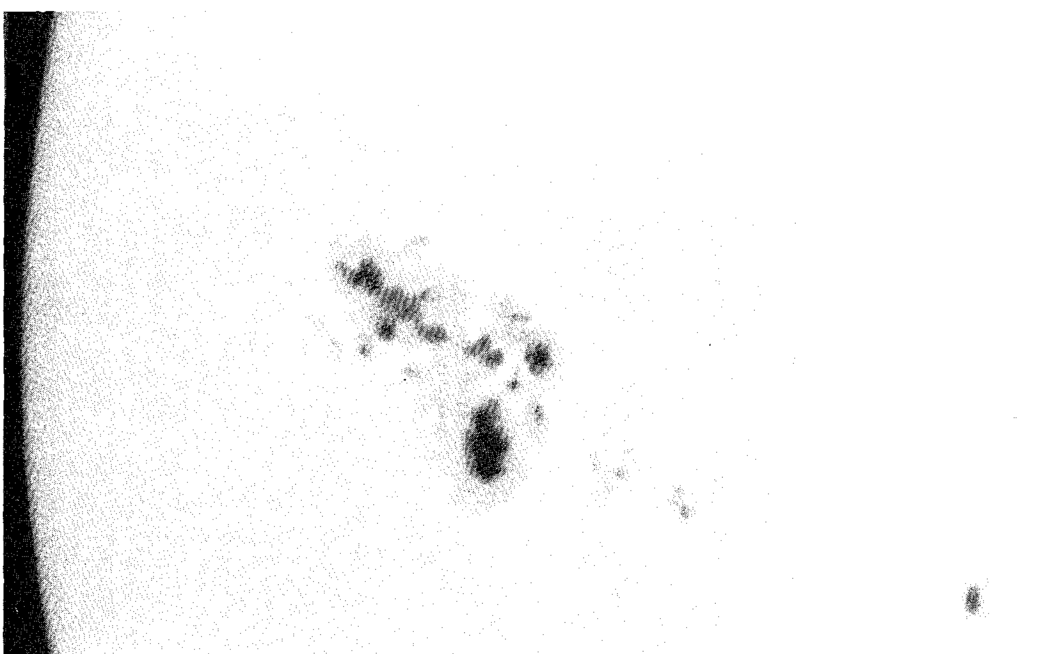
ISSN 0039-2502

The Journal Of The Association Of Lunar And Planetary Observers

The Strolling Astronomer

Volume 32, Numbers 11-12 **Published October, 1988**



The naked-eye sunspot group associated with solar active region SESC 5060. Photographed by Randy Tatum using an 18-cm. (7-in.) refractor at f/30 and a Daystar Hydrogen-alpha filter tuned to the red, simulating a white-light view. Taken 1988 JUNE 28, 12h 53m U.T., with a 1/60-second exposure on Kodak TP 2415 Film. North at top. See also text on pages 260-262.

THE ASSOCIATION OF LUNAR AND PLANETARY OBSERVERS
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P.O. Box 143
Heber Springs, AR 72543 U.S.A.

Founded In 1947

IN THIS ISSUE

THE 1983-85 APPARITION OF JUPITER: DESCRIPTIVE REPORT

By: Phillip W. Budine, A.L.P.O. Jupiter Recorder

Abstract. -- This report describes the atmospheric features of Jupiter as recorded by A.L.P.O. observers during the 1983-85 Apparition. It includes written descrIptions, drawings, and photographs of the belts and zones, the South Tropical Zone Disturbance, Long-Enduring Ovals, and the Red Spot area, differentiated into three periods (1984 FEB 01-APR 30, MAY 01-JUL 31, and AUG 01-DEC 15). NEBs-EZn blue features and the colors and intensities of other features are also described.

Introduction

This report describes the atmospheric features of Jupiter as recorded by A.L.P.O. observers during the 1983-85 Apparition, which spanned the period between the two successive conjunctions with the Sun of 1983 DEC 14 and 1985 JAN 14. Jupiter reached opposition to the Sun on 1984 JUN 29, then with a disk equatorial diameter of 46".81 and a declination of -23°.1, favoring observers in the Southern Hemisphere. The actual period of observation was 1984 FEB 01 -DEC 15. In this apparition the following observers contributed observations to the A.L.P.O. Jupiter Section. Table 1 below gives these observers' names, observing sites, telescope or telescopes used, and the types of observations that they contributed.

Table 1. A.L.P.O. Jupiter Observers, 1983-85 Apparition.

Name	Observing Site	Telescope Aperture in cm. and Type	Type of Observations
Aerts, Leo	Heist-op-den-berg, Belgium	15 RL	DD, P
Adcock, Barry	Victoria, Australia	32 RL	P, T
Barbany, Domenec	Barcelona, Spain	7.5 RR	DD
Benninghoven, Claus	Burlington, IA	20 RL	DD, S, T, DR, C
Budine, Phillip W.	Walton, NY	8.3 M	S, T
Daniels, Mark S.	Wichita, KS	20 RL	DD, T
Dragesco, Jean	Rwanda, Central Africa	35 RL	DD, P
Fabré, Ray	Aiea, HI	42 RL	DD
Haas, W.	Las Cruces, NM	32 RL	T, DR
Heath, Alan W.	Nottingham, England	30 RL	DD
Herring, Alika K.	Anaheim, CA	32 RL	DD, P
McNamara, Geoff	Sydney, Australia	32 RL	T
Maksymovicz, S.	Southern France	8 RR, 15 RL	DD, S, T
Miyazaki, Isao	Okinawa, Japan	20 RL	DD, S, T, DR
Morrow, M.J.	Ewa Beach, HI	40 RL	DD, I
Nowak, Gary T.	South Burlington, VT	20 RL, 22 RR	DD, I, DR
Olivarez, Jose	Wichita, KS	32 RL	S, T, DR
Papp, Jan	Auomas, Hungary	25 RL	DD, I, T, DR
Park, Jim	Victoria, Australia	20 RL	DD, T
Parker, Donald C.	Coral Gables, FL	32 RL	P
Pedersen, Steen	Hinnerup, Denmark	10 RR	DD, T
Robotham, Rob	Ontario, Canada	15 RL	DD, S, T, DR
Ross, Terrence	New Berlin, WI	32 RL	DD, T
Scott, Pete	Indiana, PA	20 RL	DD, T
Tatum, Randy	Richmond, VA	15 RL, 17 RR	DD, S, P, T, DR
Troiani, Daniel M.	Chicago, IL	25 RL	DD, S, T, DR
Yandrick, Richard	Willow Grove, PA	20 RL	DD

Telescopes Key: M = Maksutov, RL = Reflector, RR = Refractor.
Observation Key: C = Color Estimates, DD = Disk Drawings, DR = Descriptive Reports, I = Intensity Estimates, P = Photographs, S = Strip Sketches, T = Transit Timings.

For the purpose of clarity and comparison, this report is organized into three periods: Period I, 1984 FEB 01-APR 30; Period II, MAY 01-JUL 31; and Period III, AUG 01-DEC 15. For each period, belts and zones are described in south-to-north order. Figure 1 below shows the standard nomenclature for Jupiter's belts and zones that will be used in this report.

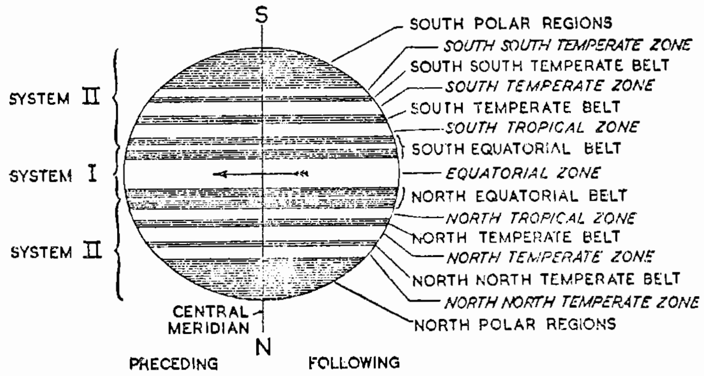

Figure 1. Standard nomenclature for the belts and zones of Jupiter, shown in a typical simply inverted view. Also shown are the nominal ranges of the rotational Systems I and II. The abbreviations used in the text are: N, North; S, South; T, Temperate; Tr, Tropical; E, Equatorial; B, Belt; and Z, Zone. The arrow shows the direction of rotation.

Belts

Period I (1984 FEB 01-APR 30):

SPR--Usually recorded darker than the NPR. Belt fragments in very high southern latitudes were observed between longitudes 031-072° (II) in late February-early March.

SSSTB--Observed only in longitude 031-072° (II) during this period.

SSTB--Observed between 301-350° (II) near mid-April.

STB--Rather dusky and wide in most longitudes. It was darker following the long-enduring Oval DE in February, and was also darker following Oval BC in March. Near Oval FA, the STB was a double belt during this period.

SEB--This belt was usually wide and dark during Period I. Near the longitude of the Red Spot, the belt was double, and a SEB Z was observed. Usually, the SEB south edge was the darker edge, but there were expceptions in some longitudes. Dark projections and bright ovals were seen in many longitudes of this belt on its southern edge.

EB--Observed during the entire period, located slightly south of the center of the Equatorial Zone (EZ).

NEB--Many dark projections, festoons, and bright ovals were seen on the NEB's southern edge, which was usually the darkest part during this period. A rift developed in the center of the belt near longitude 073° (II), as is shown in Figure 3 (p. 239) on 1984 MAR 07, when it was joined to a bright oval in the EZn and to another one in the NTrZ. During most of this period, however, the belt was single, wide, and dark, although not so dark as the SEB.

NTB--The belt was dark and prominent during the entire period.

NNTB--Observed in middle and late March. It was most prominent near longitude 250° (II), as shown in Figure 4 (p. 239).

NNNTB--Seen in late February near longitude 031° (II).

NPR--Wider than the SPR, but not so dark during this period. Usually uniformly dusky.

Perlod II (1984 MAY 01-JUL 31):

SPR--During this period the SPR was usually recorded darker and smaller than the NPR.

SSTB--A segment of this belt was seen in early and mid-May near longitude 125° (II).

STB--This belt was double both preceding and following long-enduring Oval BC and also preceding Oval DE during this period. It was darkest in the longitudes preceding and following Oval FA.

SEB--This belt was wide and dark in all longitudes except near the Red Spot Hollow (RSH), where it was rifted preceding and following the RSH area.

EB--Most observers saw the EB throughout all longitudes.

NEB--During the early part of this period rifts were observed near longitudes 050° (I) and 175° (I). Dark festoons were prominent on its south edge. This belt was single and dark during the entire period.

NTB--Prominent through 1984 MAY 23 (see/Figure 7/, p. 239). After this date the belt faded considerably and was difficult to observe by mid-June.

NNTB--A segment of this belt was observed from 1984 MAY 18 to MAY 24 near longitude 351° (II) (see Figure 8 , p. 240).

NPR--A darker polar hood area was observed from mid-May to late May. Usually the NPR was less dark than the SPR.

Period III (1984 AUG 01-DEC 15):

SPR--No change from Period II.

SSTB--Prominent from early to mid-August in the longitudes preceding Oval DE. After mid-August this belt was prominent following Oval DE. It was usually recorded as a single dark belt, although Herring observed it as double on 1984 SEP 04 near longitude 201° (II) (see Figure 24 , p. 244).

STB--Faint and double preceding Oval DE from early to mid-August, although this aspect was noted by Daniels as late as 1984 AUG 21 (see Figure 21 , p. 243). It was reported as very dark and wide following Oval DE, and as usually double between Ovals FA and BC. In early September, Herring noted this belt as triple following the BC area (see Figure 24 , p. 244).

SEB--Wide, single, and dark preceding the Red Spot (RS), but double following the RS area. The southern component (SEBs) was very dark following the RS as far as the longitude of Oval DE. The SEBs was connected to the following border of the RS area during this entire period. The SEBs was displaced southwards in those longitudes occupied by the preceding and following ends of the South Tropical Zone Disturbance (STrZ D), which then respectively preceded and followed the RS area.

