association (B.A.A.) in the United Kingdom and the Unione Astrofili Italiani (U.A.I.) in Italy, should also add significant value to the analysis. It is hoped that this study will shed some light on any seasonal effects as they might apply to the prominence of belts and zones on Saturn's Globe as well as ring features. The results of this investigation will be published in a later issue of this Journal.

Once again, we are grateful to all of the dedicated observers mentioned in this report who contributed data during 1995-96. Readers in the United States and elsewhere, who may not already be contributing observational data to the A.L.P.O. Saturn Section, are encouraged to join us in future apparitions. The continued international systematic study of Saturn by an increasingly larger and experienced observer base, using traditional methods as well as employing new technology, is important to the success of our endeavors. Comprehensive coverage of Saturn also improves opportunities for simultaneous observations and allows comparisons among data gathered by various methods.

We also seek participation of individuals who may be just beginning lunar and planetary astronomy. Enrolling in the A.L.P.O. Training Program, while concurrently joining the A.L.P.O. Saturn Section, is a great way to develop and fine-tune special talents a particular novice observer might bring to the program. The Saturn Section, and A.L.P.O. as a whole, is actively seeking, through the formation of a Youth Committee in 1996, enthusiastic young people to get involved in lunar and planetary astronomy as an educational enrichment experience. The influx and real involvement of bright, enthusiastic youngsters in the A.L.P.O. is essential to the future of the organization.

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Figures 6-31 (below and pp. 19-23). Unless otherwise stated for these illustrations: **Seeing** (S) is given on the 0-10 A.L.P.O. Scale, where 0 is the worst possible and 10 is perfect; **Transparency** (Tr) is the limiting naked-eye visual magnitude in the vicinity of Saturn; **CM(I)** is the central-meridian longitude in rotational system I (844°.3/day, applying to the NEBs, EZ, and SEBn); **CM(II)** is the same in rotational system II (812°.0/day, applying to the remainder of the Globe); **B** is the saturnicentric latitude of the Earth; and **B'** is the saturnicentric latitude of the Sun. Saturnicentric south is at the top, with celestial east (following) to the right, unless otherwise stated. Contrasts have been exaggerated for reproduction.

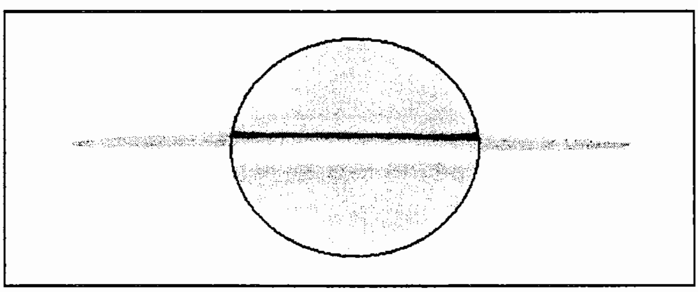


Figure 6. 1995 May 13 09^h20^m to 09^h45^m UT. J.L. Benton. 15.2-cm (6.0-in) refractor, no filter. S = 3.0, Tr = +4.0. CM(I) = 075°.9 to 090°.6, CM(II) = 315°.8 to 329°.9. B = +0°.27, B' = +2°.81.

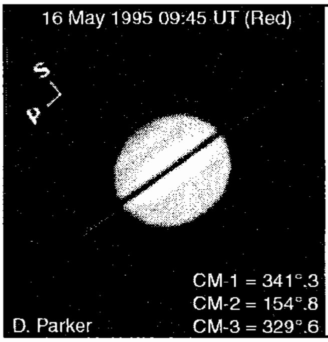


Figure 9. 1995 May 16 09^h45^m UT. D.C. Parker. 40.6-cm (16.0-in) Newtonian, CCD Camera at f/19, Schott RG610 (red) + IR rejection filters. S = Good, Tr = Good. CM(I) = 341°.3, CM(II) = 154°.8. B = +0°.21, B' = +2°.78.

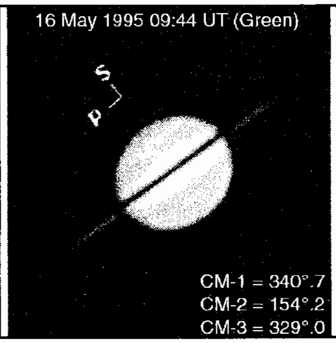


Figure 8. 1995 May 16 09^h44^m UT. D.C. Parker. 40.6-cm (16.0-in) Newtonian, CCD Camera at f/19, Schott VG9 (Green) + IR rejection filters. S = Good, Tr = Good. CM(I) = 340°.7, CM(II) = 154°.2. B = +0°.21, B' = +2°.78.

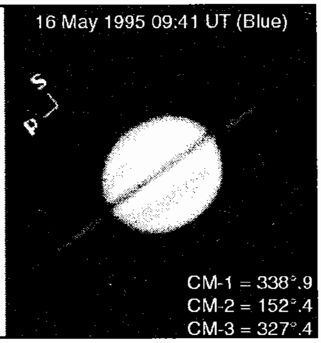


Figure 7. 1995 May 16 09^h41^m UT. D.C. Parker. 40.6-cm (16.0-in) Newtonian, CCD Camera at f/19, Schott BG12 (blue) + IR rejection filters. S = Good, Tr = Good. CM(I) = 338°.9, CM(II) = 152°.4. B = +0°.21, B' = +2°.78.

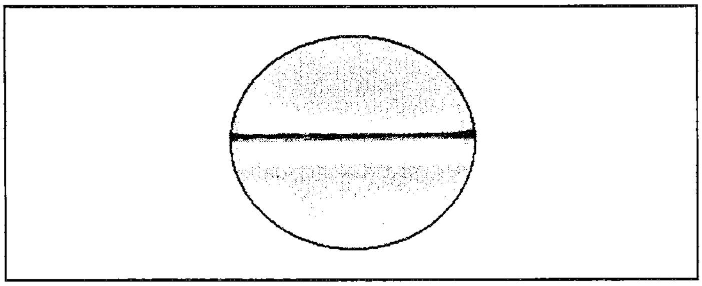
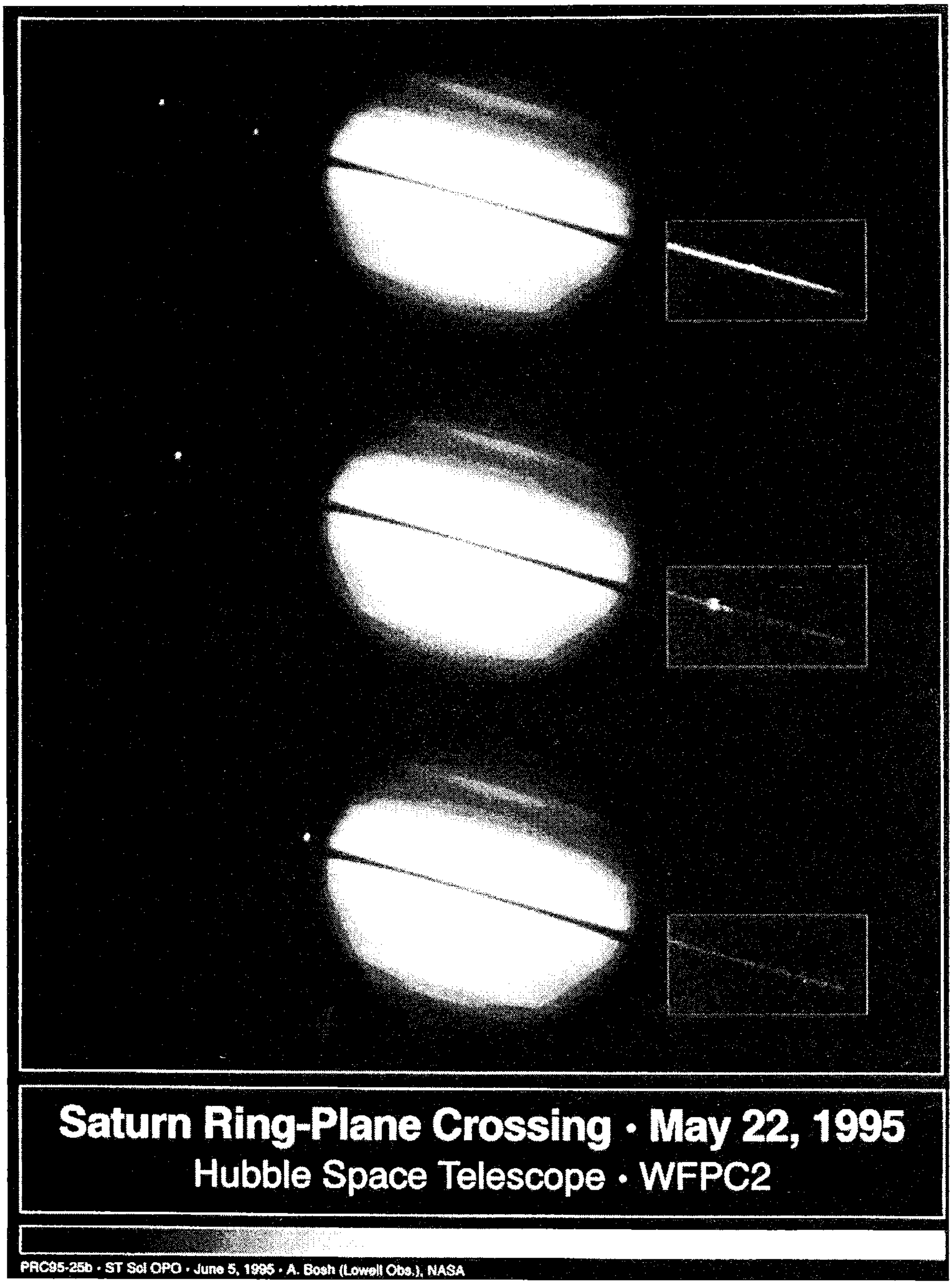


Figure 10 (left). 1995 MAY 21 09^h30^m to 09^h50^m UT. J.L. Benton. 15.2-cm (6.0-in) refractor, 98×-244×, no filter. S = 2.0-3.0, Tr = +5.0. CM(I) = 356°.1 to 008°.5, CM(II) = 315°.8 to 329°.9. B = +0°.02, B' = +2°.69. 13 hours prior to the Earth's first ring-plane crossing.

Figure 11 (below). 1995 MAY 22 . Hubble Space Telescope Image of the First Ring-Plane Crossing. B ≈ 0°.0, B' ≈ +2°.7.



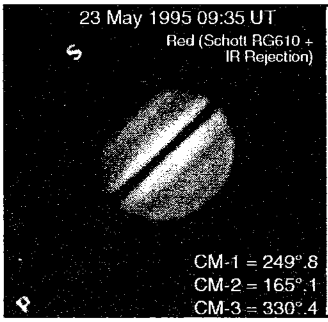


Figure 12. 1995 May 23 09^h35^m UT. D.C. Parker. 40.6-cm (16.0-in) Newtonian, CCD Camera at f/19, Schott RG610 (red) + IR rejection filters. S = Good, Tr = Good. CM(I) = 249°.8, CM(II) = 165°.1. B = -0°.04, B' = +2°.66.

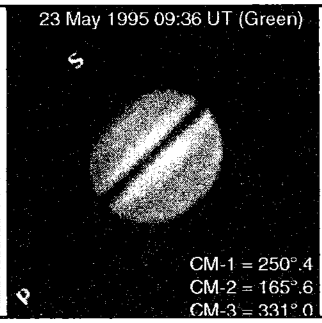


Figure 13. 1995 May 23 09^h36^m UT. D.C. Parker. 40.6-cm (16.0-in) Newtonian, CCD Camera at f/19, Schott VG9 (Green) + IR rejection filters. S = Good, Tr = Good.CM(I) = 250°.4, CM(II) = 165°.6. B = -0°.04, B' = +2°.66.

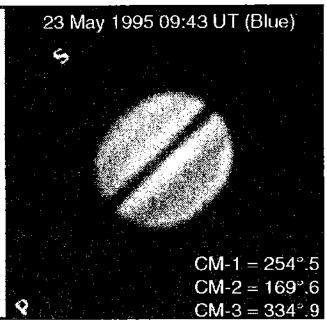


Figure 14. 1995 May 23 09^h43^m UT. D.C. Parker. 40.6-cm (16.0-in) Newtonian, CCD Camera at f/19, Schott BG12 (blue) + IR rejection filters. S = Good, Tr = Good. CM(I) = 254°.5, CM(II) = 169°.6. B = -0°.04, B' = +2°.66.