EB--Very prominent in all longitudes from early August until 1984 AUG 27, when Scott saw it as faint (see Figure 22 , p. 243). By 1984 SEP 04, Herring recorded only a thin segment of this belt (see Figure 24 , p. 244).

NEB--Wide, single, and dark during this entire period. The belt edges were usually darker than the interior. Bright ovals were prominent on its northern edge near longitude 296° (II) between 1984 AUG 15-21 (see Figure 21 , p. 243). By 1984 SEP 04, Herring noted interior structure and bright rifts near longitude 201° (II) (see Figure 24 , p.244).

NTB--This belt was observed throughout this period. Late in the period it was observed as double near longitude 200° (II). A dark section was observed near longitude 015° (II) by Maksymovicz on 1984 AUG 15 and by Scott on 1984 AUG 27 (see Figure 22 , p. 243).

NNTB--Reported as prominent in the longitudes between the RS area and Oval BC. This belt was not observed in other longitudes during this period.

NPR--No change from Period II.

Zones

Period I (1984 FEB 01-APR 30):

STZ--Usually bright throughout this period. Bright spots were seen near longitude 160° (II) during the period from mid-March to mid-April.

STrZ--Many festoons and bright ovals were observed in this zone. The STrZ Disturbance, described in detail on pp. 237-238, occupied some longitudes of this zone. In those longitudes not covered by the Disturbance, this zone was seen as bright, and as having a narrow prominent belt in its southern portion. Also in that longitude range, moving spots were reported in the Circulating Current-North.

EZ--Usually bright throughout this period, although at times the southern portion (EZs) was reported to be dull. Bright spots were seen in the EZs in March at longitude 050° (I) and in April at 155° (I) and 260° (I). The EZn was always bright and contained numerous festoons and bright ovals.

NTrZ--This zone was bright throughtout this period and bright ovals were observed in it on some occasions.

NTZ--Bright throughout this period. A bright elongated spot was seen at longitude 159° (II) by Dragesco on 1984 APR 15.

Period II (1984 MAY 01-JUL 31):

SSTZ--This zone was seen from 1984 MAY 24-JUN 01.

STZ--This zone was bright until 1984 JUN 01. It was reported as dull on that date and was dusky by mid-June. By the end of May, bright ovals were seen in this zone, south of Oval BC (see Figure 9 , p. 240).

STrZ--Usually bright and wide during the early part of this period, except in those longitudes occupied by the STrZ Disturbance (see Figure 2 , p.239). Festoons and ovals were seen here during this period, especially near Oval BC. A STrZ Belt was observed from 1984 JUN 29-JUL 27, starting near longitude 227° (II) and extending to the preceding end of the Red Spot (see Figure 10 and Figure 11 , p. 240).

EZ--Prominent and bright until 1984 JUL 11, and duller during the remainder of this period.

NTrZ--Bright and wide during this period. Some activity was reported in this zone near mid-July near longitude 055° (II). A NTrZ Belt was observed near the center of this zone from 1984 JUL 07 to the end of this period.

NTZ--Observed until 1984 JUL 11, but not reported for most longitudes after this date.

Period III (1984 AUG 01-DEC 15):

SSTZ--Observed as prominent from early August until 1984 AUG 15 and not reported after that date.

STZ--Bright and prominent from early August to 1984 AUG 27. During the remainder of this period this zone was dull and dusky in the longitudes from the RS area to Oval BC.

STrZ--Very bright and conspicuous in all longitudes except those occupied by the STrZ Disturbance.

EZ--Prominent and bright until 1984 AUG 21, when Daniels noted the northern portion (EZn) as mostly dusky (see Figure 21 , p. 243). Scott saw this zone as dull on 1984 AUG 27 (see Figure 22 , p. 243) and, by 1984 SEP 04, Herring recorded it as very dull (see Figure 24 , p. 244).

NTrZ--Very bright and wide until 1984 AUG 27, when Scott recorded it as dull (see Figure 22 , p. 243). It was still dull on 1984 SEP 04 as recorded by Herring (see Figure 24 , p. 244).

Other Features of the Planet

Period I (1984 FEB 01-APR 30):

South Tropical Zone Disturbance (STrZ D)--This object was first observed this apparition by Jean Dragesco on 1984 FEB 28, as a prominent feature with a concave edge preceding Oval DE (see Figure 2 , p. 239). The STrZ D was very dusky with festoons and bright ovals within it. By 1984 APR 04, it had darkened and preceded the RS area. The Disturbance was photographed by Dragesco on 1984 APR 04 (see Figure 5 , p. 239) and on APR 15 by Donald Parker.

Long-Enduring Ovals (in the STB)--All three ovals were located near the latitude of the center of the STB. In descending order of conspicuousness for all periods, they were: DE, BC, and FA. Oval BC was very prominent from mid-March until the end of April. Bright ovals were observed following Oval BC in the STZ from mid-March until the end of this period. Oval FA was small but conspicuous during the early part of Period I. Oval BC is very prominent on a photograph taken by Dragesco on 1984 APR 18 near central meridian 285 (II) (see Figure 6 , p. 239).

Red Spot Area--Dragesco recorded the interior of the Red Spot Hollow (RSH) as dusky in early March. On his photograph of 1984 APR 04, one can see the faint Red Spot (RS) within the southern confines of the RSH (see Figure 5 , p. 239). On 1984 APR 15 Parker photographed a prominent RSH.

Period II (1984 MAY 01-JUL 31):

South Tropical Zone Disturbance (STrZ D)--This object was recorded as a faint streak on a sketch by Benninghoven on 1984 MAY 24 (see Figure 8 , p. 240). It then developed as a dark feature with a festoon, as observed by Fabre on 1984 JUL 11 (see Figure 13 , p. 241). The STrZ D was very dusky preceding the RSH. The Disturbance was seen by Barbany on 1984 JUL 14 (see Figure 15 , p. 241), and Miyazaki saw it on 1984 JUL 19 as a dark prominent feature preceding the Red Spot area (see Figure 17 , p. 242).

Long-Enduring Ovals (in the STB)--Oval FA was near the RSH during this period. Oval BC was was shown by Parker on an excellent photograph taken on 1984 MAY 30 (see Figure 9 , p. 240), while Daniels drew it on 1984 JUL 13 (see Figure 14 , p. 241). The STB was double preceding Oval BC and was dark and single following that oval. Oval DE was drawn by Miyazaki on 1984 JUL 01 (see Figure 11 , p. 240).

Red Spot Area--During this period the Red Spot Hollow was bright and prominent until mid-July except for a slight duskiness observed by Benninghoven on 1984 MAY 24 (see Figure 8 , p. 240). On 1984 JUL 14 Barbany recorded the RSH as slightly dusky (see Figure 15 , p. 241), while on 1984 JUL 19 Miyazaki saw the interior of the RSH as very dusky with traces of the Red Spot (see Figure 17 , p. 242). A photograph by Dragesco on 1984 JUL 05 shows the STB Oval FA in conjunction with the RSH.

Period III (1984 AUG 01-DEC 15):

South Tropical Zone Disturbance (STrZ D)--The preceding concave end was drawn by Daniels on 1984 AUG 21 (see Figure 21 , p. 243), when the Disturbance was near the following limb. On 1984 AUG 27, Scott recorded festoons within the Disturbance (see Figure 22 , p. 243).

Long-Enduring Ovals (in the STB)--Oval DE was very bright and prominent on a drawing by Barbany on 1984 AUG 04 (see Figure 19, p. 242), which also shows the STB as very dark and wide following DE. This oval was also sketched by Daniels on 1984 AUG 21 (see Figure 21, p. 243), where it appears near the preceding limb. Oval FA was prominent on a sketch by Scott on 1984 AUG 27 (see Figure 22, p. 243).

Red Spot Area--On 1984 AUG 08, Robotham drew the Red Spot within the southern border of the Red Spot Hollow (see Figure 20, p. 243). On his 1984 AUG 27 disk drawing, Scott depicted the RSH as dusky with mostly faint borders (see Figure 22, p. 243).

Feature Highlights of the 1983-85 Apparition

Jupiter's South Tropical Zone Disturbance--In recent apparitions, Jupiter's South Tropical Zone Disturbance has revived! It was seen as early as December, 1978, by Randy Tatum and was also recorded by Voyager 1 as that spacecraft flew by the planet in March, 1979. By June, 1979, the Disturbance extended one-third of the way around Jupiter; and one year later it spanned nearly 200° of longitude.

Observations suggest that in October, 1980, the projected drift of the Disturbance caused its preceding end to catch up with the following end of the Great Red Spot. The leading edge of the Disturbance probably passed from one side of the Red Spot to the other in five days. Jupiter was then near conjunction with the Sun, and by the time when the planet was well seen again in December, 1980, the Disturbance had shrunk in both prominence and length (then covering 70° of longitude). From 1981 through 1983, its preceding and following ends were recorded as "remnants."

In 1984 the Disturbance was again active! In late February, 1984, Jean Dragesco observed the preceding end of the Disturbance; and by early April he recorded the trailing (following) end. Other A.L.P.O. observers reported various Disturbance-related features in the following months. In late July, 1984, Budine had a good view of the Disturbance, which then had a well-developed, concave preceding end spanning 22° of longitude. One week later, the Disturbance was 35° long and "fully developed,"according to Jose Olivarez.

The South Tropical Zone Disturbance was active through August and the beginning of September, but had largely disappeared by 1984 SEP 20. Remnants were seen through October, 1984, however.

Jupiter's NEBs-EZn Blue Features--Festoons on the south edge of the NEB quite often have very dark bases, and other dark masses may be seen in the NEBs-EZn. Jose Olivarez first noted that some of these markings were vivid blue in color and hence represented some of the deepest features seen in Jupiter's atmosphere. Olivarez reported twelve of these blue feaures in 1983!

In 1984, he and other observers recovered seven of the "blue features" that had been observed in 1983, making them "long-lived" jovian features, as they had survived since early in the 1982-83 Apparition. Jose Olivarez and other A.L.P.O. observers continued to watch these features throughout the 1983-85 Apparition. Also, seven additional blue features in the NEBs-EZn were found by Olivarez and other Jupiter Section observers in 1984! This writer has used the OL (Olivarez) prefix to identify these features because Olivarez first noted and observed their characteristics in 1983. The long-lived features first observed in 1983 are: OL-1A, OL-2, OL-3, OL-4, OL-5, OL-6, and OL-10. The new blue features first seen in 1984 are: OL-2A, OL-1, OL-7, OL-8, OL-9, OL-11, and OL-12. More information about these features will appear in the Rotation Period Report for the 1983-85 Apparition. [This article has been received and will be published in a later issue. Ed.]

Intensities and Colors in 1983-85

Table 2 below summarizes 167 visual intensity estimates contributed to the A.L.P.O. Jupiter Section in 1983-85, made by Michael J. Morrow, Gary T. Nowak, and Janos Papp. [The A.L.P.O. Intensity Scale runs from 0 for black shadows to 10 for the brightest possible planetary features. Ed.] In addition, Claus Benninghoven submitted color estimates. The mean for intensity is given for each observer and feature. Table 1 (p. 233)lists the telescopes employed by these observers. [Text continued on p. 244.]

Note: Views are simply inverted, with south at the top. Times and dates are U.T. "S" gives Seeing on the A.L.P.O. Scale (0 worst and 10 best); "T" is the A.L.P.O. Transparency Scale (0 worst, 5 best). "CM" is the Central Meridian, with the rotation System in parentheses. Telescope types are as in Table 1 (p. 233).