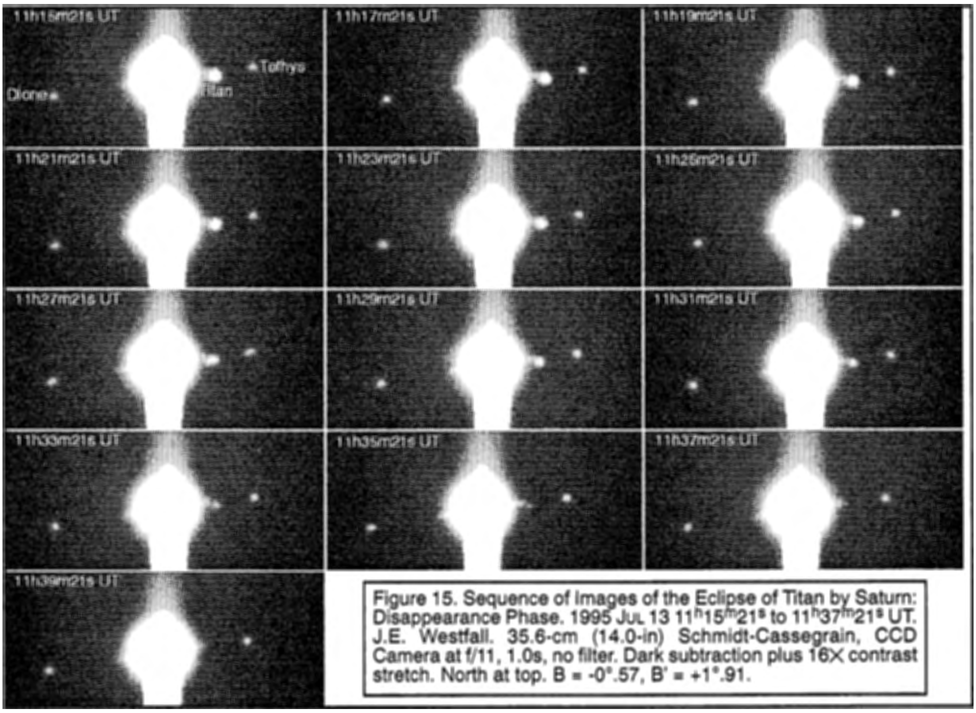


Figure 15. Sequence of Images of the Eclipse of Titan by Saturn: Disappearance Phase. 1995 Jul 13 $11^h15^m21^s$ to $11^h37^m21^s$ UT. J.E. Westfall. 35.6-cm (14.0-in) Schmidt-Cassegrain, CCD Camera at f/11, 1.0s, no filter. Dark subtraction plus 16X contrast stretch. North at top. B = -0°.57, B' = +1°.91.

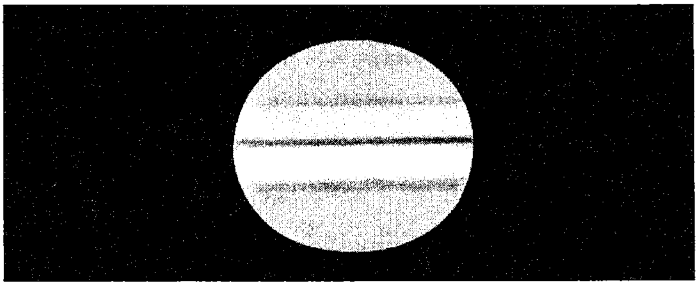


Figure 16. 1995 Jul 20 02^h30^m UT. A.W. Heath. 30.5-cm (12.0-in) Newtonian, 190X-318X, no filter. S = Fair, Tr = Good. CM(I) = 011°.1, CM(II) = 223°.6. B = -0°.49, B' = +1°.81.

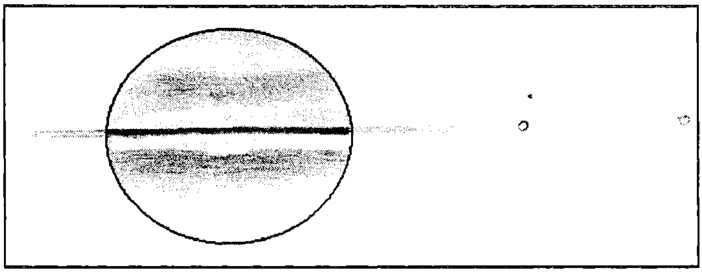


Figure 17. 1995 AUG 11 07ʰ45ᵐ to 08ʰ02ᵐ UT. R. Crotty. 25.4-cm (10.0-in) Newtonian, 274X, no filter. S = 7.0-8.0, Tr = +1.0. CM(I) = 052°.4 to 062°.4(, CM(II) = 267°.2 to 276°.8. B = 0°.00, B' = +1°.48. Approximately 4 hours after the Earth's second ring-plane crossing. Satellites to the east (right) of Globe are Enceladus (left) and Tethys (right).

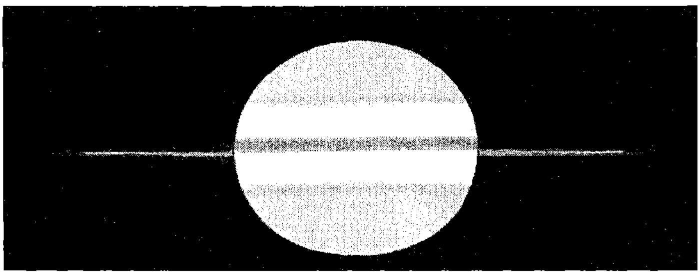


Figure 18. 1995 AUG 12 02ʰ30ᵐ UT. A.W. Heath. 30.5-cm (12.0-in) Newtonian, 190X, no filter. S = Fair to Good, Tr = Good (moonlight present). CM(I) = 352°.1, CM(II) =181°.7. B = +0°.02, B' = +1°.47.

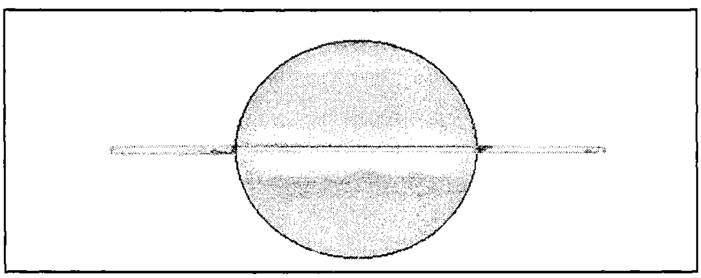


Figure 19. 1995 SEP 11 04ʰ00ᵐ UT. P. Plante. 20.3-cm (8.0-in) refractor, 428X, no filter. S = 5.0-6.0, Tr = +4.0 (moonlight). CM(I) = 176°.5, CM(II) = 115°.0. B = +1°.06, B' = +1°.03. Note dark projections in NEBs.

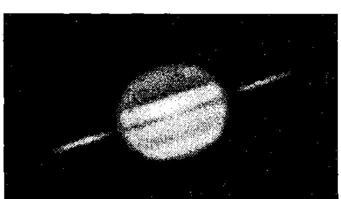


Figure 20. 1995 SEP 18 22ʰ06ᵐ UT. A. Dan. 25.4-cm (10.0-in) Newtonian, CCD Camera at f/32, 1.0s, No filter. S = V. Good, Tr = Good. CM(I) = 240°.3, CM(II) = 291°.8. B = +1°.34, B' = +0°.91. Prominent, longitudinally-extended white oval in EZn. North at top.

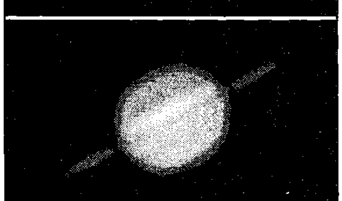


Figure 21. 1995 SEP 24 20ʰ43ᵐ UT. A. Dan. 25.4-cm (10.0-in) Newtonian, CCD Camera at f/32, 1.2s, No filter. S = Good, Tr = Good. CM(I) = 221°.3, CM(II) = 077°.4. B = +1°.55, B' = +0°.82. Diffuse white spot in EZn. North at top.

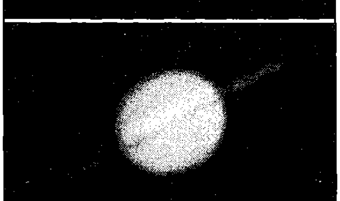


Figure 22. 1995 OCT 13 20ʰ57ᵐ UT. A. Dan. 25.4-cm (10.0-in) Newtonian, CCD Camera at f/32, 1.4s, No filter. S = Fair, Tr = Good. CM(I) = 071°.8, CM(II) = 033°.9. B = +2°.16, B' = +0°.54. Bright EZn; diffuse white spot? North at top.

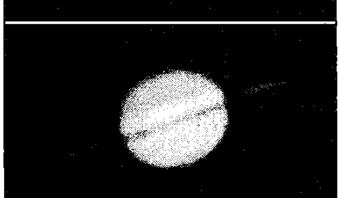


Figure 23. 1995 OCT 25 18ʰ52ᵐ UT. A. Dan. 25.4-cm (10.0-in) Newtonian, CCD Camera at f/32, 1.3s, No filter. S = Good, Tr = Good. CM(I) = 050°.2, CM(II) = 347°.5. B = +2°.44, B' = +0°.36. Bright EZn; diffuse white spot? North at top.

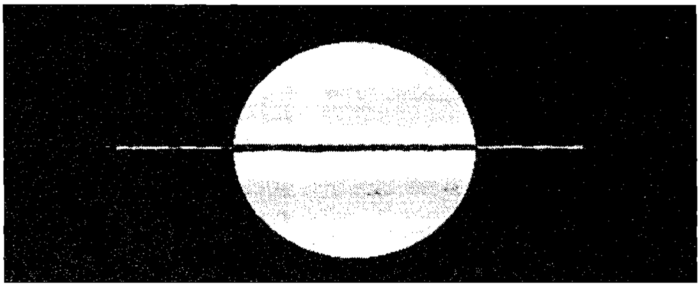


Figure 24. 1995 Nov 19 01^h37^m to 02^h00^m UT. M. Will. 15.2-cm (6.0-in) Newtonian, 230X, W23A (red-orange) Filter. S = 4.0-5.0, Tr = +3.0. CM(I) = 029°.8 to 043°.3, CM(II) = 262°.9 to 275°.9. B = +2°.66, B' = +0°.00. 2 hours after the solar ring-plane crossing.

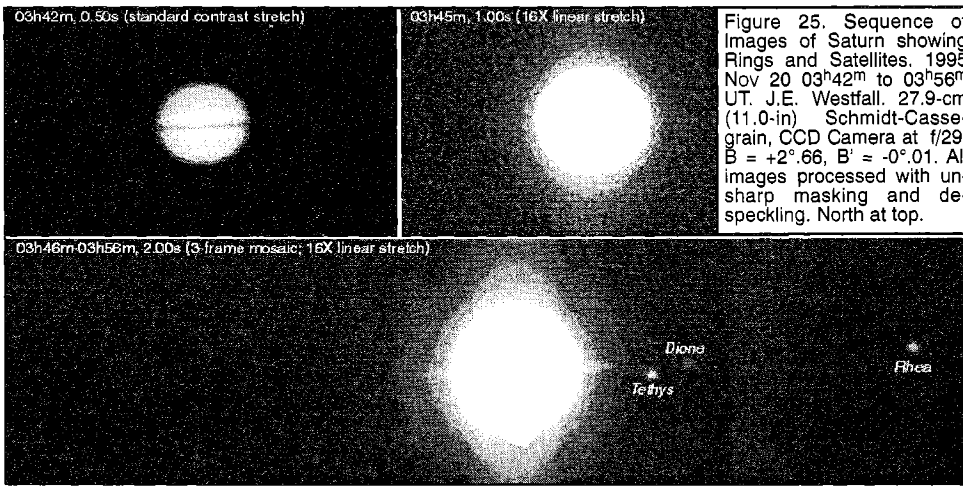


Figure 25. Sequence of Images of Saturn showing Rings and Satellites. 1995 Nov 20 03^h42^m to 03^h56^m UT. J.E. Westfall. 27.9-cm (11.0-in) Schmidt-Cassegrain, CCD Camera at f/29. B = +2°.66, B' = -0°.01. All images processed with unsharp masking and despeckling. North at top.

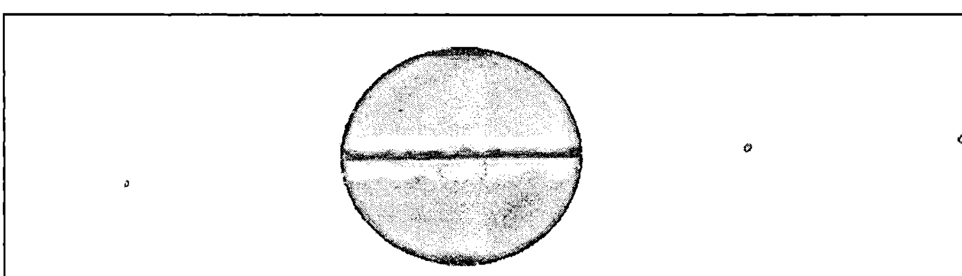
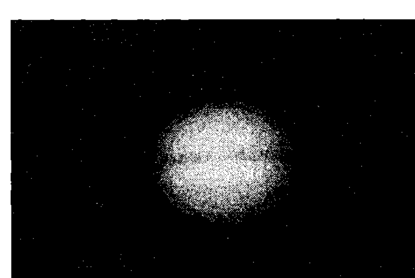


Figure 26 (above).1995 Nov 24 23^h24^m UT. P. Plante. 20.3-cm (8.0-in) refractor, 240X, no filter. S = 5.0-6.0, Tr = +3.5. CM(I) = 337°.2, CM(II) = 019°.5. B = +2°.65, B' = -0°.09. Dark projections along NEBs; suspected whitish oval in EZn. Satellites, from left to right, are: Mimas, Tethys, and Dione.