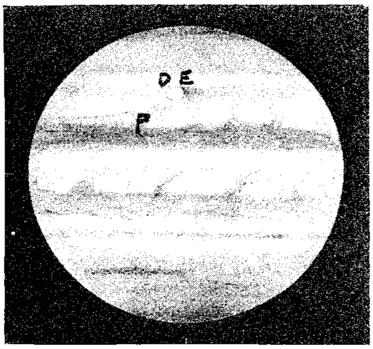

Figure 2. Drawing by Jean Dragesco. 1984 FEB 28, 05h 00m. 35-cm. RL, 244X & 320X. CM(I) = 114°; CM(II) = 320°. Note STB Oval DE and preceding end of the STrZ Disturbance.

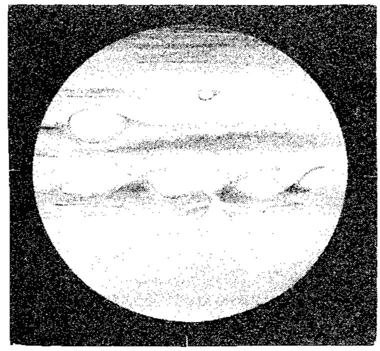

Figure 3. Drawing by Jean Dragesco. 1984 MAR 07, 04h 46m. 35-cm. RL, 244X & 320X. CM(I) = 288°; CM(II) = 073°. Note RSH and Oval FA.

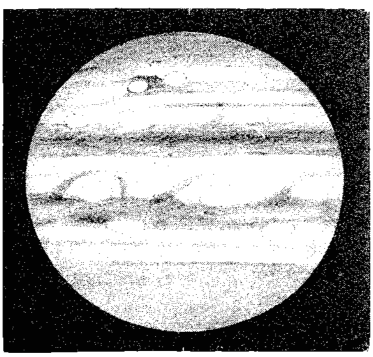

Figure 4. Drawing by Jean Dragesco. 1984 MAR 25, 04h 35m. 35-cm. RL, 244X. CM(I) = 243°; CM(II) = 250°. Note Oval BC, STZ ovals, and STrZ B.

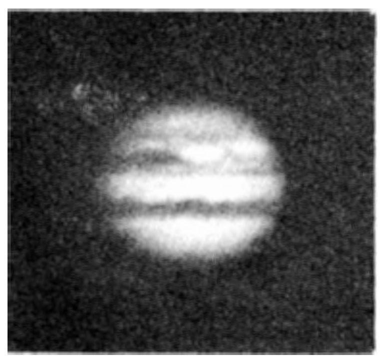

Figure 5. Photograph by Jean Dragesco. 1984 APR 04, 04h 41m U.T. 35-cm. RL. CM(I) = 025°; CM(II) = 316°. Note RSH area and Oval FA (on right).

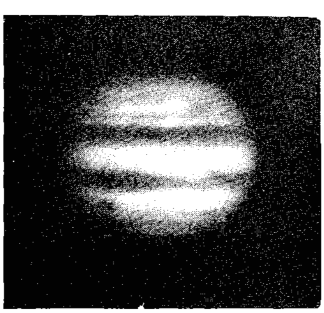

Figure 6. Photograph by Jean Dragesco. 1984 APR 18, 05h 22m. 35-cm. RL. CM(I) = 101°; CM(II) = 285°. Note Oval BC; shadow of Europa near lower left limb.

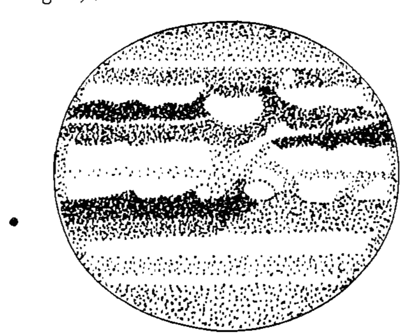

Figure 7. Drawing by Leo Aerts. 1984 MAY 23, 01h 40m U.T. 15-cm. RR, 180X. CM(I) = 095°; CM(II) = 013°. Note RSH and Oval FA.

SELECTED A.L.P.O. JUPITER SECTION DRAWINGS AND PHOTOGRAPH, 1983-85 APPARITION

Note: Views are simply inverted, with south at the top. Times and dates are U.T. "S" gives Seeing on the A.L.P.O. Scale (0 worst and 10 best); "T" is the A.L.P.O. Transparency Scale (0 worst, 5 best). "CM" is the Central Meridian, with the rotation System in parentheses. Telescope types are as in Table 1 (p. 233).

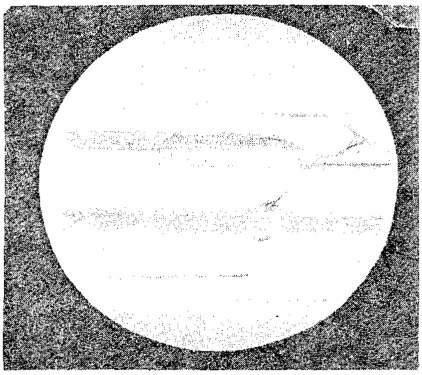

Figure 8. Drawing by Claus Benninghoven. 1984 MAY 24, 06h 49m. 20-cm. RL., 210X. S = 4-6, T = 5. CM(I) = 082°; CM(II) = 351°. Note RSH area and Oval FA in conjunction with following end of RSH.

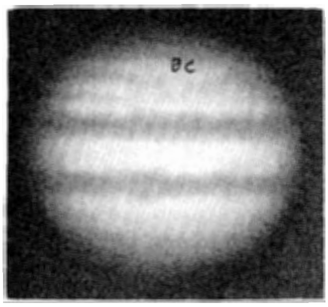

Figure 9. Photograph by Donald Parker. 1984 MAY 30, 07h 30m. 32-cm. RL. TP2415 Film, 3.5 sec. at f/123. No Filter. Developed in H&W & Dektol. S = 8, T = 4. CM(I) = 335°; CM(II) = 198°. Note Oval BC, bright spots south of BC in the STZ, dark spots along the south edge of the SEBs, and the double STB.

Figure 10. Drawing by Isao Miyazaki. 1984 JUN 29, 15h 56m. 20-cm. RL, 316X. S = 9, T = 5. CM(I) = 344°, CM(II) = 336°. Note Oval DE on left limb, Oval FA in conjunction with RSH, the STrZ Belt, and the preceding edge of the STrZ D preceding the central meridian.

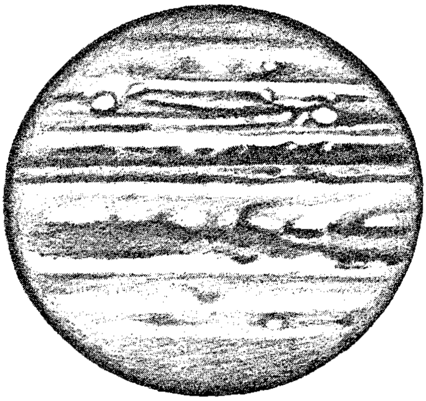

Figure 11. Drawing by Isao Miyazaki. 1984 JUL 01, 14h 34m. 20-cm. RL, 316X. S = 9, T = 4.5. CM(I) = 251°; CM(II) = 227°. Note Oval BC near left limb and Oval DE near right limb.

SELECTED A.L.P.O. JUPITER SECTION DRAWINGS, 1983-85 APPARITION

Note: Views are simply inverted, with south at the top. Times and dates are U.T. "S" gives Seeing on the A.L.P.O. Scale (0 worst and 10 best); "T" is the A.L.P.O. Transparency Scale (0 worst, 5 best). "CM" is the Central Meridian, with the rotation System in parentheses. Telescope types are as in <u>Table 1</u> (p. 233).

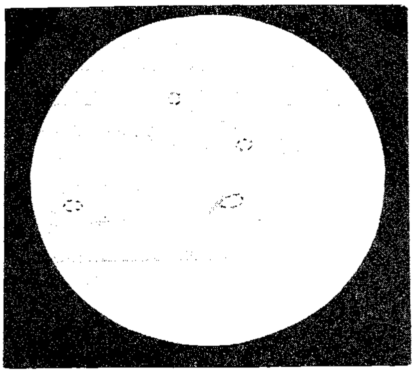

Figure 12. Drawing by Daniel Troiani. 1984 JUL 07, 04h 20m. 25-cm. RL, 283X. S = 3, T = 5. CM(I) = 104°; CM(II) = 038°. Note Oval FA, RSH, and NNTB dark section.

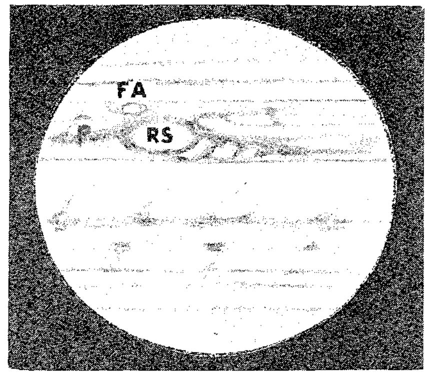

Figure 13. Drawing by Ray Fabre. 1984 JUL 11, 07h 55m. 42-cm. RL, 222X & 310X. S = 9, T = 5. CM(I) = 147°; CM(II) = 050°. Note Oval FA, dark festoon connecting north edge STB with south edge SEBs. This feature later developed into a darker STrZ D. Note also the RSH and the STrZ Belt.

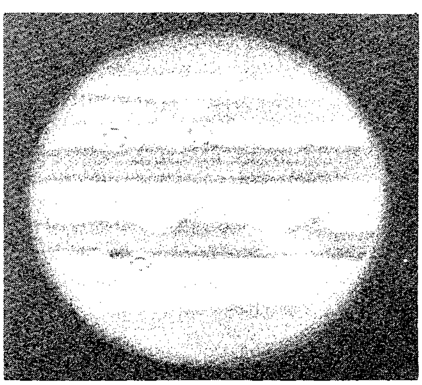

Figure 14. Drawing by Mark Daniels. 1984 JUL 13, 03h 26m. 20-cm. RL, 165X. S = 6, T = 5. CM(I) = 299°; CM(II) = 188°. Note Oval BC.

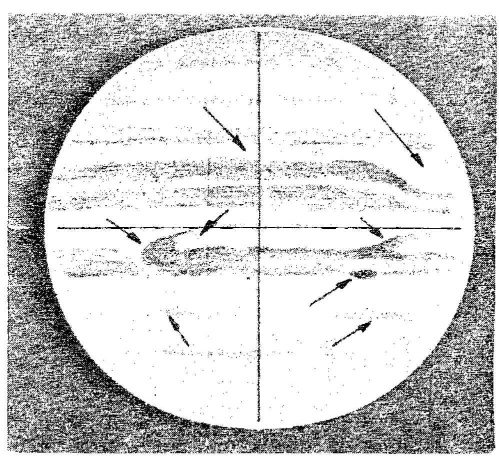

Figure 15. Drawing by Domenec Barbany. 1984 JUL 14, 23h 35m. 7.5-cm. RR, 152X. CM(I) = 115°; CM(II) = 349°. Note STrZ Disturbance and RSH.

SELECTED A.L.P.O. JUPITER SECTION DRAWINGS, 1983-85 APPARITION

Note: Views are simply inverted, with south at the top. Times and dates are U.T. "S" gives Seeing on the A.L.P.O. Scale (0 worst and 10 best); "T" is the A.L.P.O. Transparency Scale (0 worst, 5 best). "CM" is the Central Meridian, with the rotation System in parentheses. Telescope types are as in Table 1 (p. 233).

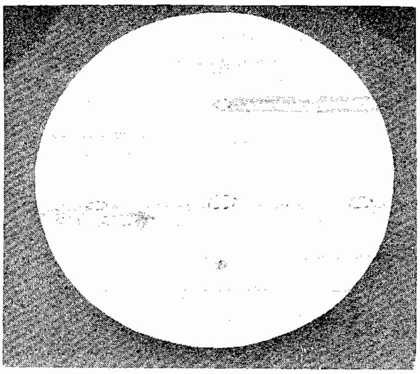

Figure 16. Drawing by Daniel Troiani. 1984 JUL 16, 02h 54m. 37-cm. RL, 330X & 410X. S = 3, T = 5. CM(I) = 034°; CM(II) = 260°. Note Oval DE, double STB, and preceding end of STrZ Disturbance remnant.

Figure 17. Drawing by Isao Miyazaki. 1984 JUL 19, 13h 53m. 20-cm. RL, 316X. S = 7-8, T = 4. CM(I) = 190°; CM(II) = 029°. Note Oval FA, RSH with RS visible within the interior of the Hollow, and the STrZ Disturbance.

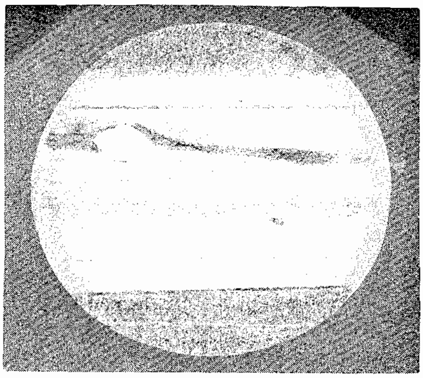

Figure 18. Drawing by Pete Scott. 1984 JUL 29, 02h 40m. 20-cm. RL, 222X. S = 8, T = 3. CM(I) = 279°; CM(II) = 046°. Note double STB, RSH area with partially visible RS, and the STrZ Disturbance preceding the RS.

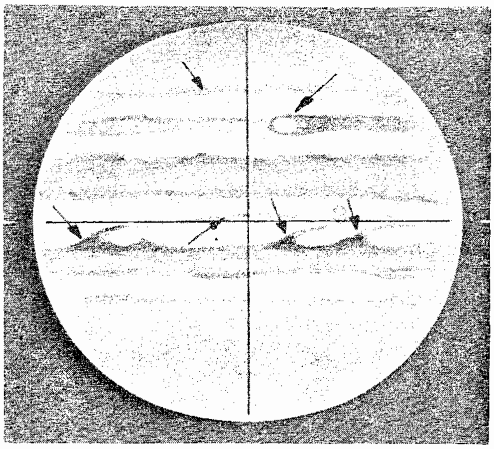

Figure 19. Drawing by Domenec Barbany. 1984 AUG 04, 23h 05m. 7.5-cm. RR, 130X & 152X. CM(I) = 174°; CM(II) = 248°. Note Oval DE.

SELECTED A.L.P.O. JUPITER SECTION DRAWINGS, 1983-85 APPARITION

Note: Views are simply inverted, with south at the top. Times and dates are U.T. "S" gives Seeing on the A.L.P.O. Scale (0 worst and 10 best); "T" is the A.L.P.O. Transparency Scale (0 worst, 5 best). "CM" is the Central Meridian, with the rotation System in parentheses. Telescope types are as in Table 1 (p. 233).

Figure 20. Drawing by Rob Robotham. 1984 AUG 08, 01h 53m. 15-cm. RL, 160X. S = 7-8, T = 2-3. CM(I) = 030°; CM(II) = 081°. Note RS area.

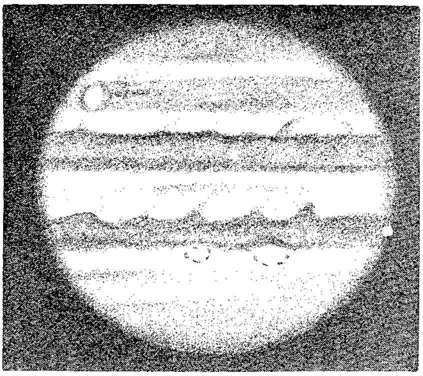

Figure 21. Drawing by Mark Daniels. 1984 AUG 21, 03h 35m. 20-cm. RL, 190X. S = 10, T = 5. CM(I) = 345°; CM(II) = 296°. Note Oval DE, STrZ festoons, preceding end of STrZ Disturbance near right limb, and Io beginning to transit on the right limb.

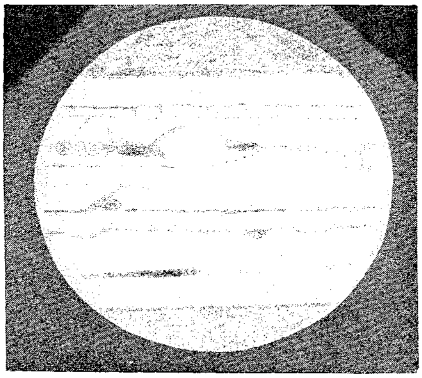

Figure 22. Drawing by Pete Scott. 1984 AUG 27, 01h 10m. 20-cm. RL, 222X. S = 7-8, T = 2.5. CM(I) = 123°; CM(II) = 029°. Note Oval FA, RS area, and STrZ Disturbance.

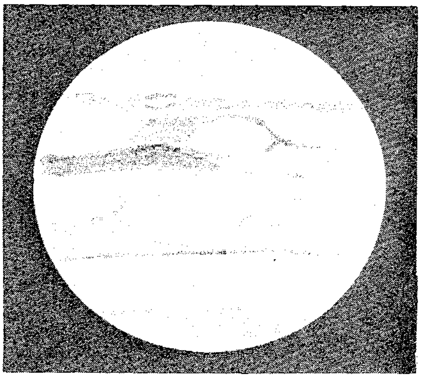

Figure 23. Drawing by Rick Yandrick. 1984 SEP 03, 01h 30m. 20-cm. RL, 200X. S = 8, T = 3. CM(I) = 160°; CM(II) = 013°. Note Oval FA, RS area, and STrZ Disturbance.

Note: Views are simply inverted, with south at the top. Times and dates are U.T. "S" gives Seeing on the A.L.P.O. Scale (0 worst and 10 best); "T" is the A.L.P.O. Transparency Scale (0 worst, 5 best). "CM" is the Central Meridian, with the rotation System in parentheses. Telescope types are as in Table 1 (p. 233).

Figure 24. Drawing by Alika Herring. 1984 SEP 04, 02h 33m. 32-cm. RL, 289X. S = 2-4, T = 5. CM(I) = 356°; CM(II) = 201°. Note belt detail in Southern Hemisphere including a triple STB to the right of the CM.

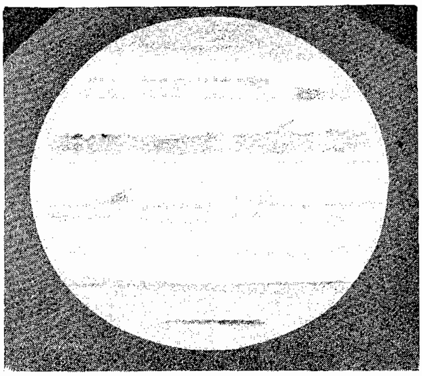

Figure 25. Drawing by Pete Scott. 1984 SEP 07, 00h 45m. 20-cm. RL, 222X. S = 8, T = 4. CM(I) = 044°; CM(II) = 226°. Note Oval DE and preceding end of STrZ Disturbance remnant.

[Text continued from p. 238.]

Table 2. Intensity and Color Estimates, 1983/85 Jupiter Apparition.

Feature	Intensities			Colors
	Morrow	Nowak	Papp	Benninghoven
SPR	5.0	5.9	---	---
SSTZ	5.9	---	---	---
SSTB	4.8	---	---	---
STZ	5.9	---	7.0	---
STB	4.5	5.3	3.5	Grey
STrZ	6.2	---	6.6	White
RSH	6.1	7.0	6.0	White
SEB	3.0	3.8	3.3	Reddish-Brown
EZ	6.9	6.3	7.0	White
EB	5.0	---	---	---
NEB	3.0	4.1	3.0	Red
NTrZ	6.0	---	6.5	White
NTB	4.7	5.4	---	Grey
NTZ	5.6	---	---	White
NNTB	4.8	---	---	---
NNTZ	5.6	---	---	---
NPR	5.1	6.0	---	---

Acknowledgements

I wish to give special thanks for outstanding effort in making observations of Jupiter, for valuable assistance, and for correspondence with this Recorder during the 1983-85 Apparition to the following A.L.P.O. Jupiter Section observers: Isao Miyazaki, Dr. Jean Dragesco, Dr. Donald C. Parker, Claus Benninghoven, Jose Olivarez, Richard Yandrick, Pete Scott, Randy Tatum, and Mark S. Daniels. Also, thanks to all the other observers who contributed and helped make this one of the most-observed Jupiter apparitions in recent years!

GALILEAN SATELLITE ECLIPSE TIMINGS: 1986/87 REPORT

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

Abstract. --The A.L.P.O. Jupiter Section received 396 visual and 21 photoelectric timings of the eclipses of Jupiter's four Galilean Satellites during the 1986/87 Apparition. Using an aperture-residual regression model, the observed times are compared with the eclipse times as predicted by the Sampson and the "E-2" models of satellite motion. All four satellites differed significantly from the Sampson model, with Ganymede continuing to follow its cyclical deviation. None of the Galilean Satellites differed significantly from the E-2 model; including Europa, which had been significantly "slow" for the three previous apparitions.

Introduction

This report covers the tenth jovian apparition studied by the A.L.P.O. Jupiter Section's Galilean Satellite Eclipse Timing Program, which analyzes visual and photoelectric timings of the satellites Io, Europa, Ganymede, and Callisto as they enter and leave Jupiter's shadow. These observed times are then compared with those predicted by two published ephemerides so that we may improve our knowledge of these bodies' orbits, plan space missions such as Galileo, and investigate the effect of tides on Io and Europa. The first ephemeris is that developed by R.A. Sampson in 1910, used for the predictions in the Astronomical Almanac through 1986 [United States Naval Observatory 1985]. The second is called the "E-2" Ephemeris, and was developed by Dr. Jay Lieske of the Jet Propulsion Laboratory [Lieske 1981]. In 1987, the Astronomical Almanac switched over to the E-2 Ephemeris, and hence this is our last report which investigates the Sampson model. Previous reports of our program are listed in the references at the end of this report (p. 257) [Westfall 1983-84, 1986a, 1986b, and 1987].

The 1986/87 Apparition of Jupiter fell between the two successive solar conjunctions of 1986 FEB 18 and 1987 MAR 27, with Jupiter's opposition occurring on 1986 SEP 10, when the planet's declination was 2°2 north. Jupiter's position near the celestial equator meant that it was conveniently high in the sky for observers in both hemispheres. Also, the jovigraphic latitude of the Sun increased from +0°5 to +2°4 during the apparition, causing the series of eclipses of Callisto to end with the partial event of 1987 JAN 06.

Observations

The A.L.P.O. Jupiter Section received 396 visual and 21 photoelectric eclipse timings for the 1986/87 Apparition. This makes the total number received for the ten-apparition period 2937 visual and 29 photoelectric timings. Besides A.L.P.O. members' results, we once again received a significant number of timings from the Royal Astronomical Society of New Zealand and the National Association of Planetary Observers (in Australia). For the first time, we also received many timings from the Agrupacion Astronomica de Sabadell in Spain. The A.L.P.O. members contributed 44 percent of the visual timings (174), the R.A.S.N.Z. and N.A.P.O. jointly supplied 34 percent (136), while the Sabadell members submitted 22 percent (86). All observations are listed in the Appendix on pp. 253-257, with observers and organizations indicated on p. 256.

Table 1 (p. 246) gives summary statistics on the visual timings that were received. It is clear from that table that the inner satellite's eclipses were timed more frequently than the outer, largely explained by the fact that the inner satellites have shorter orbital periods and thus are eclipsed more often. Note also that Callisto was eclipsed during only the first nine months of the apparition. As always, eclipse reappearances were timed more frequently than disappearances, the respective totals being 248 (63 percent) and 148 (37 percent). In the case of Io, and usually in the case of Europa, disappearances must be timed before opposition, often in the morning hours. Thus, there were many more timings after opposition (276 or 70 percent) than before (120 or 30 percent). The first timing made this apparition was on 1986 MAY 02, with Jupiter 56° west of the Sun; the last was on 1987 FEB 14, at elongation 31° east.