Figure 27 (right). 1995 Nov 28 19^h00^m UT. C. Viladrich. 20.3-cm (8.0-in) Schmidt-Cassegrain, 15s exp using TP2415 hyper film W15 (yellow) Filter. S = Excellent, Tr = Good. CM(I) = 318°.9 ,CM(II) = 238°.3. B = +2°.62, B' = -0°.14. Bright EZn.



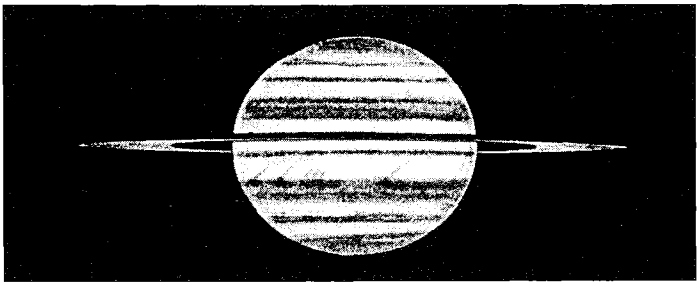


Figure 28. 1995 DEC 10 17^h20^m UT. M. Cicognani. 40.6-cm (16.0-in) Schmidt-Cassegrain, 460×, W12 (deep yellow) Filter. S = Average, Tr = Good. CM(I) = 311°.1, CM(II) = 204°.8. B = +2°.46, B' = -0°.32. Dark spots and projections from NEBs.

Figure 29. 1996 JAN 01 17^h00^m UT. M. Cicognani. 40.6-cm (16.0-in) Schmidt-Cassegrain, 460×, W12 (deep yellow) Filter. S = Fair, Tr = Good. CM(I) = 151°.3, CM(II) = 054°.9. B = +1°.87, B' = -0°.65. Dark spots and projections from NEBs; bright EZn.

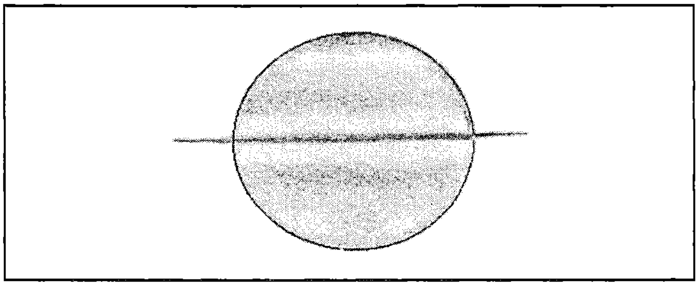


Figure 30. 1996 JAN 21 23^h50^m UT. P. Plante. 20.3-cm (8.0-in) refractor, 285×, no filter. S = 4.0-5.0, Tr = +3.0. CM(I) = 002°.0, CM(II) = 289°.0. B = +1°.05, B' = -0°.95.

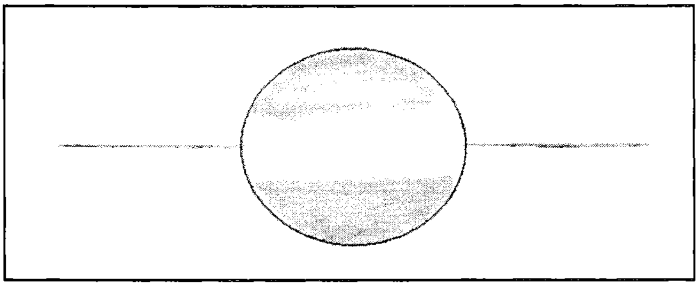


Figure 31. 1996 FEB 18 23^h10^m to 23h12^m UT. F. J. Melillo. 20.3-cm (8.0-in) Schmidt-Cassegrain, 220×, no filter. S = 5.0, Tr = +4.0. CM(I) = 208°.2 to 209°.4, CM(II) = 352°.9 to 354°.0. B = -0°.39, B' = -1°.37.

GALILEAN SATELLITE ECLIPSE TIMINGS: THE 1993/94 APPARITION

By: John E. Westfall, A.L.P.O. Assistant Jupiter Coordinator, Galilean Satellites

ABSTRACT

The A.L.P.O. Jupiter Section received 562 visual timings of the eclipses of Jupiter's Galilean satellites Io, Europa, and Ganymede from 46 observers for the 1993/94 Apparition (Callisto underwent no eclipses during this apparition). For each satellite, eclipse visual disappearance and reappearance timings were adjusted for telescope aperture and were then combined for comparison with the Jet Propulsion Laboratory's "E-2" Ephemeris. None of the three satellites studied were found to differ significantly in position from the E-2 Ephemeris.

INTRODUCTION

The 1993/94 Apparition of Jupiter was the eighteenth studied by the A.L.P.O. Jupiter Section's Galilean Satellite Eclipse Timing Program. The satellites timed were Io (1), Europa (2), and Ganymede (3); Callisto (4) was not eclipsed in 1993/94. 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. 31). [Westfall 1983-84, 1986a, 1986b, 1987, 1988, 1989, 1991, 1992, 1994, 1996, and 1998]

Table 1 (below) lists some significant dates for the 1993/94 Jupiter Apparition. All dates and times in this report are in Universal Time (UT); also, an *apparition* is the period between successive conjunctions, while an *observing season* is the period of actual observation. The 1993/94 observing season began 31 days after conjunction, with Jupiter 24° west of the Sun; it ended 46 days before the next conjunction, at solar elongation 36° east.

Table 1. 1993/94 Jupiter Apparition Chronology.
[Meeus, 1995; U.S. Nautical Almanac Office, 1992 & 1993]

		d	h
Conjunction with the Sun	1993	Oct 18	10
First Eclipse Timing	1993	Nov 18	05
Opposition to the Sun	1994	Apr 30	09
Closest Approach to Earth	1993	May 01	17
Last Eclipse Timing	1994	Oct 02	09
Conjunction with the Sun	1994	Nov 17	20

At closest approach, Jupiter's distance from the Earth was 4.42272 AU [astronomical units; 1 AU = 149,597,870 km], with an equatorial diameter of 44".53. At opposition, Jupiter had a visual magnitude of -2.5 and a geocentric declination of -13°.4, so that observers in the Earth's Southern Hemisphere were favored over those in the Northern Hemisphere for this apparition.

OBSERVATIONS

The 562 timings received for 1993/94 bring our 18-apparition total to 8237 visual timings. Contributing to this total were 373 timings (66 percent) by 16 New Zealand and Australian observers coordinated by Brian Loader of the Royal Astronomical Society of New Zealand. As Jupiter moved farther south, the Australia-New Zealand observers' contribution became increasingly significant. A total of 46 persons made observations. The timings themselves and the list of observers are given in *Table 9* (pp. 32-35). Ten new contributors joined our program in 1993/94, but 34 of the contributors from the previous (1992/93) Apparition were not heard from. Fortunately, the 1993/94 observers were unusually productive, averaging 12.2 timings per observer; the 18-apparition average is only 8.1 timings per observer per apparition. We wish here to single out those observers for the 1993/94 Apparition who had contributed observations for at least five apparitions. *Table* 2 (p. 25) gives their names, nations and number of apparitions.

Table 2. Long-Term Participating Observers, Galilean Satellite Eclipse Timing Program (through 1993/94).

William Abrahams (Australia, 9)
Sandro Baroni (Italy, 5)
Colin Bembrick (Australia, 8)
J.L. Blanksby (Australia, 7)
Paul H. Bock (United States, 6)
Chen Dong Hua (P.R. China, 5)
Per Barner Darnell (Denmark, 5)
Ross Dickie (New Zealand, 5)
Joaquim Garcia (Portugal, 7)
Rui Gonçalves (Portugal, 7)
Walter Haas (United States, 10)
Robert Hays (United States, 8)
Alfred Kruijshoop (Australia, 8)
Patricia Larkin (Australia, 5)
Brian Loader (New Zealand, 13)
Malcolm MacDonald (New Zealand, 7)
Craig MacDougal (United States, 9)
Harry Moller (Australia, 6)
Jens Østergaard Olesen (Denmark, 7)
R. Parmentier (United States, 7)
John Priestly (New Zealand, 10)
Charlie Smith (Australia, 7)
John Westfall (United States, 17)

Timings for the 1993/94 Apparition were made by observers in 10 countries in four continents, as shown in *Table 3* (below). There remain longitude gaps in our coverage, such as much of the Pacific Basin and Asia. Observers from five countries were particularly productive; the countries were Australia, New Zealand, Portugal, Italy, and Canada. It is, however, disappointing that less than one quarter of the observers were from the United States and that the Americans averaged so few timings per observer.

The size of telescope used significantly affected the timings. Most observers used a single telescope, but 16 used two or three instruments. The 68 telescopes used are tallied by aperture in *Table 4* (upper right); instruments have been grouped by aperture range (gaps indicate no telescopes in those ranges). The most popular aperture continues to be 20 cm, although the median size was 15 cm. Five small telescopes, 5.0 to 6.0 cm in aperture, were used, comprising 7 percent of the instruments. The 10 fairly large telescopes, 31.8 to 65 cm aperture, constituted 15 per cent of those used. The range of apertures continues to be large, showing that almost any size of telescope can be used in our program.

Table 3. Nationalities of Observers and Observations, 1993/94 Apparition.

Nation of Residence	Number of Observers	Number of Timings	Timings per Observer
Australia	11	283	25.7
United States	11	37	3.4
P.R. of China	7	40	5.7
New Zealand	5	90	18.0
Denmark	3	14	4.7
Italy	3	10	3.3
Portugal	2	37	18.5
Brazil	2	25	12.5
Canada	1	20	20.0
Poland	1	6	6.0
Mean	--	56.2	12.2

Table 4. Number of Telescopes Used, by Aperture, 1993/94 Apparition.

Aperture (cm)	No. of Teles.	Aperture (cm)	No. of Teles.
5.0	1	20.0	12
6.0	4	21.2	1
7.0-7.5	2	25.0-28.0	7
8.0	4	30.0	2
9.0	3	31.8-32.0	4
10.0	3	35.6	1
11.0-11.4	4	40.0	2
12.7-13.1	3	43.0	1
14.5-15.0	11	60.0	1
18.0	1	65.0	1

Table 5 (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 events that occurred during the observing season only. As always, the closer a satellite is to Jupiter, the greater the number of timings made of its eclipses because the frequency of satellite eclipses decreases outward from Jupiter. Slightly over one-half of the eclipses that occurred for all three satellites were actually timed, which is a rough indicator of our longitude distribution's effect on missing events. The "efficiency" in covering eclipse events did not differ significantly by satellite or by type of event.

Table 5. Summary Statistics By Event Type, 1993/94 Apparition.

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

Event Type	Number of Timings	Number of Events* Total	Timed
1D	123	91	47 (52 %)
1R	158	89	51 (57 %)
1	281	180	98 (54 %)
2D	77	57	29 (51 %)
2R	83	57	29 (51 %)
2	160	114	58 (51 %)
3D	68	42	23 (55 %)
3R	53	41	20 (49 %)
3	121	83	43 (52 %)
D	268	190	99 (52 %)
R	294	187	100 (53 %)
Total	562	377	199 (53 %)

* During observing season.

Table 6. Number of Timings by Month, 1993/94 Apparition.			
(Solar elongation range in parentheses; restricted to observing season)			
1993	Nov	(024°-034°W)	3
	Dec	(034°-061°W)	8
1994	Jan	(061°-089°W)	33
	Feb	(089°-116°W)	33
	Mar	(116°-148°W)	81
	Apr	(148°-180°W)	79
	May	(180°-146°E)	76
	Jun	(146°-116°E)	99
	Jul	(116°-088°E)	86
	Aug	(088°-062°E)	51
	Sep	(062°-037°E)	7
	Oct	(037°-036°E)	6
Before Opposition		237	(42.2 %)
After Opposition		325	(57.8 %)

As is usual, the number of timings varied considerably from month to month, as shown in *Table 6* (above) and *Figure 1* (below).

The most intensive observing was for the four months centered on opposition, when Jupiter was above the horizon for most of the night. There is a bias toward post-opposition timings, although less than in the 1992/93 Apparition, when only 38.1 percent of the timings were made before opposition. Even so, observers should make more pre-opposition timings in the future, even though this means observing after midnight.

Figure 1 shows the typical visibility patterns for the different eclipse phenomena for the different satellites. In the case of Io, eclipse disappearances are usually visible only before opposition, and reappearances visible only after. This is most often the case for Europa as well; but when Jupiter is near aphelion both the disappearance and reappearance events of the same eclipse can be seen near quadrature, as was observed for seven eclipses from 1994 Jan 22 - Feb 16 and from 1994 Jul 05 - Aug 06. Finally, disappearances and reappearances for the same eclipses of Ganymede are observable for most of an apparition except near opposition or conjunction.