Weighted by the number of timings, 20 cm. continues as the most popular instrument aperture. The mean aperture was 18.7 cm., inflated slightly by the several timings made with large telescopes (such as the 100-cm. reflector of Pic du Midi Observatory in France); the median aperture was only 16.2 cm. It is interesting to note that one of the "visual" timings was actually made by watching a video monitor but did not differ significantly from the "truly visual" timings (J. Bourgeois; the reappearance of Europa on 1986 DEC 12). One "timing" was actually a verbal comment that the satellite never completely entered Jupiter's shadow (A. Abbott; the eclipse of Callisto on 1987 JAN 06).

Table 1. Summary Statistics: 1986/87 Galilean Satellite Eclipse Visual Timings.

By Event Type*	
1D	48 Timings
1R	114
1	162
2D	36
2R	83
2	119
3D	39
3R	26
3	65
4D	25
4R	25
4	50
Disappearances	148
Reappearances	248

By Month (with Solar Elongation Range)		
1986 MAY	(056-079° W)	5 Timings
JUN	(080-105° W)	24
JUL	(106-135° W)	36
AUG	(136-168° W)	43
SEP	(168 W-159° E)	49
OCT	(158-126° E)	94
NOV	(125-096° E)	74
DEC	(095-068° E)	44
1987 JAN	(067-043° E)	21
FEB	(043-031° E)	6

By Telescope Aperture cm.	
5	25 Timings
6.0, 6.3	43
8	7
9	6
10.0, 10.2	38
11.0-11.5	11
12	7
13	2
15	41
16	24
20	92
21.0, 21.5	17
25.0, 25.4	34
26	2
30	9
32	1
35.6, 36.0	18
53	14
100	5

* As will be done throughout this report, satellites are numbered as follows: 1 = Io, 2 = Europa, 3 = Ganymede, and 4 = Callisto. D represents eclipse disappearance and R represents reappearance.

Reduction

The "raw" timings are reduced separately for disappearances and for reappearances for each satellite and for each ephemeris. The first step in analysis is to determine the time difference between observation and prediction; a positive residual indicates that an event was "late;" a negative one, that it was "early." In each case, it is assumed that telescope aperture is the only factor causing timings to differ. A linear regression model is then applied, with the independent variable being the reciprocal of telescope aperture in centimeters and the dependent variable being the residual in seconds of time. As a check of this method, the diameter of each satellite is estimated from the difference between its disappearance and reappearance residuals, indicating the time it takes Jupiter's shadow edge to cross the disk of the satellite, as corrected for the angle at which the satellite enters and leaves the shadow.

This method is explained in detail in our 1975-82 report [Westfall 1983-84]; and the criteria for rejecting timings are described in the 1985/86 Apparition report [Westfall 1987]. In the 1986/87 apparition, 25 timings were dropped from the Sampson Ephemeris analysis (6.8 percent), while 34 were excluded from the E-2 Ephemeris analysis (8.6 percent). Timings thus excluded are indicated by asterisks in the residuals column in the Appendix.

1986/87 Results

Figure 26 (p. 248) graphs the results of the timing reductions for all ten apparitions from 1976/77 to 1986/87, and the 1986/87 results are detailed in Table 2 (p. 249) for the Sampson Ephemeris and in Table 3 (p. 251) for the E-2 Ephemeris. Note that the Sampson predictions were given to only 1-minute precision, as opposed to 1 second for the E-2 predictions; hence, the standard errors of quantities tend to be larger for the Sampson analyses.

Each table describes results for each Galilean Satellite in a separate column. Going down the rows of the two tables, the first set of items is for eclipse disappearances and the second set is for reappearances. In each case, the number of timings received is given first, followed in parentheses by the number used in the regression analysis. The next item is the coefficient of determination ("R-squared"), which describes the proportion of the variance of the timings that is explained by the aperture-regression model. Third, the two regression coefficients are given with their 1-standard error uncertainty ranges; all such uncertainty ranges are preceded by the " ± " symbol. Finally, the standard error of estimate for the regression model is given, followed by the predicted time residuals for three commonly used apertures.

The disappearance and reappearance data are combined to give the "orbital residuals;" how far "ahead" (negative) or "behind" (positive) its predicted position the satellite was observed to be. This value, and its 1-standard error uncertainty range, is given in units of seconds of time, degrees of orbital arc, and kilometers.

The results of the satellite diameter check described above are given at the bottom of the two tables, where the satellite diameters are given in seconds of time and in kilometers, the latter both uncorrected ("Prelim.") and corrected ("Corr.") for the angle of entrance into or out of Jupiter's shadow. The corrected value is then compared with the "standard" Voyager-derived satellite diameter; Io, 3640 km.; Europa, 3066 km.; Ganymede, 5216 km.; and Callisto, 4890 km.

Table 2 and Table 3 indicate the statistical significance of the differences of the following values from 0: the coefficient of determination ("R-squared"), the orbital residual in seconds of time, and the difference between the observed and standard satellite diameters. Statistical significance is shown by "-" for not significant, "*" for significance at the 5-percent level, and "**" for significance at the 1-percent level.

Sampson Ephemeris. --As is shown in Table 2 (p. 249), between 18 and 70 percent of the variance among the individual timings was removed by using the aperture-regression model, which was statistically significant in all eight cases. As in previous apparitions, the uncertainties of the regression coefficients increase with distance of the satellite from Jupiter. This effect is probably due to progressively slower satellite motions and wider shadow penumbrae as one moves outward from Jupiter. For all satellites except Ganymede, the absolute values of the B-coefficients (the "aperture effect") were greater for reappearances than for disappearances. This difference was significant only for Io.

The residuals from the Sampson model are graphed in Figure 26 (p. 248) and are given in Table 2 (p. 249). They show that the Sampson predictions are significantly in error for all four satellites. The absolute amounts of error in 1986/87, as compared with 1985/86, increased for all four satellites, with the increases significant for Io and Europa.

Over the 1976/77-1986/87 period, the orbital residuals for Io, Europa, and Callisto showed no clear time trend. The ten-apparition mean residual for Io was -102.5 ± 3.1 seconds and that for Europa was -71.0 ± 8.7 seconds. Only six apparitions were observed for Callisto's eclipses, giving a mean residual of -170.7 ± 26.5 seconds. Once again, Ganymede was a special case, with the following pattern of orbital residuals:

	s s		s s		s s
1976/77. .	-141.0 ± 14.4	1980/81. .	+35.0 ± 19.8	1985/86. .	-43.7 ± 16.6
1977/78. .	-113.8 ± 10.2	1981/82. .	+58.4 ± 21.1	1986/87. .	-75.2 ± 10.6
1978/79. .	- 31.2 ± 10.1	1982/83. .	+48.0 ± 20.0		
1979/80. .	+ 95.5 ± 23.5	1983/85. .	+19.4 ± 11.0		

[Text continued on p. 250.]

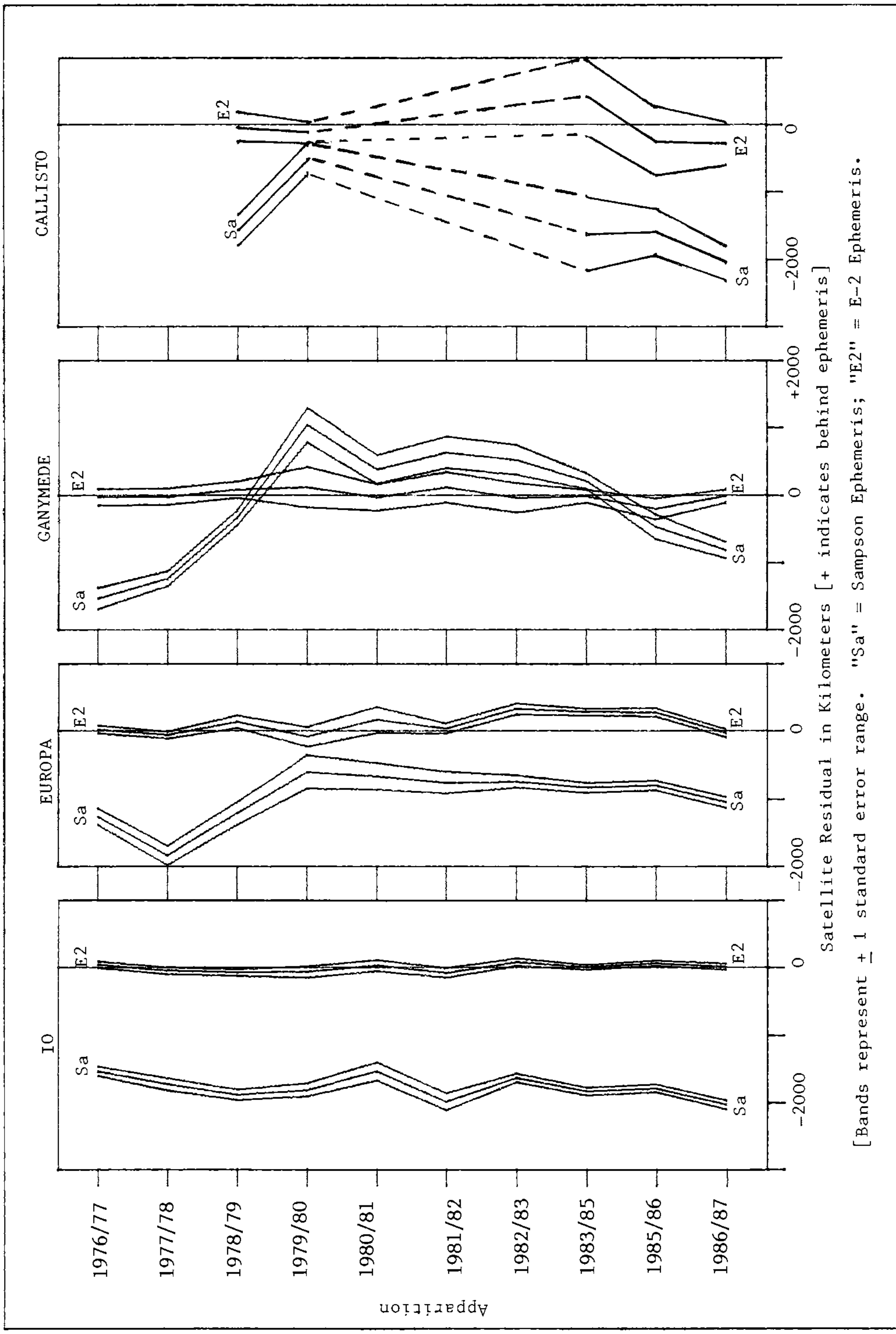

Figure 26. Graphs of orbital residuals for the Galilean Satellites for the 1976/77 through the 1986/87 Apparitions, showing deviations in kilometers from the Sampson ("Sa") and the E-2 ("E2") Ephemerides. The bands represent ± 1 standard error ranges. Note that Callisto did not undergo eclipses during the 1980/81, 1981/82, and 1982/83 Apparitions. See also text.