Reduction

The first step in reduction was to segregate the timings by satellite and by whether they were of a disappearance or a reappearance. Observations were compared with the predictions of the "E-2" Ephemeris developed by 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 9*. The next step was to correct for aperture with a linear regression model in which the

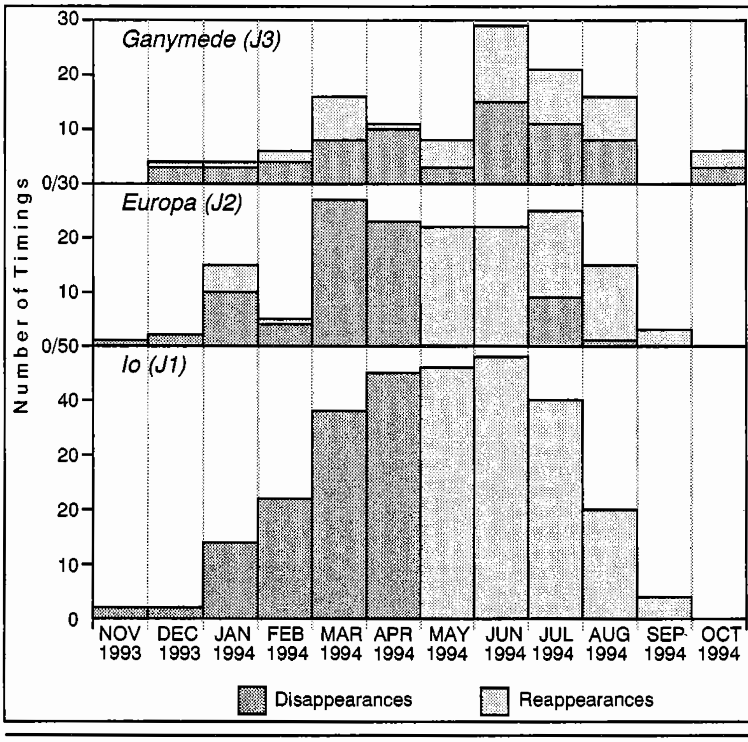


Figure 1. Number of timings of Galilean satellite eclipses by month, satellite, and type of event, during the 1993/94 Apparition of Jupiter.

dependent variable (y) was the residual in seconds and the independent variable (x) was the reciprocal of the telescope aperture in centimeters. The form of the model is:

(1) $y_{est} = A + Bx$,

where A and B are the regression coefficients.

A total of 60 timings, or 10.7 percent of the timings, were not used because of differences from the regression model that were significant at the 5-percent level (i.e., would occur due to chance less than 5 percent of the time) as measured in terms of the standard error (given in *Table 7*, p. 29). For each satellite and type of event this 5-percent significance criterion was applied twice in succession; the first application typically removing the timings most likely subject to blunders in recording the times, while the second application was intended to eliminate timings subject to severely unfavorable observing conditions. The timings deleted for the 1993/94 Apparition are shown by italicized residuals in *Table 9*.

A sample application of the above method of reduction is shown for disappearances of Io in 1993/94 in *Figure 2* (below). Note that the regression line's slope and position changed significantly when the aberrant timings were deleted. The great majority (15 of 17) of the deleted observations were "early" disappearances. This is what one would expect because unfavorable conditions, whether due to poor seeing or transparency, proximity of the satellite to the limb of Jupiter, poor optics, or bad eyesight, would make the satellite less visible during its entrance into Jupiter's shadow.

Two statistics describe how well Equation (1) fits the observed residuals. One, the standard error (S.E.), is the root-mean-square difference between Equation 1 and each observation. The other statistic, R^2, measures what proportion of the variance (squared differences among the residuals) is removed by Equation (1).

To check the reduction method described above, the writer estimated the

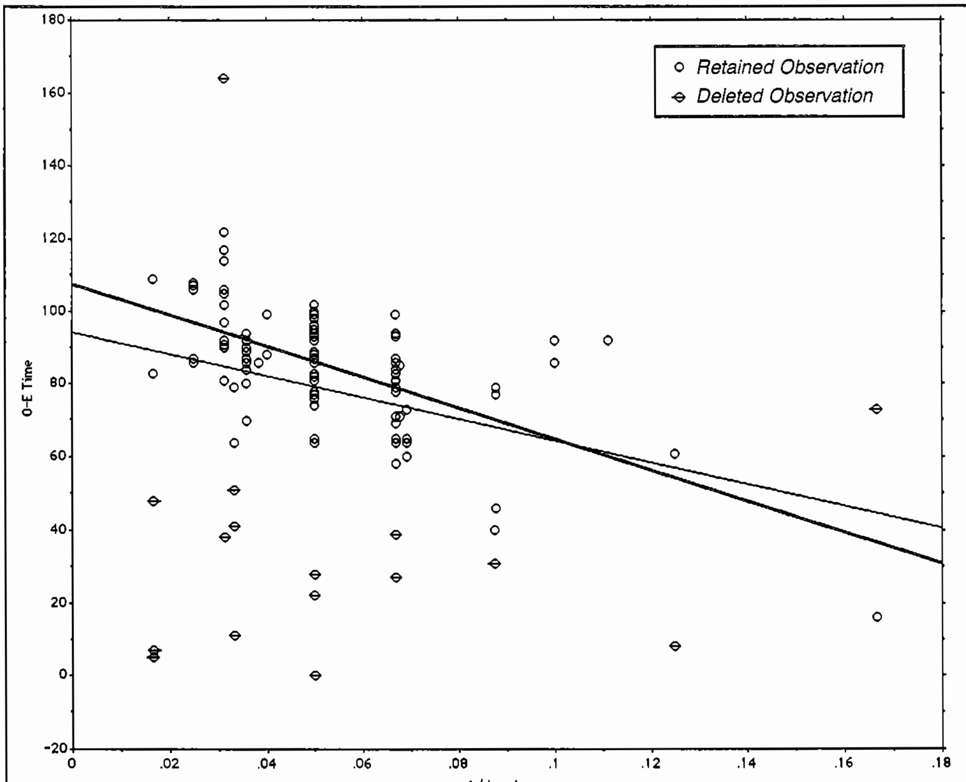


Figure 2. Eclipse Disappearances of Io, 1993/94 Apparition of Jupiter. The (O - E) difference between observed times and the E-2 Ephemeris is shown by the vertical axis, while the reciprocal of telescope aperture (in cm) is plotted horizontally. The thinner regression line is that based on all 123 observations; the heavier line on the 106 remaining after 17 were rejected.

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 mean angle of entry or exit from the shadow, the diameter in kilometers was calculated and is shown in Table 7.

1993/94 Results

Details for the 1993/94 Apparition follow in Table 7. This table gives results for each of the three inner 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 finally used in the regression analysis after aberrant timings had been deleted. The next item is the mean residual for the timings that were retained, followed by the coefficient of variation (R^2), 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. Following this are the predicted residuals for four commonly used telescope apertures.

The orbital 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). This measure of the amount the satellite is "behind" (positive) or "ahead of" (negative) its predicted position is given in seconds, kilometers, and degrees of orbital arc in Table 7.

The results of the satellite diameter estimation described above are given at the bottom of each column, where the calculated satellite diameter is given in seconds of time and in kilometers. The latter value is corrected for the mean cosine of 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, 3138 km; and Ganymede, 5262 km [United States. Nautical Almanac Office, 1998]).

Table 7 also shows the statistical significance of the differences of the following values from zero: R^2, 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 "(ns)" for not significant, "*" for significant at the 5-percent level, and "**" for significant at the 1-percent level (these percentages give the probability of such results having occurred due solely to chance).

There are six event types listed in Table 7; eclipse disappearances and reappearances for each of the three satellites analyzed. As shown by the R^2 values, in four of the six cases the aperture-regression model significantly reduced the variance among the timings. Nonetheless, the majority of the variance among the timings remained unaccounted for in our simple residual-aperture model. Naturally, the uncertainties in our timings represent the combined effect of many variables that are not considered in our analysis, for example: type of instrument, magnification, optical quality, atmospheric conditions, distance and phase angle of Jupiter, apparent distance of the satellite from Jupiter's limb, keenness of the observer's eye, or possible use of an occulting bar (an object placed at the focus of a positive eyepiece to block out Jupiter itself). Clearly, only some of these variables are quantifiable, and for some we have no data at all. Nonetheless, with the large number of timings we are now receiving each apparition, a more complex statistical analysis is possible, which might reduce the amount of uncertainty.

The uncertainty of the timings is indicated by the standard error, which increased with distance from Jupiter as follows, where the standard error of disappearances is given first, followed by that of reappearances: 12 and 22 seconds for Io, 25 and 31 seconds for Europa, and 64 and 63 seconds for Ganymede. 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. In addition, the standard error of timings was greater for reappearances than disappearances for two satellites; a difference probably due to the uncertainty in locating the position in one's telescopic field where an emerging satellite will first appear; whereas, in a disappearance, the satellite can be followed continuously to the moment of extinction.

Table 7. Galilean Satellite Timings Compared With E-2 Ephemeris, 1993/94.

	Satellite		
	Io	Europa	Ganymede
Disappearance			
Number of Observations	123 (106)	77 (67)	68 (64)
Mean Residual (seconds)	+84.8 ±1.5	+96.8 ±3.2	+381.6 ±8.0
Coefficients:			
R^2	0.3755**	0.1259**	0.0033 (ns)
A (seconds)	+107.1 ±3.1	+116.1 ±7.0	+391.9 ±24.1
B	-423 ±54	-345 ±113	-207 ±454
Standard Error (seconds)	±12.4	±25.0	±64.1
Aperture Residual (seconds):			
6-cm	+37 ±6	+59 ±13	+357 ±54
10-cm	+65 ±3	+82 ±6	+371 ±24
20-cm	+86 ±1	+99 ±3	+382 ±8
40-cm	+97 ±2	+107 ±5	+387 ±14
Reappearance			
Number of Observations	158 (146)	83 (73)	53 (46)
Mean Residual (seconds)	-85.2 ±1.9	-111.3 ±3.7	-396.2 ±9.7
Coefficients:			
R^2	0.1175**	0.0400 (ns)	0.0997*
A (seconds)	-100.7 ±4.0	-124.6 ±8.5	-439.7 ±21.8
B	+260±59	+231 ±134	+741 ±336
Standard Error (seconds)	±22.1	±31.3	±63.3
Aperture Residual (seconds):			
6-cm	-57 ±7	-86 ±15	-316 ±37
10-cm	-75 ±3	-102 ±7	-366 ±17
20-cm	-88 ±2	-113 ±4	-403 ±10
40-cm	-94 ±3	-119 ±6	-421 ±15
Orbital Residual			
Seconds	-3.2 ±2.5 (ns)	-4.2 ±5.5 (ns)	-23.9 ±16.3 (ns)
Orbital Arc (degrees)	-0.007 ±.006	-0.005 ±.006	-0.014 ±.009
Kilometers	-55 ±44	-58 ±76	-260 ±177
Diameter			
Seconds	207.9 ±5.0	240.7 ±11.0	831.6 ±32.5
Kilometers	3425 ±83	2766 ±127	5411 ±211
Compared with Standard (km)	-205 ±83* (-5.6%)	-372 ±127** (-11.8%)	+149 ±211 (ns) (+2.8%)

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 converted to degrees of orbital arc and to kilometers. The timing results for none of the three satellites differed significantly from the E-2 Ephemeris.

The accuracy of our method of analysis was assessed approximately by using the A-coefficients to estimate the diameters of the satellites, and then to compare these estimates with the diameters that were derived from the Voyager Missions. In the cases of Io and Europa there were significant differences, both underestimates. Ganymede's estimated diameter did not differ significantly from the standard values. The signs of the diameter differences follow the trend found for most previous apparitions and may be an effect resulting from the increase in the size of Jupiter's penumbral shadow zone as one moves outward in the satellite system.

Comparison with 1992/93 Apparition

Both Io and Europa were significantly "early" in the 1992/93 Apparition, but did not differ significantly from the E-2 Ephemeris during 1993/94. The apparent "decelleration" for Io, +1.6±3.5 seconds, was not significant. On the other hand, Europa's decelleration of +14.3±6.9 seconds was significant at the 5-percent level. Ganymede did not differ significantly from the E-2 Ephemeris for either apparition, and its "acceleration" of -20.9±18.9 seconds was not significant.

The last previous report [Westfall, 1998] discussed the possibility of a consistent

Table 8. Changes in Estimated Satellite Diameters; 1990/91-1993/94 Apparitions.*			
Satellite	1990/01-1991/92	1991/92-1992/93	1992/93-1993/94
Io	-265±100**	-141±109 (ns)	+627±115**
Europa	-361±136**	-24±141 (ns)	+183±161 (ns)
Ganymede	-466±214*	+11±233 (ns)	+238±160 (ns)

* Units are kilometers. Changes are defined by subtracting the earlier apparition from the later. Statistical significance is shown as in Table 7.

change in the apparent diameters of the satellites over time, as estimated by the duration of eclipse ingress and egress. The report concluded that the apparent satellite diameters had decreased from 1990/91 to 1991/92, but then did not change significantly from 1991/92 to 1992/93. However, between 1992/93 and 1993/94, the diameters of Io, Europa, and Ganymede appeared to increase; that for Io being significant, as shown in *Table 8* (above).

Long-Term Results

The orbital residuals for Io, Europa, Ganymede, and Callisto for the 17 apparitions from 1976/77 through 1993/94 are graphed in *Figure 3* (below; there were too few timings made in the 1975/76 Apparition to determine its orbital deviations). In the figure, the error bars represent a ±1 standard-error range, and a deviation from the ephemeris significant at the 5-percent level would have to equal at least about ±2 standard errors.

The diagram shows that the widths of the error bars have tended to diminish over time, chiefly due to the greater accuracy caused by an increasing number of timings submitted to the program. There are hints of cyclical variations for some of the satellites, particularly for Europa and Ganymede, perhaps in a 12-year cycle associated with Jupiter's orbital period. We hope that we will receive sufficient timings for enough future apparitions to investigate long-term trends in the deviations.

Conclusion

We encourage suitably-equipped observers to use their CCD or video cameras to time the eclipses of Jupiter's four major satellites and report their results to the program headed by Anthony Mallama [E-mail: tmallama@stx.com ; Mallama, 1991; Mallama *et al.*, 1994]; conventional photometers are difficult to use accurately because of the effect of scattered light from Jupiter. However, we need also to continue the visual timings which remain the mainstay of our program and provide comparability with the body of similar visual timings that goes back to the Seventeenth Century.

Naturally, we hope that both recent and long-term participants will continue and

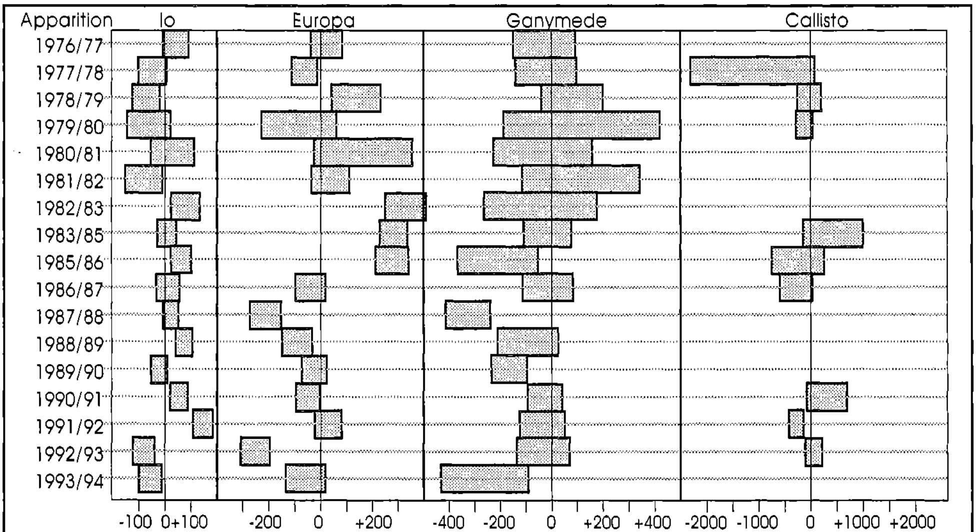


Figure 3. Graph of deviations of the Galilean satellites from the E-2 Ephemeris for the 1976/77 through the 1993/94 Apparitions. Units are in kilometers. The width of each bar represents ±1 standard error. Note the different scale for Callisto, which was not eclipsed in every apparition.

new ones will join us. For information on this program, please contact the writer, whose address is given in the A.L.P.O. staff listing (inside back cover). Along with instructions, he can send you a timing report form, which should be returned at the end of each apparition (not of the calendar year). You will also need predictions of these events, which are published each year in the *Astronomical Almanac*, *Observer's Handbook of the Royal Astronomical Society of Canada*, and *The Handbook of the British Astronomical Association*, as well as every month in *Sky & Telescope* magazine.

We thank the many observers who participated in this A.L.P.O. project for the 1993/94 Apparition of Jupiter. Remember that your timings become more accurate as you accumulate experience. Likewise, the more visual timings that are made, the more accurate our results.

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Table 9. Galilean Satellite Eclipse Timings, 1993/94 Apparition.

UT Date mmdd	Geometry r	°	Obs. No.	Cond. STB	Res. sec.
Io Disappearances					
1993					
1118	0.4	-17	42	110	+64
1128	0.5	-18	28	122	+74
1205	0.6	-18	46	002	+16
1214	0.7	-18	9	000	+90
1994					
0106	0.9	-18	9	010	*+38*
			28	011	+78
			27	000	+90
0113	1.0	-18	27	010	+80
0115	1.0	-18	9	000	+102
0122	1.0	-18	28	220	*+28*
			5	000	+78
			21a	000	+87
			38a	000	+93
			18	100	+99
0126	1.0	-18	13a	101	+92
			12	110	+108
0129	1.0	-18	28	012	+81
			27	100	+94
0205	1.0	-18	37	101	+61
			17	100	*+73*
			28	011	+98
0207	1.0	-18	41	011	+46
			21a	000	+93
			9	000	+122
0211	1.0	-18	42	000	+65
			13b	001	+94
0214	1.0	-18	24a	000	+79
			28	010	+86
			9	000	+91
			27	000	+92
0216	1.0	-18	15	000	+86
0221	1.0	-18	30a	001	+58
			5	101	+79
			28	010	+81
			38a	000	+81
			27	000	+94
			9	000	+97
0223	1.0	-18	10b	101	+99
0228	0.9	-18	27	000	+84
			28	012	+88
0302	0.9	-18	24a	001	+64
			28	011	+82
			38a	000	+84
			21a	000	+95
			18	001	+100
0309	0.8	-18	28	010	+92
0311	0.8	-18	41	110	*+31*
			24	000	+86
			10b	120	+88
			15	001	+99
0313	0.8	-18	35	- - -	+60
			12	111	+86
			13c	001	+93
0315	0.8	-18	44	122	+85
0316	0.8	-18	5	000	+69
			21a	010	+76
			27	000	+89
			28	010	+89
0318	0.7	-18	5	000	+83
			38a	000	+83
			18	100	+96
			21a	000	+96
0320	0.7	-18	16	100	+92
0322	0.7	-18	29	000	*0*
			35	- - -	+64
0323	0.7	-18	30a	000	+71
			28	010	+83
0325	0.6	-18	5	111	+84
			38a	010	+84
			28	011	+88
			21a	001	+95
			18	000	+102
			9	000	*+164*
0327	0.6	-18	24a	000	*+41*
			23a	100	+88
			33	001	+102
0329	0.6	-18	35	- - -	+73
			26	000	+109
0401	0.5	-18	7	000	+79
			27	000	+86
			23a	000	+89
			2	100	+92
0403	0.5	-18	5	200	+79
			2	100	+86
			9	000	+106
0405	0.5	-18	26	000	+83
0407	0.4	-18	29	001	*+22*
			13b	100	+87
			12	011	+107
0408	0.4	-18	5	100	+79
			27	000	+80
			21a	000	+88
			9	010	+114
0410	0.4	-18	28	010	+81
			27	000	+87
			9	010	+117
0412	0.3	-18	26	000	*+5*
0414	0.3	-18	35	- - -	+65
			12	111	+106
0415	0.3	-18	44	112	+71
0417	0.2	-18	31a	011	*+8*
			24a	000	*+51*
			38a	000	+64
			5	100	+65
			7	000	+77
			27	000	+87
			21a	000	+94
			9	010	+105
0419	0.2	-18	15	200	+64
			9	000	+92
0421	0.2	-18	26	000	*+48*
			16	000	+81
0423	0.1	-18	12	111	+87
0424	0.1	-18	5	022	*+27*
			27	000	+70
			21a	001	+77
			9	110	+114
0426	0.1	-18	24a	000	*+11*
			5	122	*+39*
			38a	010	*+39*
			21a	100	+78
0428	0.0	-18	26	000	*+7*
			41	000	+40
Io Reappearances					
1994					
0501	0.0	-18	44	122	-99
0501	0.0	-18	8	122	-53
			29	000	*+137*
0503	0.1	-18	21a	100	-83
			5	000	-77
			38a	001	-75
			27	000	-72
0505	0.1	-18	21a	000	-107
			33	000	-78
			5	100	-71
			10	000	-68
			39	000	-58
			41	000	-49
0507	0.1	-18	41	010	-50
0508	0.2	-18	29	000	*+12*
0510	0.2	-18	9	010	-99
			27	010	-86
0512	0.2	-18	9	010	*-166*
			27	000	-90
			7	000	-76
			21a	100	-76
			31a	011	*+18*
0514	0.3	-18	41	000	-93
			43a	100	-73
			24a	000	-41
0519	0.4	-18	7	000	-104
			40	201	-85
			9	000	-78
			27	020	-76
			45	010	-76
			31a	100	*0*
0521	0.4	-18	9	000	-45
			40	101	-43
			22	210	*-13*
0523	0.4	-18	15	000	-103
			6	011	-93
0524	0.5	-18	12	101	-100
			13b	101	-95
			29	001	-63
0526	0.5	-18	9	110	-141
			46a	112	-81
0528	0.5	-18	9	000	-117
			40	101	-107
0530	0.6	-18	41	111	-103
0531	0.6	-18	12	111	-117
			13b	100	-83
0604	0.6	-18	23a	000	-110
			10b	000	-104
			45	000	-83
			2	000	-62
			5	120	-43
			31a	021	*+82*
0606	0.7	-18	2	001	-103
			10b	100	-96
0609	0.7	-18	13c	212	-45
0611	0.7	-18	9	000	-145
			40	101	-104
			21a	000	-87
			5	120	-63
0613	0.8	-18	9	000	-145
			21a	110	-84
			24a	020	*+34*
0615	0.8	-18	20	000	-122
			22	211	-113
			15	100	-111
			32a	100	-102

Table 9. Galilean Satellite Eclipse Timings, 1993/94 Apparition—*Continued.*

Io Reappearances—Continued

UT Date mmdd	Geom-etry r	°	Obs. No.	Cond. STB	Res. sec.
1994					
0615	0.8	-18	14	12 -	-52
0616	0.8	-18	12	101	-106
			42a	100	-104
			13b	111	-58
			34	000	-31
0620	0.8	-18	18	000	-113
			38a	000	-103
			21a	000	-100
			40	201	-100
			5	001	-97
			9	110	-87
0622	0.9	-18	23a	001	-100
			41	001	-97
			32a	000	-96
0623	0.9	-18	13b	201	-95
0627	0.9	-18	18	100	-112
			40	101	-109
			21a	000	-98
			7	000	-97
			28	111	-96
			30	000	-90
			5	100	-84
			9	000	-83
			24a	000	-55
			31	000	-28
0629	0.9	-18	2	000	-92
			41	220	-80
			24a	000	-47
0704	1.0	-18	21a	000	-96
			7	222	-64
			9	110	-40
0706	1.0	-18	18	000	-110
			40	101	-108
			21a	000	-93
			9	110	-84
0708	1.0	-18	25	221	-103
			14	11 -	-73
0709	1.0	-18	13c	000	-90
			12	211	-87
			35	011	*-6*
0713	1.0	-18	9	110	-115
			23a	000	-109
			33	100	-108
			1a	100	-107
			21a	100	-90
			40	100	-89
			2	001	-86
			4	000	-85
			10b	200	-79
			24a	000	-47
0715	1.0	-18	23a	001	-96
			2	002	-88
			43b	100	-73
			43	000	-44
0720	1.0	-18	9	110	-105
			28	112	-96
			45	001	-22
0722	1.0	-18	10a	001	-109
			9	110	-107
0724	1.0	-18	36	001	-104
			15	000	-96
0725	1.0	-18	12	211	-112
			13c	202	-99
0725	1.0	-18	3	000	-89
			13	201	-50
0729	1.0	-18	9	110	-115
			4	000	-84
			24	000	-81
0801	1.0	-18	35	011	-104
			13c	101	-91
0805	1.0	-18	9	110	-108
0807	1.0	-18	2	102	-83
			23a	102	-71
0812	1.0	-18	28	111	-80
0814	1.0	-18	10a	101	-91
			38	011	-30
0816	1.0	-18	32	000	-78
0821	1.0	-18	23a	110	-102
			2	111	-90
			4	000	-71
			21a	010	-61
			10b	101	-57
			5	021	-51
0823	1.0	-18	41	010	-75
0824	1.0	-18	35	111	*-201*
0828	0.9	-18	28	011	-81
			21a	110	-77
			5	210	-73
0913	0.8	-18	5	120	-52
			10	201	*+92*
0920	0.7	-18	28	112	-64
			27	000	*-22*