Table 2. Galilean Satellites Compared With Sampson Ephemeris, 1986/87.*

Satellite . .	Io	Europa	Ganymede	Callisto
Disappearance–				
Number of Observations	48 (46)	36 (33)	35 (35)	24 (21)
Coefficients:				
R-squared	.271**	.172*	.360**	.632**
A (seconds)	- 5.2 ± 6.0	+ 25.7 ± 9.3	+213.0 ± 13.3	+ 366.6 ± 39.3
B	-227 ± 56	-205 ± 81	-572 ± 132	-2234 ± 391
Standard Error (Sec.)	± 22.1	± 28.7	± 43.1	± 95.5
Aperture Residual (Sec.):				
6 cm.	-43 ± 5	- 9 ± 8	+118 ± 13	- 6 ± 38
10 cm.	-28 ± 3	+ 5 ± 5	+156 ± 8	+143 ± 22
20 cm.	-17 ± 4	+15 ± 6	+184 ± 9	+255 ± 25
Reappearance––				
Number of Observations	105 (95)	74 (68)	24 (24)	23 (22)
Coefficients:				
R-squared	.411**	.241**	.268**	.697**
A (seconds)	-229.6 ± 4.6	-179.4 ± 7.5	-363.5 ± 16.7	- 868.0 ± 51.8
B	+409 ± 51	+408 ± 89	+501 ± 177	+3410 ± 503
Standard Error (Sec.)	± 24.3	± 32.4	± 46.6	± 135.7
Aperture Residual (Sec.):				
6 cm.	-161 ± 5	-111 ± 9	-280 ± 18	-300 ± 50
10 cm.	-189 ± 3	-139 ± 5	-313 ± 10	-527 ± 30
20 cm.	-209 ± 3	-159 ± 4	-338 ± 11	-698 ± 34
Orbital Residual ------				
Seconds	-117.4 ± 3.8**	- 76.9 ± 6.0**	- 75.2 ± 10.6**	-250.6 ± 32.5**
Orbital Arc	-0°.276 ± °.009	-0°.090 ± °.007	-0°.044 ± °.006	-0°.063 ± °.008
Kilometers	- 2034 ± 66	- 1056 ± 82	- 818 ± 116	-2058 ± 267
Diameter ------				
Seconds	224.6 ± 7.6	205.1 ± 12.0	576.5 ± 21.3	1234.6 ± 65.0
km.(Prelim.)	3887 ± 131	2817 ± 165	6270 ± 232	10141 ± 534
km.(Corr.)	3833 ± 129	2708 ± 158	5786 ± 214	6526 ± 344
Comp. with Standard	+193 (+5.3%)-	-358 (-11.7%)*	+570 (+10.9%)**	+1636(+33.5%)**

* Note that the data in the above table are restricted to the year 1986.

[Text continued from p. 247.]

The Observed-Sampson residuals for Ganymede are graphed against time in Figure 27 below. For the entire period, excluding the deviant value for 1979/80, the best sinusoidal fit to the residuals is given by the equation:

$$\text{Residual} = -61.5\ \text{sec.} + 117.7\ \text{sec.}[\sin(26.2^{\circ}T - 44.6^{\circ})],$$

where T = the number of apparitions since that of 1976/77. This model gives a very good fit (R-squared = 0.982**). The equation above is plotted in Figure 27. The time agrument, 26.2 degrees per apparition, implies that the residual is cylical with a period of 13.74 jovian apparitions or 15.01 Earth years.

Only for Io did the computed satellite diameter approximately agree with the Voyager value. The diameter difference was quite large for Callisto, but here the widely varying angle of entrance into or exit from Jupiter's shadow made the diameter correction very approximate.

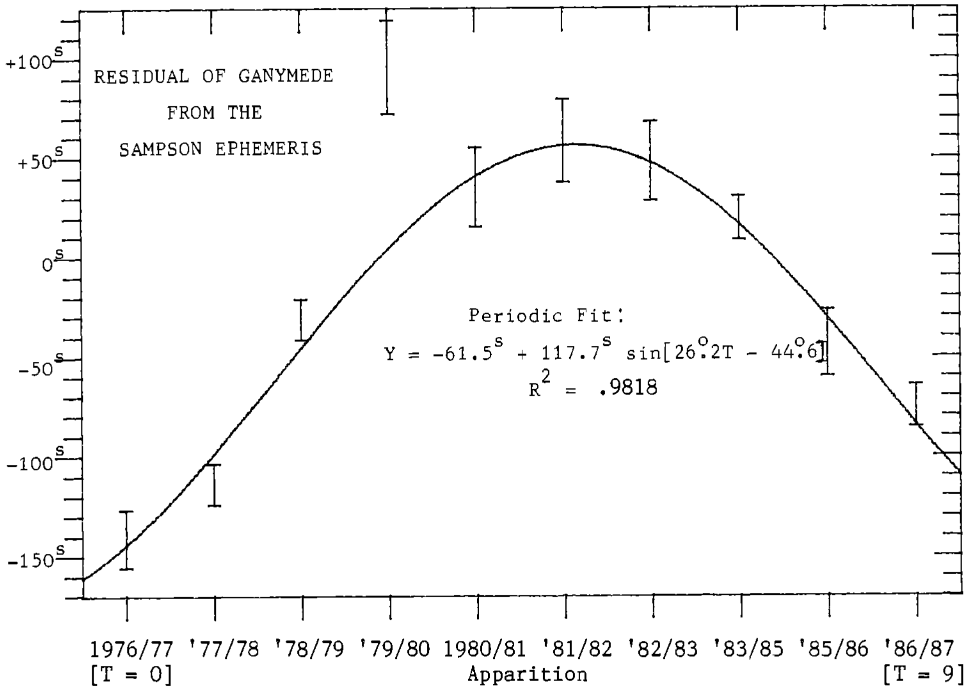

Figure 27. Residual of the satellite Ganymede from the Sampson Ephemeris from the 1976/77 through the 1986/87 Apparitions. Vertical bars represent observed residuals with ± 1 standard error ranges. The curve represents a sinusoidal fit to the residuals, with its equation and coefficient of determination given. See also the text above.

E-2 Ephemeris. --As shown in Table 3 (p. 251), the residual-aperture model removed between 31 and 59 percent of the variance of the timings. The pattern of error with distance from Jupiter was similar to that for the Sampson Ephemeris analysis above. For no satellite was there a significant difference between the absolute B-values for disappearance and reappearance.

There was no significant difference between the timing results and the E-2 Ephemeris for any of the Galilean Satellites. In particular, Europa was back in place after having been significantly behind the E-2 Ephemeris for the last three apparitions (1982/83, 1983/85, and 1985/86). This orbital difference was about 300 kilometers, and the reason it has gone away is unknown.

Note that although the timing-derived diameters for Io and Europa agreed fairly well with the Voyager-derived values, the outer two satellites' diameters differed significantly. The highly oblique angle of shadow entrance and exit for Callisto, mentioned in the Sampson analysis, probably explains the large discrepancy for that satellite. [Text continued on p. 252.]

Table 3. Galilean Satellites Compared With E-2 Ephemeris, 1986/87.

Satellite . .	Io	Europa	Ganymede	Callisto
Disappearance-				
Number of Observations	48 (42)	36 (34)	39 (37)	25 (22)
Coefficients:				
R-squared	.567**	.406**	.458**	.528**
A (seconds)	+100.5 ± 3.4	+117.5 ± 6.0	+289.3 ± 11.2	+ 682.3 ± 48.5
B	-224 ± 31	-248 ± 53	-630 ± 116	-2284 ± 483
Standard Error (Sec.)	± 11.9	± 19.0	± 36.9	± 118.2
Aperture Residual (Sec.):				
6 cm.	+63 ± 3	+ 76 ± 5	+184 ± 12	+302 ± 46
10 cm.	+78 ± 2	+ 93 ± 3	+226 ± 6	+454 ± 26
20 cm.	+89 ± 2	+105 ± 4	+258 ± 7	+568 ± 31
Reappearance--				
Number of Observations	114 (104)	83 (73)	26 (26)	25 (24)
Coefficients:				
R-squared	.307**	.324**	.350**	.592**
A (seconds)	- 99.3 ± 3.9	-123.3 ± 6.0	-291.6 ± 14.0	- 751.7 ± 58.1
B	+292 ± 43	+411 ± 71	+549 ± 153	+3287 ± 582
Standard Error (Sec.)	± 20.7	± 25.4	± 40.5	± 159.7
Aperture Residual (Sec.):				
6 cm.	-51 ± 4	- 55 ± 7	-200 ± 16	-204 ± 59
10 cm.	-70 ± 2	- 82 ± 3	-237 ± 9	-423 ± 34
20 cm.	-85 ± 2	-103 ± 3	-264 ± 9	-587 ± 38
Orbital Residual				
Seconds	+ 0.6 ± 2.6-	- 2.9 ± 4.3-	- 1.2 ± 9.0-	- 34.7 ± 37.8-
Orbital Arc	+0°.001 ± °.006	-0°.003 ± °.005	-0°.001 ± °.005	-0°.009 ± °.009
Kilometers	+ 11 ± 45	- 40 ± 58	- 13 ± 98	- 285 ± 311
Diameter				
Seconds	199.8 ± 5.2	240.8 ± 8.5	580.9 ± 18.0	1434.0 ± 75.7
km.(Prelim.)	3461 ± 90	3308 ± 117	6319 ± 195	11779 ± 622
km.(Corr.)	3400 ± 88	3175 ± 112	5800 ± 179	7416 ± 391
Comp. with Standard	-240 (-6.6%)**	+109 (+3.6%)-	+584 (+11.2%)**	+2526(+51.7%)**

Photoelectric Timings

Photoelectric timings of Galilean Satellite eclipses are used to determine the moment when the satellite is at one-half its uneclipsed brightness, using a series of brightness readings taken at frequent intervals throughout eclipse disappearance or reappearance [Westfall 1985]. This method is becoming more popular; and five observers contributed 21 such timings, which are summarized in Table 4 below. The timings by Casas, Gomez, Langhans, and Westfall were reduced by fitting a linear regression line to the observed brightnesses and times. For those observers, the " ± " uncertainties represent one standard error, but are estimates for Gonzalez. Note also that, for the two events of 1986 OCT 14, the differences between the observers considerably exceed the statistical uncertainties. The statistical significance of the orbital residuals is symbolized as in Table 2 and Table 3.

Table 4. Galilean Satellite Eclipse Photoelectric Timings: 1986/87.

Event Type	U.T. Date	Observer(s)	Universal Time of Half Brightness (h m s ± s)	Residual from E-2 Ephemeris
1D	1986 JUL 04	Langhans	11 36 45.5 ± 0.9	- 0 ± 1-
1D	JUL 13	Langhans	07 59 12.8 ± 0.9	- 5 ± 1**
1D	JUL 20	Langhans	09 53 22.2 ± 0.8	- 2 ± 1*
1R	NOV 30	Langhans	06 00 29.3 ± 1.0	+ 6 ± 1**
2D	1986 JUN 21	Langhans	11 25 40.7 ± 0.9	- 2 ± 1*
2R	SEP 29	Gonzalez	02 43 19 ± 6	+ 17 ± 6**
2R	OCT 13	Westfall	08 01 03.9 ± 4.4	+ 96 ± 4**
2R	OCT 31	Gonzalez	02 35 28 ± 10	0 ± 10-
2R	1987 JAN 13	Gomez	18 20 41.0 ± 2.6	- 75 ± 3**
3D	1986 JUL 06	Langhans	09 20 02.8 ± 0.9	+ 8 ± 1**
3D	AUG 18	Langhans	09 24 23.8 ± 0.9	- 14 ± 1**
3D	1987 JAN 08	Casas & Gomez	18 04 34.7 ± 2.1	+ 22 ± 2**
3R	1986 SEP 23	Gonzalez	08 52 01 ± 10	+ 4 ± 10-
3R	DEC 11	Langhans	05 05 12.3 ± 0.9	- 27 ± 1**
3R	" "	Westfall	05 05 15.3 ± 3.8	- 24 ± 4**
4D	1986 OCT 14	Westfall	05 50 41.4 ± 56.0	-121 ± 56*
4D	" "	Gonzalez	05 52 00 ± 10	- 41 ± 10**
4R	OCT 14	Westfall	08 39 10.9 ± 34.7	-217 ± 35**
4R	" "	Gonzalez	08 42 09 ± 15	- 40 ± 15**
4R	" "	Langhans	08 43 20.9 ± 1.1	+ 32 ± 1**
4R	OCT 31	Gonzalez	02 49 23 ± 10	- 59 ± 10**

Unweighted Means:		
	Satellite 1 = + 3.1 ± 2.4- (s)	Satellite 2 = + 7.2 ± 27.3- (s)
	Satellite 3 = + 5.2 ± 8.0-	Satellite 4 = -74.3 ± 30.3*

The photoelectric measurements are compared with only the E-2 Ephemeris because the 1-minute precision of the Sampson predictions is not sufficient to analyze a small number of observations. Most of the photoelectric results differ significantly from the E-2 predictions, but they show considerable scatter. The means of the photoelectric results do not differ significantly from the predictions nor from the visual determinations for Io, Europa, and Ganymede. The photoelectric results for Callisto differ significantly from the E-2 Ephemeris, although not from the visual results. This might indicate that Callisto truly was slightly "ahead" of its predicted position. On the other hand, if the rather discordant Westfall photometry is not used, the photoelectric mean for Callisto is -27.0 ± 20.1 seconds, not significantly different from the E-2 ephemeris and very similar to the visual result. Although the photoelectric method is obviously subject to errors itself, it does appear to be more accurate than the visual approach (allowing comparable uncertainties with fewer observations) and also provides independent results.
[Conclusion of text on p. 257.]