Europa Disappearances

UT Date mmdd	Geom-etry r	°	Obs. No.	Cond. STB	Res. sec.
1993					
1126	0.8	-33	28	212	+68
1218	1.2	-34	42	200	+69
1221	1.2	-34	9	000	+168
1994					
0108	1.4	-34	15	100	+105
0122	1.5	-34	28	220	*+32*
			5	000	+89
			38a	001	-96
			18	100	+115
			21a	000	+116
0126	1.6	-34	13a	101	+121
			12	110	+128
0129	1.6	-34	27	100	+100
			28	012	+106
0205	1.6	-34	37	101	+20
			17	101	+52
0216	1.5	-34	9	000	+108
0223	1.5	-34	28	011	+110
0302	1.4	-34	28	011	+106
			27	000	+129
0309	1.3	-34	30a	000	+55
			28	012	+109
			27	000	+121
0313	1.2	-34	36a	010	+88
			9	000	+144
0320	1.1	-34	5	200	+90
			9	000	+94
			38a	000	+96
			21a	000	+109
			18	000	+115
0324	1.0	-34	35	- - -	+114
0327	0.9	-34	27	010	+77
			5	012	+86
0327	0.9	-34	7	000	+94
			28	012	+109
			23a	000	+114
			38a	010	+122
			21a	000	+127
			18	001	+134
			9	010	*+176*
0331	0.8	-34	35	- - -	+56
			36b	101	+90
			26	000	+107
			22	200	+112
			15	100	+118
0403	0.8	-34	21	000	+91
			28	111	+91
			5	000	+94
			27	000	+154
			9	010	*+216*
0410	0.6	-34	28	010	+83
			27	000	+108
0414	0.5	-34	21a	010	+93
			41	010	+99
			10b	100	+108
			9	110	*+217*
0418	0.4	-34	26	000	+51
0421	0.3	-34	38a	020	*-12*
			24a	000	*+8*
			2	001	+84
			5	001	+89
			21a	000	+98
			18	100	+107
			1a	200	+114
0425	0.1	-34	26	010	*+5*
0428	0.0	-34	5	111	*+18*
			24a	000	+45
			27	000	+81
0705	-0.0	-33	41	102	+63
0712	0.0	-33	23a	000	+42
			2	001	+62
0719	0.1	-33	33	110	+72
			40	201	+74
			21a	010	+96
			9	110	+110
0726	0.1	-33	28	121	*-12*
			9	110	*+186*
0806	0.0	-33	41	121	+92

Europa Reappearances

UT Date mmdd	Geom-etry r	°	Obs. No.	Cond. STB	Res. sec.
1994					
0115	0.0	-33	9	000	-42
0122	0.0	-33	21a	002	-31
			38a	000	*0*
			27	010	*+14*
			7	000	*+155*
0216	0.0	-33	9	010	-148
0502	0.1	-33	24a	000	*-6*
			2	122	*+81*
0505	0.2	-33	42	100	+50
0509	0.3	-33	9	000	-130
			28	112	-88
0512	0.4	-33	29	000	*+8*
0516	0.5	-33	9	000	-186
			27	000	-164
			40	100	-160
			20	000	-146
			28	011	-127

Table 9. Galilean Satellite Eclipse Timings, 1993/94 Apparition—*Continued.*

Europa Reappearances—Cntd.

UT Date mmdd	Geometry r	Geometry °	Obs. No.	Cond. STB	Res. sec.
0516	0.5	-33	1	000	-117
			24a	220	-43
			46a	111	*+28*
0520	0.6	-33	15	000	-149
0523	0.7	-33	9	110	*-215*
			40	102	-135
			7	001	-95
			5	122	-90
0527	0.8	-33	32a	000	-150
			14	11 -	-104
			25	111	-93
0603	0.9	-33	32	110	-142
			10b	100	-133
			24a	010	-73
0606	1.0	-33	42a	100	-144
			44a	122	-137
			11	200	-131
			13c	101	-126
			12	111	-107
			29	001	-97
			8	121	-83
0610	1.1	-33	40	101	-151
0613	1.2	-33	13b	101	-128
			29	000	-97
			34	000	-32
0617	1.2	-33	9	000	-136
			2	011	-120
			28	111	-104
			24a	000	-79
			30	000	-78
			37	111	-55
0624	1.4	-32	9	010	-139
			7	000	-123
0705	1.5	-32	2	000	-116
			41	010	-116
0712	1.5	-32	9	110	*-210*
			33	000	-149
			5	210	-127
			10b	100	-113
			23a	000	-110
			24a	010	-54
0719	1.6	-32	40	101	-153
			9	110	-144
			27	020	-128
			7	222	-121
			10a	101	-118
			23	000	-103
			21a	011	-94
0726	1.6	-32	28	112	-109
0806	1.6	-32	33	100	-118
			23a	010	-113
			10b	011	-95
0813	1.6	-32	9	110	-124
			38a	000	-124
0816	1.5	-32	35	111	-116
0820	1.5	-32	18	100	-128
			38a	000	-119
			28	122	-110
			21a	000	-95
			5	101	-93
			7	222	*+30*
0824	1.5	-32	6	000	-117
0831	1.4	-32	41	001	-97
0914	1.2	-32	10b	201	-93
0914	1.2	-32	4	000	-80
0921	1.1	-32	28	211	-88

Ganymede Disappearances

UT Date mmdd	Geometry r	Geometry °	Obs. No.	Cond. STB	Res. sec.
1993					
1219	1.8	-49	9	000	+398
1226	2.0	-49	28	012	+350
			27	000	+395
1994					
0131	2.4	-50	24	000	+271
			21a	000	+393
			15	101	+428
0207	2.4	-51	28	010	+409
			27	000	+438
0222	2.3	-51	42	000	+336
			35	- - -	+377
0308	2.0	-51	24a	000	+334
			23a	100	+468
0315	1.8	-52	24a	000	+323
			27	000	+419
			28	110	+437
0322	1.6	-52	9	000	+303
0329	1.3	-52	12	011	+380
			8	222	+458
0406	1.0	-52	35	- - -	+393
			13c	101	+408
			26	000	+502
0420	0.4	-52	9	110	+305
			41	000	+351
0427	0.1	-53	24a	010	*+67*
			30a	002	*+153*
			27	000	+295
			9	110	+352
			21a	000	+361
0526	0.1	-53	40	202	+263
			41	211	+320
			9	000	+355
0602	0.3	-53	24a	000	*+203*
			5	010	+314
			21a	010	+323
			9	000	+327
			39	000	+332
			7	002	+377
			18	000	+455
			1a	200	+461
			40	001	+485
0609	0.6	-53	46a	110	+245
			7	010	+310
			9	110	+344
			28	110	+369
0623	1.0	-54	12	201	+277
			13b	201	+287
0701	1.1	-54	19	000	+409
			15	000	+445
0708	1.2	-54	24a	000	*+219*
			9	110	+383
			5	002	+424
			18	002	+488
0715	1.3	-54	33	220	+444
			10b	- - 1	+453
			9	110	+465
			27	010	+467
			40	101	+467
0805	1.4	-54	35	000	+427
0820	1.2	-54	24	000	+316
0820	1.2	-54	23a	100	+435
			33	000	+466
0827	1.1	-54	5	200	+322
			21a	000	+343
			38a	100	+389
			18	100	+436
1002	0.3	-54	2	102	+354
			23a	001	+371
			33	200	+389

Ganymede Reappearances

UT Date mmdd	Geometry r	Geometry °	Obs. No.	Cond. STB	Res. sec.
1993					
1219	0.6	-49	9	000	-410
1994					
0124	1.2	-50	38a	000	*+355*
0215	1.2	-51	44	122	-379
0222	1.1	-51	35	- - -	-394
0308	0.9	-52	23a	100	-419
			24a	000	*-187*
			41	221	*+48*
0315	0.7	-52	27	000	-389
			28	010	-370
			5	010	-331
			24a	022	*+100*
0330	0.3	-52	26	000	*-126*
0406	0.1	-52	35	- - -	*-163*
0519	0.7	-53	15	000	-458
			41	001	-386
			10b	212	-265
0526	1.0	-54	40	102	-435
			9	000	-425
0602	1.3	-54	18	000	-496
			40	001	-492
			9	110	-449
			39	010	-428
			5	010	-400
			30	000	-389
			21a	000	-320
			7	222	-256
0609	1.6	-54	28	110	-413
0616	1.8	-54	42a	100	-482
			44	121	-447
			13b	100	-391
			12	101	-321
			34	000	-260
0708	2.3	-54	18	000	-497
			5	000	-453
			9	110	*+328*
0715	2.4	-54	9	110	-455
			28	021	-409
			31b	011	-384
			21a	010	-328
0729	2.4	-55	13c	101	-398
			12	201	-355
			13	100	-325
0806	2.4	-55	15	001	-433
0813	2.4	-55	41	120	-251
0820	2.3	-55	18	000	-496
			33	000	-488
			5	001	-417
			21a	110	-392
			23a	100	-339
			38a	000	-334
1002	1.3	-55	38a	000	-471
			5	101	-416
			4a	000	-378

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 (as projected onto the shadow), in degrees, of the center of the satellite in relation to the shadow center.

C. *Obs.No.:* Observer number as listed below, where the first figure in parentheses represents the aperture in centimeters of the telescope used and the second the number of timings submitted using that telescope.

D. *Cond.:* Conditions of observation; in order, seeing (S), transparency (T), and field brightness (B). The 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 eclipse UT as predicted by the E-2 Ephemeris from the observed eclipse UT. The former, originally given in Ephemeris Time, was converted to UT using an assumed ΔT value of +60 seconds prior to 1994 AUG 25, and +61 seconds thereafter. Italicized residuals denote timings that were not used in the regression analysis because they differed from the regression model at the 5-percent significance level.

Identification Numbers, Telescope Apertures, and Numbers of Timings: Participating Observers, 1993/94 Jupiter Apparition

Id. No.	Name	Aper. (cm)	No. Tmgs.
1	Abrahams, W.	6	1
1a	" " "	20	3
2	Allely, T.	10	15
3	Baroni, S.	20	1
4	Bembrick, C.	7	4
4a	" " "	25	1
5	Blanksby, J.L.	15	37
6	Bock, P.H., Jr.	12.7	2
7	Chen, D.H.	11.4	15
8	Darnell, P.B.	18.0	3
9	de Rosamond, A.A.	32	63
10	Dickie, R.	9	2
10a	" " "	20	3
10b	" " "	25	13
11	Foglia, S.	11.4	1
12	Garcia, J.	40	16
13	Gonçalves, R.	5	2
13a	" " "	9	2
13b	" " "	15	9
13c	" " "	20	8
14	Haas, W.H.	31.8	3
15	Hays, R.H., Jr.	15	12
16	Himes, D.	32	2
17	Jia, R.-j.	6.0	2
18	Kruijshoop, A.	20	18
19	Kube, D.	13.1	1
20	Kube, J.	13.1	1
21	Larkin, P.	8	1
21a	" " "	20	38
22	Laskowski, S.	31.8	3
23	Loader, B.	10	1
23a	" " "	20	18
24	MacDonald, M.	26	4
24a	" " "	30	24
25	MacDougal, C.	15	2
26	Maluf, W.J.	60	10
27	Matthews, T.	28	33
28	Moller, H.	20	42
29	Olesen, J.O.	20	8
30	O'Yiang, T.-j.	10	3
30a	" " "	15	4
31	Pan, X.-q.	7.5	1
31a	" " "	8.0	4
31b	" " "	15.0	1
32	Parmentier, R.	15	2
32a	" " "	25	3
33	Priestley, J.	20	10
34	Rasmussen, A.	11	3
35	Roncato, T.	14.5	15
36	Samolyk, G.	30	1
36a	" " "	43	1
36b	" " "	65	1
37	Si, Q.-d.	8.0	3
38	Skilton, P.	6	1
38a	" " "	15	20
39	Skilton, R.	15	3
40	Smith, C.	25	18
41	Sullivan, M.W.	11.43	20
42	Testa, L.	20	5
42a	" " "	40	3
43	Westfall, J.	9.0	1
43a	" " "	27.9	1
43b	" " "	35.6	1
44	Zbigniew, B.	14.8	5
44a	" " "	21.2	1
45	Zhang, X.-j.	8.0	3
46	Zhao, Q.-S.	6.0	1
46a	" " "	20	3

Observer Identification Numbers by Country

Australia: 1, 4, 5, 9, 18, 21, 27, 28, 38, 39, 40

Brazil: 26, 35

Canada: 41

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James P. Carroll—Farewell, Friend

By: Daniel P. Joyce, Assistant Coordinator, Mars Section, Secretary, Chicago Astronomical Society

It certainly was with a heavy heart that my "Martian" colleague, Dan Troiani, and I conducted the regular monthly Skywatch program at Cernan Earth & Space Center on Saturday night, November 28th. We had to announce the passing of not only a great personal friend of ours but one of astronomy's most ardent supporters just three days earlier. "Jimmy", as he liked to be known, had in fact come upon the world of telescope making at one of those very monthly skywatches eleven and a half years earlier.

He came armed with an 8-inch SCT, one of the standard models of the day, to that watch in the spring of 1987. As I approached him to thank him for bringing some equipment along to help out with the effort, he mentioned that he was just back from Florida, a habit of his over winter. He said that while cruising through the Everglades one day he happened upon someone whose bike tire had gone flat and asked if he could help out (we would soon learn not to be surprised by this kind of spontaneous generosity). It turned out the disabled cyclist was in fact trying to get himself back to the site of the Winter Star Party, where Jim found a gathering of really great people doing really fun astronomy, something he said he had an interest in for some time but was just getting around to taking up in earnest.

Jim said that he saw people down there getting into electronic imagery, and that there might be a future for it (he was better at that game than Nostradamus, eh?). He was so soft-spoken that I had no idea of his abounding energy, but when I got around to telling him of North Park Village Optical Shop, it hit like a bolt of lightning. It wasn't long before he said he'd like to try a 10-inch, and an f/4 to boot, for photography. I invited him to come down to the shop, and it turned out that he had leisure time as he owned three seats on the Mercantile Exchange and was renting them out. Needless to say, he was very intrigued with the place, as I was at the time figuring the Peoria Astronomical Society 24-inch f/4.1 for their Jubilee Observatory site. It would not be long before he understood enough about the grinding process to help dozens of shop students through that part of the ordeal.