APPENDIX: Galilean Satellite Eclipse Timings, 1986/87 Apparition.

Event Type	& U.T.Date yymmdd	Ob. No.	Con.	Obser. U.T. hhmmss	Residual Samp/E-2 s s	Geometry r +o
1D	860517	26b	000	164803	+ 3/+ 93	1.1/ 7
1D	860524	24	021	184123	- 37/+ 41	1.1/ 7
1D	860602	26a	000	150430	- 30/+ 64	1.1/ 7
1D	860609	24	000	165823	- 37/+ 51	1.2/ 7
1D	860616	26b	000	185308	+ 8/+ 91	1.2/ 7
1D	860618	26b	100	132128	- 32/+ 82	1.2/ 7
1D	860622	21	212	021826	- 34/+ 78	1.2/ 7
		33a	010	021829	- 31/+ 81	
1D	860627	11b	111	094423	+ 23/+ 99	1.1/ 8
1D	860709	24	010	190318	- 42/+ 61	1.1/ 8
1D	860711	24	000	133157	- 63/+ 66	1.0/ 8
		22	000	133228	- 32/+ 97	
1D	860715	33a	100	022912	- 48/+ 80	1.0/ 8
		21	201	022914	- 46/+ 82	
		3	210	022920	- 40/+ 88	
1D	860718	22	000	152646	- 14/+110	1.0/ 8
1D	860720	12	100	095500	0/+ 95	1.0/ 8
1D	860723	3	111	225114	- 46/+ 47*	0.9/ 8
1D	860727	17b	100	114837	- 23/+ 65	0.9/ 8
		26b	100	114858	- 2/+ 86	
		27	000	114909	+ 9/+ 97	
		17d	200	114918	+ 18/+106	
1D	860731	21	100	004553	- 7/+ 77	0.8/ 8
1D	860803	28	000	134352	+ 52*+130*	0.8/ 8
1D	860805	2	000	081112	- 48/+ 56	0.7/ 9
1D	860807	2	000	023946	- 74/+ 59	0.7/ 9
		33a	000	023958	- 62/+ 71	
		21	000	024005	- 55/+ 78	
1D	860810	24	100	153659	- 61/+ 64	0.6/ 9
1D	860815	33a	000	230250	- 10/+ 71	0.6/ 9
		3	221	230305	+ 5/+ 86	
1D	860819	22	001	120029	- 31/+101	0.5/ 9
1D	860821	7c	000	062909	+ 9/+107	0.4/ 9
1D	860823	14	001	005731	- 29/+ 91	0.4/ 9
1D	860824	24	100	192508	- 52/+ 34	0.4/ 9
1D	860826	28	000	135403	- 57/+ 52*	0.3/ 9
		25a	110	135441	- 19/+ 90	
1D	860831	41	---	212010	- 50/+ 69	0.2/ 9
1D	860904	12	000	101751	- 9/+ 95	0.1/ 9
		22	110	101751	- 9/+ 95	
1D	860906	12	221	044600	- 60/+ 64	0.1/ 9
		11b	001	044710	+ 10/+134*	
1D	860907	33a	200	231332	- 88*- 1*	0.1/ 9
		3	000	231415	- 45/+ 42*	
		36	120	231432	- 28/+ 59	
		34b	200	231500	0/+ 87	
		44	000	231501	+ 1/+ 88	
		42c	000	231505	+ 5/+ 92	
1R	860911	25a	010	142526	- 94*/- 62	0.0/ 9
1R	860915	11b	011	032208	-232/- 97	0.1/ 9
		6	000	032301	-179/- 44	
1R	860916	33a	121	215148	-132*- 36	0.1/ 9
1R	860922	9	111	051613	-227/-129	0.3/10
		11b	001	051635	-205/-107	
		12	000	051646	-194/- 96	
1R	860925	19b	000	181439	-201/- 63	0.3/10
		21	200	181457	-183/- 45	
1R	860927	26b	110	124300	-180/- 85	0.4/10
		19a	000	124330	-150/- 55	
		25a	020	124401	-119*- 24*	
1R	860929	9	110	071016	-284*-170*	0.4/10
		17c	000	071127	-213/- 99	
		17a	000	071224	-156/- 42	

Event Type	& U.T.Date yymmdd	Ob. No.	Con.	Obser. U.T. hhmmss	Residual Samp/E-2 s s	Geometry r +o
1R	861001	7b	000	014008	-232/- 99	0.4/10
		38	000	014105	-175/- 42	
1R	861004	19a	000	143735	-205/- 97	0.5/10
		18	000	143746	-194/- 86	
1R	861006	9	010	090528	-272/-147*	0.5/10
		12	000	090612	-228/-103	
		27	000	090618	-222/- 97	
		24	000	090755	-125/ 0	
1R	861008	12	100	033514	-226/- 84	0.6/10
		2	020	033659	-121/+ 21*	
1R	861009	32	001	220354	-186/- 87	0.6/10
		21	000	220355	-185/- 86	
		30	01-	220438	-142/- 43	
		39	---	220447	-133/- 34	
1R	861011	19b	000	163246	-194 - 80	0.6/10
1R	861013	27	010	110109	-231/-101	0.7/10
		26b	020	110110	-230/-100	
1R	861015	7c	000	052954	-246/-101	0.7/10
1R	861017	6	000	235912#	-168/- 67	0.7/10
1R	861018	32	102	182741	-199/- 84	0.7/10
1R	861020	25a	001	125602	-238/-109	0.8/10
1R	861025	42b	200	202243	-197/- 86	0.9/10
		37	110	202245	-195/- 84	
		32	111	202254	-186/- 75	
		40	010	202300	-180/- 69	
		39	---	202304	-176/- 65	
1R	861029	23b	000	092032	-208/- 71	0.9/10
		24	000	092053	-187/- 50	
1R	861031	9	110	034805	-235/-144	0.9/11
		7c	000	034837	-203/-112	
		7b	000	034846	-194/-103	
		17c	100	034856	-184/- 93	
		8	110	034857	-183/- 92	
		7a	000	035036	- 84*+ 7*	
1R	861105	18	001	111512	-228/-101	1.0/11
		19b	000	111525	-215/- 88	
		25a	112	111529	-211/- 84	
		24	000	111548	-192/- 65	
		23a	000	111601	-179/- 52	
		20	000	111706	-114*+ 13*	
1R	861107	9	210	054329	-271/-131	1.0/11
		7c	000	054406	-234/- 94	
		17c	200	054413	-227/- 87	
		8	110	054417	-223/- 83	
		7b	000	054432	-208/- 68	
		17a	100	054459	-181/- 41	
1R	861109	14	111	001308	-172/- 82	1.0/11
		6	000	001319	-161/- 71	
1R	861110	1	01-	184041	-259/-158*	1.0/11
		21	000	184144	-196/- 95	
		33a	000	184144	-196/- 95	
		38	001	184210	-170/- 69	
		30	021	184247	-133/- 32	
1R	861112	26b	200	131029	-211/- 98	1.0/11
1R	861114	20	002	073959	-181/- 56	1.0/11
1R	861116	9	011	020704	-296*-161*	1.1/11
		4	111	020842	-198/- 63	
1R	861117	38	001	203720	-220*- 75	1.1/11
		16	110	203732	-208/- 63	
1R	861121	25a	001	093425	-215/-108	1.1/11
		23a	000	093443	-197/- 90	
		20	000	093548	-132*- 25	

Event Type	& U.T.Date yymmdd	Ob. No.	Con.	Obser. U.T. hhmmss	Residual Samp/E-2 s s	Geometry r to
1R	861123	9	110	040228	-272/-155*	1.1/11
		7c	100	040317	-223/-106	
		8	11-	040340	-200/- 83	
1R	861124	32	201	223233	-207/- 81	1.1/11
		42a	---	223233	-207/- 81	
		30	22-	223255	-185/- 59	
1R	861126	16	111	170155	-185/- 48	1.1/11
1R	861128	26b	200	113003	-237/- 90	1.1/11
		25c	010	113010	-230/- 83	
		19b	000	113013	-227/- 80	
1R	861130	17c	200	055854	-186/- 89	1.1/11
		17b	100	055914	-166/- 69	
1R	861203	21	000	185628	-212/- 96	1.1/11
		15	100	185637	-203/- 87	
		30	21-	185644	-196/- 80	
		16	010	185654	-186/- 70	
		33a	101	185708	-172/- 56	
1R	861207	23a	000	075830	+ 30*+166*	1.1/11
1R	861209	12	000	022304	-236/- 92	1.1/11
1R	861210	1	00-	205125	-215/-121	1.1/11
		40	011	205205	-175/- 81	
1R	861214	26b	210	094933	-207/- 94	1.1/12
		19b	000	094938	-202/- 89	
		23a	---	095007	-173/- 60	
1R	861219	16	010	171626	-214/- 74	1.1/12
1R	861221	24	110	114611	-109/- 19	1.1/12
1R	861226	33a	100	191148	-192/- 75	1.1/12
		30	11-	191222	-158/- 41	
1R	870101	8	11-	023832	----/- 63	1.0/12
1R	870102	33a	210	210743	----/- 42	1.0/12
1R	870106	25a	002	100438	----/- 89	1.0/12
		27	210	100506	----/- 61	
1R	870108	17c	100	043335	----/- 82	1.0/12
		17b	000	043401	----/- 56	
1R	870111	16	112	173152	----/- 44	0.9/12
1R	870118	33a	110	192648	----/- 69	0.9/12
1R	870129	25a	201	101945	----/- 70	0.8/13
2D	860502	26b	200	172612	+ 12/+103	1.5/ 8
2D	860603	24	100	170004	- 56/+ 58	1.8/10
		26a	000	170022	- 38/+ 76	
2D	860610	24	000	193445	- 15/+ 66	1.9/10
2D	860614	11b	110	085300	+ 60/+121	1.9/10
2D	860621	17a	000	112650	- 10/+ 66	1.8/11
		17c	100	112736	+ 36/+112	
2D	860625	33a	111	004351	- 69*+ 42*	1.8/11
2D	860628	24	000	140135	- 25/+ 54	1.8/11
		28	000	140206	+ 6/+ 85	
		22	121	140217	+ 17/+ 96	
2D	860705	24	000	163702	+ 2/+ 75	1.7/11
		22	000	163735	+ 35/+108	
2D	860709	11b	201	055518	+ 18/+118	1.7/12
2D	860712	24	000	191225	+ 25/+ 81	1.7/12
		22	000	191323	+ 83*+139	
2D	860723	12	000	110622	+ 22/+121	1.5/12
2D	860727	33a	101	002329	- 31/+ 68	1.4/13
		3	111	002414	+ 14/+113	
2D	860730	18	100	134216	+ 16/+124	1.3/13
2D	860803	2	000	025915	- 45/+ 52	1.2/13
		4	010	025937	- 23/+ 74	
		33a	000	025952	- 8/+ 89	
		31	210	030002	+ 2/+ 99	
		3	110	030010	+ 10/+107	
		21	000	030014	+ 14/+111	