His expertise in foam/fiberglass composites was demonstrated early on, and the tube for the 10-inch was a masterwork in fiberglass. The tube assembly in the December, 1989 *Sky & Telescope* article "The Ten Best Ideas of the Year" housing Bill Benesch's 5.25-inch Daley Solarscope was a result of Bill watching a recording of Jim doing that 10-inch tube. And the tube for Howard Klauer's 8-inch Daley Solarscope, another sensation at Astrofest, was done much the same way. Jim told me that his real dream telescope was a 20-inch, or thereabouts, Newtonian, mounted on a Porter split ring. As fate would have it, just a few months later JMI of Colorado was introducing its 18-inch split-ring scope, and Jim immediately contacted them to see if he could get one without optics and if the truss rods could be customized for an f/6. As soon as he found out he could get it that way, he ordered a full-thickness blank and the JMI assembly.

Jim ground it in his basement and polished and figured it in the Village shop. I never had a student so intent on a project in my 20-something years of teaching the craft. But it still in no way prevented him from showering other students in the shop with his ever-friendly and wise counsel, whether it was edging the glass or assembly of the finished telescope product. He would sometimes bring the "1-inch" to the Winter Star Party and stop over by Don Parker's place on the way down. Setting it up on Don's driveway, many agreed that it could outperform Don's vaunted 16-inch f/6. There were some skeptics who felt that cold CCD camera work such as that Don was doing would always exceed high-sensitivity video in detail, contrast and resolution; but Jim's exhibit of Jupiter imagery at the 1994 A.L.P.O. convention at Greenville, S.C. made believers of the most entrenched doubters. Others have been inspired to try it themselves. Jim had other equipment that was built up over the years, and I've been assured that all of it will be in safe hands. But far more than the equipment, as superbly crafted and thoughtfully designed as it often was, Jim built friendships. He would not hesitate to help out a friend's disabled car, even if it meant enduring below-zero wind chills for extensive periods. Then HE would offer the friend to go for dinner with him!

Jim had been suffering from chronic leukemia for the past five years and was distressed that it and the therapy were diminishing his energy level. The Force was strong in him; how sorely he will be missed.

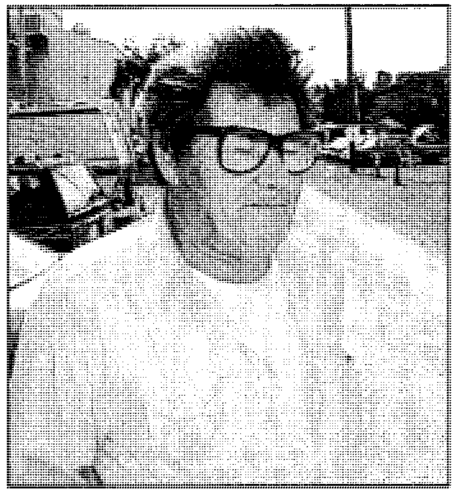

Figure 1. Jim Carroll, photographed at the Winter Star Party in January, 1998. Courtesy of Dan Troiani.

BOOK REVIEWS

Edited by Jose Olivarez

Sky Atlas 2000.0 , Second Edition (Deluxe Version).

By Wil Tirion and Roger W. Sinnott.

Cambridge University Press, 40 West 20th Street, New York, NY 10011-4211. Cambridge University Press edition, Deluxe Version, 1998. 30 large pages. Price: $49.95 (ISBN 0 521 627621).

Reviewed by Jose Olivarez

Sky Atlas 2000.0, Second Edition, Deluxe Version, is the most beautiful star atlas yet published. In both accuracy and beauty, it supersedes the 1981 first edition. Twenty-six star charts, covering both hemispheres, and seven detailed charts of selected regions comprise this Atlas which has been published jointly by Cambridge University Press and Sky Publishing Corporation.

In this stunning edition, the Milky Way representation is greatly enhanced. It is portrayed by four shades of blue that represent appropriate brightness levels found by the Dutch astronomer Antoinie Pennekoek. This improvement makes the Milky Way representation look more structured and contoured than in the first edition—a nice effect! Also, by going down to magnitude +8.5 instead of +8.0 (the limit of the first edition), Sky Atlas 2000.0 nearly doubles the number of stars plotted (from 43,000 to 81,312). The number of deep-sky objects is also increased in this atlas as well, but more modestly to about 2,700.

But it is the *stars* for this edition that are its most sweeping enhancement. They are taken from the Hipparcos and Tycho Catalogues. All stars measured by Hipparcos to have a visual magnitude of +8.5 or brighter are included. For double stars, the same cutoff applies to the combined magnitude of the pairs. All told, the number of stars shown as single, double, or variable is 81,312 .

The portrayal of deep-sky objects—star clusters, nebulae, and galaxies—is improved in *Sky Atlas 2000.0* with many changes in the extent and shape of nebulae plotted in the Milky Way field. Dark nebulae outlines plotted in the Milky Way are also new to this edition. The outlines are adapted from those shown in the more detailed *Millennium Star Atlas.* Also, in a major improvement over the first edition, the ellipses of galaxies are oriented the same way as they appear in the sky, regardless of size. These are shown to a cutoff of about magnitude +13 (in blue light).

That *Sky Atlas 2000.0*, Deluxe Version, is a beautiful piece of work is clear when one examines charts number 22 and 25. These charts depict the Scorpius-Sagittarius and Crux regions of the Milky

Way and are spectacular displays of galactic detail, forms and color!

There are two special charts at the back of the Atlas, consisting of enlargements of areas of special interest. Chart A shows enlarged fields for Barnard's Star (plotting its proper motion) and the Alpha and Beta Centauri region with Proxima Centauri's proper motion plotted. A detailed enlargement of the Pleiades is also shown, as are enlargements of the star fields around the North and South Celestial Poles. Chart B consists of enlargements of the Virgo Cluster of Galaxies (B1) and the Central Part of Orion (B2). Both of these charts are stunning!

Sky Atlas 2000.0, Second Edition (Deluxe Version), retails for $49.95 and can also be ordered from Sky Publishing Corporation, 49 Bay State Road, Cambridge, MA 02138. Sky Atlas 2000.0, Second Edition, Deluxe Version, is well worth the price—it is a beauty!

The Planet Venus.

By Mikhail Ya. Marov
and David H. Grinspoor
(with translations by Tobias Owen, Natasha Levchenko, and Ronald Masteler)

Yale University Press, P.O. Box 209040, New Haven, CT. 06520-9040. 1998. 464 pages with 226 b/w illustrations.Price: $65.00 cloth (ISBN 0-300-04975-7).

Reviewed by Jose Olivarez

The Planet Venus is largely written by its principal author, Mikhail Ya. Marov, a Venus specialist, and is based on a manuscript originally written by him in Russian but recently updated with David Grinspoor as a co-author. This book is different from other books on Venus now in print because it emphasizes a Russian view of the planet; Dr. Marov was chief scientist for Soviet Venera Spacecraft studies of Venus.

The Planet Venus is a large book of 464 pages that also integrates data from the Galileo, Magellan, Pioneer-Venus, and other space missions. It summarizes the history of Venus research, covers the atmosphere, geomorphology and tectonic history, and considers its geology. The authors also offer various theories to explain the planet's slow retrograde rotation, its lack of magnetic field, and its bizarre atmospheric dynamics. Unique illustrations include photographs and detailed diagrams of the Venera Spacecraft and high-quality images of the surface of Venus never before presented in English-language publications. Sample chapters include "Venus as a planet of the Solar System", "The Surface: Relief, Composition, and Geology", and "Clouds". Chapter 2, "The History of Investigations", contains an informative account of the Soviet Venera Space Missions to the planet.

The Planet Venus is mainly intended for professionals and students in the planetary sciences. According to solar system specialist, Dale Cruikshank, "*The Planet Venus* adeptly brings together three decades of spacecraft scientific investigations of Venus."

The Moon Book.

By Kim Long

Johnson Books, 1880 South 57th Court, Boulder, Colorado 80301. 1998. 149 pages. Price: $12.50 paper (ISBN 1-55566-230-7).

Reviewed by Jose Olivarez

The first edition of *The Moon Book* was created in 1988 as a publishing venture to answer questions related to the Moon Calendar which is published annually by Johnson Books. This edition is revised and expanded and brims with Moon facts and lore from cover to cover. Possibly every factual detail that any student or teacher would want to know about the Moon and its movement is presented here. Sample topics covered include "The Moon's Orbit", "Lunar Phases", "Moon Size and Brightness", "Earthshine" and "Moon Calendars". This little book is also well illustrated throughout with clear charts and diagrams. A lunar chart (LPC-1) prepared by the Defense Mapping Agency Aerospace Center is also included, as are lists of lunar vital statistics.

The Moon Book is a handy little guide book to have around when a lunar question pops into your head. Get a copy and keep in on your reference shelf !

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By: Michael Mattei

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4 October, 1998 ..... pp. 145-192.

(Abbreviations: I. = Issue, IBC = Inside Back Cover, OFC = Outside Front Cover)

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SUBJECT INDEX

ASTROCON '99 IS HERE !!!

Greetings to all of our friends and colleagues in The Association of Lunar and Planetary Observers!

This is the official announcement of the 1999 Astronomical League's 52nd annual convention, ASTROCON '99 A Thousand Years of Stars & Space.

This event is being held at Eastern Washington University in Cheney, Washington, just outside Spokane, July 13th through 17th, 1999. This will be the first time in 10 years that the convention has been held in the Northwest and 8 years since being held on the West Coast!

I think that you will find that we have an absolutely stellar line-up of Special Speakers and Events for ASTROCON '99:

Dr. F. Story Musgrave, multiple mission shuttle astronaut and Hubble Space Telescope Primary Repair mission specialist.

Jack Horkheimer, host of the Stargazer television series on the PBS network and Director of the Miami Space Transit Planetarium.

Dr. Donald Parker, Executive Director of A.L.P.O. and Jack Newton, two of the world's most renowned astrophotographers.

Dr. Paul Weissman, NASA /JPL project scientist for the Deep Space 4 Mission to comet Temple 1.

Dr. Thomas McCord, NASA /JPL project scientist for the Galileo and Cassini/Huygens Missions.

Alan Macfarlane, pioneer in the field of video astronomy.

Edward Mannery, University of Washington, co-designer of the Sloane-Kettering Digital Sky Survey Telescope.

Andrew Fraknoi, Astronomical Society of the Pacific.

Dennis Schatz, Director of the Pacific Science Center.

I am sure that you are all wondering why the ALCON is being referred to as ASTROCON '99. The name change is due to the fact that we are co-hosting the convention with the Astronomical League, The Association of Lunar and Planetary Observers, The International Dark Sky Association (IDA), The American Association of Variable Star Observers (AAVSO), and The International Occultation Timing Association (IOTA)

Our educational offerings will include Project Astro for the amateur astronomer and Universe in the Classroom for teachers, both presented by Astronomical Society of the Pacific (ASP). Continuing education credits (CEUs) will be available.

We will also be conducting special workshops for children presented by the Pacific Science Center and Spokane Astronomical Society Amateur Telescope Makers (many of whom were involved in the construction of Hercules, Dan Bakken's 41.2-inch truss tube reflector).

Other activities planned are the AstroSoftware Workshop, Space Exploration Education, Historical Exhibits, planetarium and IMAX shows and, of course, star parties at two sites!

Because we believe that Astronomy is an exciting experience that should be shared by all members of the family, we will be providing three levels of AstroForum seminar topics every hour (Expert, Intermediate, and Beginning).

The staff at ASTROCON 99 is ready to process your Registration via On-Line Shopping with a Secured Server that accepts Visa and Mastercard at:

http://www.SpokaneAstronomical.org/astrocon99

You will also find all the details necessary to make your stay enjoyable with many options for Lodging, Transportation, and Food, featuring exciting tours and destinations in the Great Northwest. So why not spend your summer vacation with us at ASTROCON '99!

No one will want to be left out of this history making event!

See you in July,

Enjoy Clear Dark Skies

Mickey Moreau

President
Spokane Astronomical Society

Chairman
ASTROCON '99

A.L.P.O. Papers: If you wish to give a paper during the A.L.P.O. session, send its title, with an abstract, desired presentation time, and description of AV needs via e-mail to: dan@runway.net . The Astronomical League requests that, in addition to the A.L.P.O. Session, you repeat your paper as a 15-20 minute public presentation. There will also be an A.L.P.O. Display, and you are invited to bring materials for it.

A.L.P.O. ANNOUNCEMENTS

SECTION CHANGES

Jeff Beish Rejoins Mars Section Staff.—Jeff D. Beish, who for many years served on the staff of our Mars Section, has rejoined our staff with the title of Acting Assistant Mars Coordinator. Jeff's address is: Jeff D. Beish, 14522 Bisbee Court, Woodbridge, VA 22193 (E-mail: cecropia@gte.net). One of his new duties will be writing *The Martian Chronicle*, the newsletter of the Section.

Snail-Mail Address Change for Harry Pulley.—Our Acting Mercury Coordinator, Harry C. Pulley, IV, has moved to: 532 Whitelaw Road, Guelph, Ontario, Canada N1K 1A2. His telephone number and e-mail address remain as before.

E-Mail Address Change for Walter Haas.—A.L.P.O. Founder Walter H. Haas' E-mail address is now: haasw@zianet.com . His postal address remains as before.

OTHER A.L.P.O. NEWS

Generous Gift.—The Wilbur Smith Foundation recently presented the A.L.P.O. with a check for $3000. This generous bequest has been added to the A.L P.O. Endowment Fund, which was established using a previous $5000 gift from the same source. We wish to thank the foundation for their generosity, which has made our Endowment Fund possible.

A.L.P.O. Donors.—The following A.L.P.O. members recently have generously contributed to our two special categories of membership. We here express our appreciation to the following individuals:

Sustaining Memberships ($50 per year minimum)—Charles E. Allen III, Stephen L. Davis, William Dembowski, Robert K. Dickson, Douglas R. Hansen, Robert H. Hays, Mike Hood, John T. Hopf, H.W. Kelsey, Robert D. Lunsford, Ashley T. Mc Dermott, Arthur K. Parizek, Donald C. Parker, Ibrahim G. Picard, the Richmond Astronomical Society, Timothy J. Robertson, John Sanford, Guido E. Santacana, Takeshi Sato, Mark L. Schmidt, Robert D. Smith, Richard Ulrich, and Richard J. Wessling.

Sponsors ($100 per year minimum)—Julius L. Benton, Jr., Darryl J. Davis, Leland A. Dolan, David J. Lehman, Thomas C. Peterson, James Phillips, Cecil C. Post, Lee M. Smojver, Gerald Watson, Matthew Will, and Thomas R. Williams.

Meeting Reminders.—We remind our readers that the A.L.P.O. is planning two meetings in 1999.

A.L.P.O. Paper Session at RTMC/1999.—The Riverside Telescope Makers Conference theme for 1999 will be the Solar System; the A.L.P.O. will conduct a Paper Session at this time-honored event. As always, RTMC will be held over Memorial Day Weekend at Cape Oakes, near Big Bear in southern California at 7200 feet above sea level. A.L.P.O. members wishing to deliver papers should contact the RTMC Paper Session Scheduler directly: Allan Guthmiller, 1900 Chickasaw, Henderson, NV 89105 (Telephone: 702-558-3548 [home] / 702-564-4782 [work]. FAX: 702-564-4778. E-mail: RTMC-STARRYAL@JUNO.COM).

A.L.P.O./Astronomical League Convention for 1999.—Please see the previous page for information on this coming meeting.

OTHER AMATEUR AND PROFESSIONAL ANNOUNCEMENTS

North American Meteor Network Website Address Changed.—The new web address of the North American Meteor Network (NAMN) is: http:/web.infoave.net/~meteorobs

The following meetings, classes, and other events are scheduled in the coming months. Information contacts are given in brackets.

March 15-19, 1999: 30th Lunar and Planetary Science Conference. At Houston, Texas. [30th LPSC, Publications and Program Services Department, Lunar and Planetary Institute, 3600 Bay Area Blvd., Houston, TX 77058-1113. Telephone: 1-281-486-2158, FAX: 1-281-486-2160, E-mail: simmons@lpi.jsc.nasa.gov , Web: http://cass.jsc.nasa.gov/meetings/LPSC99/]

April 11-14, 1999: Fifth Annual K-12 Education Workshop. At Space Science Institute, Boulder, Colorado. [Susan Solari, Space Science Institute, 1540 - 30th St., Suite 23, Boulder, CO 80303-1012. Telephone: 1-303-492-5184, FAX: 1-303-492-3789, E-mail: solari@colorado.edu, Web (Space Science Institute): http://www.spacescience.org]

April 19-23, 1999: European Geophysical Society General Assembly. At The Hague, The Netherlands. [Web: http://www.mpae.gwdg.de/EGS/egsga/denhaag99/denhaag99.htm]

April 28-30, 1999: Workshop on Thermal Emission Spectroscopy and Analysis of Dust, Disks, and Regoliths. At Houston, Texas. Sponsored by the Lunar and Planetary Institute and NASA. [Thermal99 Workshop, Lunar and Planetary Institute, 3600 Bay Area Blvd., Houston, TX 77058-1113. Telephone: 1-281-486-2158, FAX: 1-281-486-2160, E-mail: simmons@lpi.jsc.nasa.gov , Web: http://cass.jsc.nasa.gov/meetings/thermal99/]

June 8-11, 1999: From Giant Planets to Cool Stars. At Flagstaff, Arizona, sponsored by Northern Arizona University and NASA. "The emerging interdisciplinary field of brown dwarf and extrasolar giant planet studies." [Web: http://www.phy.nau.edu/~gpcs99/]

June 13-18, 1999: Gordon Research Conference on Origins of Solar Systems. At Henniker, New Hampshire. [Alan Boss, DTN-CIW, 5241 Broad Branch Rd., NW, Washington, DC 20015-1305. E-mail: boss@dtm.ciw.edu, Web: http://www.grc.uri.edu/]

June 16-29, 1999: Mount Wilson Summer Program for Undergraduates. The tenth Mount Wilson summer program in astronomy and astrophysics for undergraduate students. Sponsored by the Consortium for Undergraduate Research and Education in Astronomy (CUREA). The tuition fee is $1550, covering all expenses, and the application deadline is April 15, 1999. [Prof. Joseph L. Snider, CUREA Director, Department of Physics, Oberlin College, 110 North Professor St., Oberlin, OH 44074. Telephone: 1-440-775-8335, FAX: 1-440-775-8886, E-mail: joseph.l.snider@oberlin.edu , Web: http://www.astro.wisc.edu/~faison/curea/curea.html]

July 1-7, 1999: The Astronomical Society of the Pacific, the Royal Astronomical Society of Canada, and the American Association of Variable Star Observers. At Toronto, Ontario, Canada on the University of Toronto Campus. [Laurie Keechler, ASP Meeting Planner, 390 Ashton Ave., San Francisco, CA 94112. Web: http://www.aspsky.org]

July 11-16, 1999: 62nd Annual Meteoritical Society Meeting. At Johannesburg, South Africa. [Wolf Uwe Reimold, Department of Geology, Wits University, Private Bag 3, P.O. Wits 2050, Johannesburg, South Africa. Telephone: +27-11-716-2946, FAX: +27-11-339-1697, E-mail: 065msoc@cosmos.wits.ac.za , Web: http://www.wits.ac.za/metsoc99/]

July 13-17, 1999: ALCON 99, The Astronomical League Convention. *See previous page.*

July 26-30, 1999: Asteroids, Comets, & Meteors Conference. At Cornell University, Ithaca, New York. [Beth E. Clark, ACM Conference, Space Sciences Building, Cornell University, Ithaca, NY 14853-6801. Telephone: 1-607-254-8895; FAX: 1-607-255-9002; E-mail: acm@scorpio.tn.cornell.edu ; Web: http://scorpio.tn.cornell.edu/ACM]

August 1-22, 1999: 35th International Astronomical Youth Camp. In a castle near Vep (near Szombathley), Hungary. Includes observing the 1999 AUG 11 total solar eclipse. [IWA e.V., c/o Gwendolyn Meeus, Parkstraat 91m 3000 Leuven, Belgium. E-mail: info@iayc.org]

August 2-6, 1999: Sixth Bioastronomy Meeting: Bioastronomy 99: A New Era in Bioastronomy. At the Kohala Coast, Hawai'i. [Karen Meech, Institute for Astronomy, 2680 Woodlawn Dr., Honolulu, HI 96822. Telephone: 808-956-6828, FAX: 808-956-6828, E-mail: meech@ifa.hawaii.edu, Web: http://www.ifa.hawaii.edu/~meech/bioast/]

August 4-8, 1999: Fourth Meeting of (not only) European Planetary and Cometary Observers (MEPCO'99). At the Black Sea coast near Varna, Bulgaria—one of the premier sites for observing the August 11 total solar eclipse, shortly after the meeting. [E-mail: astro@ms3.tu-varna.acad.bg (Veselka Radeva); Web: http://aibn91.astro.uni-bonn.de/~dfischer/mepco.html]

August 7-13, 1999: Solar Eclipse August 1999 Symposium: Research Amateur Astronomy in the VLT Era. At Garching (near Munich), Germany. Sponsored by the Vereinigung der Sternfreunde, VdS and the European Southern Observatory. [Klaus Reinsch, E-mail: reinsch@neptun.uni-sw.gwdg.de , Web: http://neptun.uni-sw.gwdg.de/sonne/eclipse99_conference.html]

August 22-26, 1999: The Origin of Elements in the Solar System: Implications of Post-1957 Observations. At the Annual Meeting of the American Chemical Society, New Orleans, Louisiana. [Oliver K. Manuel, Department of Chemistry, University of Missouri, Rolla, MO 65401. Telephone: 573-341-4420, FAX: 573-341-6033, E-mail: oess@umr.edu , Web: http://www.umr.edu/~oess/]]

August 22-27, 1999: Ninth Annual V.M. Goldschmidt Conference. At Cambridge, Massachusetts. [Stein B. Jacobson, Department of Earth and Planetary Sciences, Harvard University, Cambridge, MA 02138. Telephone: 617-495-5233, FAX: 617-496-4387, E-mail: goldschmidt@eps.harvard.edu , Web: http://cass.jsc.nasa.gov/meetings/gold99/]

The Association of Lunar and Planetary Observers

Founded by Walter Haas in 1947, the A.L.P.O. now has about 500 members. Our dues include a subscription to our quarterly Journal *(J.A.L.P.O.), The Strolling Astronomer*, and are $23.00 for one year ($40.00 for two years) for the United States, Canada, and Mexico; and $30.00 for one year ($54.00 for two years) for other countries. One-year Sustaining Memberships are $50.00; Sponsorships are $100.00. 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 advertisement, $50.00 per half-page, and $35.00 per quarter-page. Classified advertisements are $10.00 per column-inch. There is a 10-percent discount for a three-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." All cash or check dues payments should be sent directly to: A.L.P.O. Membership Secretary, P.O. Box 171302, Memphis, TN 38187-1302. When writing to our staff, please provide stamped, self-addressed envelopes. Note that the A.L.P.O. maintains a World-Wide Web homepage at: http://www. lpl.arizona.edu/alpo/

Keeping Your Membership Current.—The top line of your *J.A.L.P.O.* mailing label gives the volume and issue number when your membership will expire (e.g., "41.1" means Vol. 41, No. 1). We also include a First Renewal Notice in that issue, and a Final Notice in the next one. Please let the Membership Secretary know if your address changes. Dues payments should be made directly to the Membership Secretary.

A.L.P.O. Monograph Series

A.L.P.O. monographs are publications that we believe will appeal to our members, but which are too lengthy for our Journal. Order them from our Editor (P.O. Box 16131, San Francisco, CA 94116 U.S.A.) for the prices indicated, which include postage; make checks to "A.L.P.O."

Monograph Number 1. ***Proceedings of the 43rd Convention of the Association of Lunar and Planetary Observers. Las Cruces, New Mexico, August 4-7, 1993.*** 77 pages. Price: $12.00 for the United States, Canada, and Mexico; $16.00 elsewhere.

Monograph Number 2. ***Proceedings of the 44th Convention of the Association of Lunar and Planetary Observers. Greenville, South Carolina, June 15-18, 1994.*** 52 pages. Price: $7.50 for the United States, Canada, and Mexico; $11.00 elsewhere.

Monograph Number 3. ***H.P. Wilkins 300-inch Moon Map.*** 3rd Edition (1951), reduced to 50 inches diameter; 25 sections, 4 special charts; also 14 selected areas at 219 inches to the lunar diameter. Price: $28.00 for the United States, Canada, and Mexico; $40.00 elsewhere.

Monograph Number 4. ***Proceedings of the 45th Convention of the Association of Lunar and Planetary Observers. Wichita, Kansas, August 1-5, 1995.*** 127 pages. Price: $17.00 for the United States, Canada, and Mexico; $26.00 elsewhere.

Monograph Number 5. ***Astronomical and Physical Observations of the Axis of Rotation and the Topography of the Planet Mars. First Memoir, 1877-1878.*** By Giovanni Virginio Schiaparelli, translated by William Sheehan. 59 pages. Price: $10.00 for the United States, Canada, and Mexico; $15.00 elsewhere.

Monograph Number 6. ***Proceedings of the 47th Convention of the Association of Lunar and Planetary Observers, Tucson, Arizona, October 19-21, 1996.*** 20 pages. Price $3.00 for the United States, Canada, and Mexico; $4.00 elsewhere.

Monograph Number 7. ***Proceedings of the 48th Convention of the Association of Lunar and Planetary Observers. Las Cruces, New Mexico, June 25-29, 1997.*** 76 pages. Price: $12.00 for the United States, Canada, and Mexico; $16.00 elsewhere.

Monograph Number 8. ***Proceedings of the 49th Convention of the Association of Lunar and Planetary Observers. Atlanta, Georgia, July 9-11, 1998.*** 122 pages. Price: $17.00 for the United States, Canada, and Mexico; $26.00 elsewhere.

Other Publications of the A.L.P.O.

(Checks must be in U.S. funds, payable to an American bank with bank routing number.)

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 October, 1998.

Order from: A.L.P.O. Membership Secretary, P.O. Box 171302 Memphis, TN 38187-1302 U.S.A:

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