Event Type	& U.T.Date yymmdd	Ob. No.	Con.	Obser. U.T. hhmmss	Residual Samp/E-2 s s	Geometry r to
2D	860806	26b	010	161725	- 35/+ 67	1.2/13
2D	860810	4	010	053612	+ 12/+ 94	1.1/13
2D	860820	33a	101	213028	- 32/+ 69	0.7/14
		3	221	213105	+ 5/+106	
2D	860824	24	100	104906	+ 6/+ 68	0.6/14
		17b	100	104942	+ 42/+104	
		17d	200	105010	+ 70/+132	
2D	860831	28	000	132448	- 72*- 15*	0.4/15
		22	000	132708	+ 68/+125	
2D	860904	11b	221	024514	+ 14/+108	0.2/15
2R	860911	12	102	080711	-109/- 72	0.0/16
		11b	100	080718	-102/- 65	
		17c	120	080742	- 78*- 41*	
		17a	020	081125	+145*+182*	
2R	860914	29	110	212636	- 84/- 51	0.1/16
		34a	110	212710	- 50*- 17*	
2R	860922	14	001	000330	-150/- 99	0.4/17
2R	860925	25a	100	132155	-185/-105	0.5/17
		19b	000	132206	-174/- 94	
		18	000	132209	-171/- 91	
2R	860929	17c	201	024010	-230/-172*	0.6/17
		9	211	024047	-193/-135	
		7c	000	024115	-165/-107	
		17a	101	024210	-110/- 52	
2R	861006	9	110	051826	-214/-163	0.9/17
		11b	100	051906	-174/-123	
		12	000	051913	-167/-116	
2R	861009	40	111	183800	-180/-113	1.0/18
		21	000	183812	-168/-101	
		32	001	183822	-158/- 91	
		34b	020	183902	-118/- 51	
2R	861013	9	111	075635	-205/-173	1.1/18
		12	000	075734	-146/-114	
2R	861016	32	212	211641	-139/- 94	1.2/18
2R	861020	25a	000	103559	-181/-117	1.2/18
		28	000	103632	-148/- 84	
2R	861023	42c	120	235453	-187/-115	1.3/18
		32	201	235521	-159/ -87	
		39	---	235601	-119/- 47	
		37	220	235617	-103/ -31*	
2R	861027	25a	100	131428	-212/-126	1.4/18
2R	861031	7c	010	023310	-170/-138	1.5/19
		7b	010	023339	-141/-109	
		8	110	023343	-137/-105	
		6	000	023407	-113/- 81	
		2	110	023423	- 97/- 65	
		7a	010	023625	+ 25*+ 57*	
2R	861107	9	210	051120	-220/-173	1.6/19
		7c	000	051152	-188/-141	
		11b	101	051213	-167/-120	
		7b	000	051224	-156/-109	
		8	10-	051237	-143/- 96	
		17c	200	051241	-139/- 92	
		7a	000	051252	-128/- 81	
2R	861110	1	10-	183100	-240/-187*	1.6/19
		21	000	183225	-155/-102	
		30	011	183231	-149/- 96	
		33a	000	183236	-144/- 91	
		38	001	183307	-113/- 60	
		39	---	183315	-105/- 52	
2R	861114	20	001	075227	- 93/- 37	1.7/19
2R	861117	38	001	211205	-115/- 52	1.7/20

Event Type	& U.T.Date	Ob. No.	Con.	Obser. U.T.	Residual Samp/E-2	Geometry
	yymmdd			hhmmss	s s	r +o
2R	861121	25a	000	103002	-178/-113	1.7/20
		23a	000	103059	-121/- 56	
		27	100	103442	+102*+167*	
2R	861128	19b	000	130900	-180/-110	1.8/20
2R	861202	11b	210	022849	-191/-111	1.8/20
2R	861205	21	001	154758	-182/-101	1.8/20
2R	861209	12	010	050748	-132/-100	1.8/21
2R	861212	1	100	182630	-150/-117	1.8/21
		32	102	182642	-138/-105	
		33b	100	182645	-135/-102	
		40	011	182652	-128/- 95	
		30	001	182656	-124/- 91	
		43	100	182702	-118/- 85	
		42a	---	182714	-106/- 73	
2R	861219	32	212	210522	-158/-107	1.7/21
		30	11-	210610	-110/- 59	
		39	---	210701	- 59/- 8	
2R	861223	23b	020	102343	-257*-189*	1.7/21
		18	102	102508	-172/-104	
		19b	000	102511	-169/-101	
		24	100	102608	-112/- 44	
2R	861226	14	000	234414	-166/- 90	1.7/21
2R	870113	33b	120	182019	----/- 97	1.5/22
		43	120	182031	----/- 85	
2R	870127	11b	202	233606	----/-100	1.2/23
2R	870204	17c	102	021345	----/- 99	1.1/23
		17b	001	021415	----/- 69	
2R	870214	33a	102	180949	----/- 81	0.9/24
		35	222	181017	----/- 53	
		30	21-	181031	----/- 39	
		32	202	181038	----/- 32*	

Event Type	& U.T.Date	Ob. No.	Con.	Obser. U.T.	Residual Samp/E-2	Geometry
3D	860607	24	000	172021	+141/+195	3.0/15
3D	860622	33a	021	012139	+ 99/+170	3.0/16
		21	200	012227	+147/+218	
3D	860713	24	100	132256	+116/+174	2.6/18
		28	000	132430	+210/+268	
		26b	000	132454	+234/+292	
		22	110	132500	+240/+298	
		27	000	132520	+260/+318	
3D	860804	2	000	012537	+ 97/+192	1.9/19
		33a	021	012606	+126/+221	
		21	000	012705	+185/+280*	
3D	860818	17a	000	092907	+187/+268	1.3/20
		11b	100	092947	+227/+308	
		17c	000	092955	+235/+316	
3D	861021	39	---	214026	+ 86/+163	0.3/24
		30	011	214110	+130/+207	
		40	010	214125	+145/+222	
		32	001	214140	+160/+237	
		34b	100	214211	+191/+268	
3D	861029	6	000	014307	+127/+206	0.5/25
		7b	010	014415	+195/+274	
		7c	020	014447	+227/+306	
3D	861105	7a	000	054436	+ 96/+169	0.7/25
		7b	100	054525	+145/+218	
		9	110	054655	+235/+308	
		7c	100	054705	+245/+318	
3D	861112	27	000	094910	+190/+264	0.9/26
		25a	101	094935	+215/+289	
3D	861126	16	111	175245	+105/+176*	1.1/27
		15	100	175332	+152/+223	
3D	861203	30	21-	215517	+137/+208	1.1/27

Event Type	& U.T.Date	Ob. No.	Con.	Obser. U.T.	Residual Samp/E-2	Geometry
	yymmdd			hhmmss	s s	r +o
3D	861211	13	100	015725	+145/+218	1.1/28
3D	861225	24	110	100103	+ 63/+152	1.0/28
		26b	100	100208	+128/+217	
		19b	000	100238	+158/+247	
3D	870108	40	021	180720	----/+187	0.8/29
		30	011	180749	----/+216	
		32	001	180832	----/+259	
3D	870123	8	11-	021210	----/+198	0.4/30

Event Type	& U.T.Date	Ob. No.	Con.	Obser. U.T.	Residual Samp/E-2	Geometry
3R	860531	24	000	164629	-211/-115	1.1/14
3R	860629	17d	210	084533	-267/-213	1.0/16
		17b	210	084615	-225/-171	
3R	860713	26b	000	164344	-316/-265	0.8/17
		27	000	164351	-309/-258	
		24	000	164518	-222/-171	
3R	860804	11b	121	044446	-314/-233	0.1/19
3R	860916	11b	101	044547	-373/-279	0.3/22
3R	860923	7c	000	084719	-341/-278	0.7/22
		12	121	084749	-311/-248	
3R	860930	19b	010	124837	-323/-258	1.1/23
3R	861014	21	200	205017	-343/-278	1.7/24
		40	011	205030	-330/-265	
		37	220	205110	-290/-225	
3R	861022	11b	210	005057	-363/-281	2.0/24
		32	001	005059	-361/-279	
3R	861029	9	110	045101	-419/-347	2.3/25
		8	110	045223	-337/-265	
3R	861105	24	000	085442	-318/-203	2.5/25
		25a	112	085450	-310/-195	
3R	861112	27	000	125525	-395/-288	2.6/25
		26b	220	125540	-380/-273	
3R	861126	15	100	205852	-368/-277	2.8/26
3R	861204	14	010	005953	-367/-282	2.8/27
3R	870116	11b	101	010853	----/-315	2.3/30
		8	21-	011010	----/-238	

Event Type	& U.T.Date	Ob. No.	Con.	Obser. U.T.	Residual Samp/E-2	Geometry
4D	860516	11b	010	094321	+141/+422	4.7/29
4D	860705	24	000	162013	+ 73/+346	4.8/36
		22	000	162211	+191/+464	
4D	860722	11b	022	103155	- 65*+211*	4.1/38
		26b	101	103555	+175/+451	
		12	001	103710	+250/+526	
4D	860808	11a	101	044631	- 89/+213	3.0/41
		2	000	044756	- 4/+298	
4D	860824	5	001	230719	+199/+534	1.5/44
4D	860927	23a	000	113601	-179*+152	0.3/49
		19a	000	114015	+ 75/+406	
		26b	110	114225	+205/+536	
4D	861014	7a	000	055954	+114/+433	1.6/52
		8	10-	060151	+231/+550	
		7b	000	060345	+345/+664	
		11b	211	060352	+352/+671	
		7c	001	060518	+438/+757	
		9	112	060546	+466/+785	
4D	861031	6	000	001911	- 49/+339	2.8/56
		33a	111	002042	+ 42/+430	
		32	201	002302	+182/+570	
4D	861116	38	001	184222	+ 22/+418	3.5/59
4D	861203	19b	000	131045	+345/+733	3.8/63
		25b	000	131419	+559*+947*	
4D	870106	10,	001	020711	----/+981*	3.4/73
		0	001	("did not disappear")		

Event Type	& U.T.Date yymmdd	Ob. No.	Con.	Obser. U.T. hhmmss	Residual Samp/E-2 s s	Geom-etry r to
4R	860602	11b	110	074505	-535/-331	3.5/31
4R	860619	33a	000	015419	-401/-238	3.5/33
4R	860808	12	000	080850	-550/-420	1.5/41
		6	000	081055	-425/-295	
		2	000	081529	-151/- 21	
4R	860910	21	010	202743	-197/- 64	0.1/46
4R	860927	25a	010	143225	-335*-200*	1.4/49
4R	861014	9	112	083018	-882/-751	2.8/52
		7c	000	083208	-772/-641	
		26b	001	083210	-770/-639	
		7b	000	083358	-662/-531	
		23a	000	083420	-640/-509	
		7a	000	083424	-636/-505	
		17c	001	083500	-600/-469	
4R	861031	8	11-	023946	-734/-636	3.8/55
		7c	010	024050	-670/-572	
		7b	010	024121	-639/-541	
		7a	010	024218	-582/-484	
		6	000	024348	-492/-394	
		2	110	024453	-427/-329	
4R	861116	1	00-	204121	-999/-965	4.4/59
4R	861220	26b	121	085310	-890/-932	4.5/67
		24	001	090737	- 23/- 65	
4R	870106	8	21-	025700	----/-857	3.9/73
		10	001	030401	----/-436	
		0	001	("did not disappear")		

Key:

a. Event Type; 1 = Io, 2 = Europa, 3 = Ganymede, 4 = Callisto, D = Disappearance, R = Reappearance. "U.T." indicates Universal Time.

b. "Ob. No." = Observer Number as listed below. In parentheses are the aperture used and the number of visual timings. Numbers 0 - 17d refer to A.L.P.O. observers (174 timings); 18 - 28 refer to observers of either or both the Royal Astronomical Society of New Zealand and the National Association of Planetary Observers (Australia) (136 timings); and 29 - 44 designate observers of the Agrupacion Astronomica de Sabadell (Spain; 86 timings).

0 = Abbott, A. (32 cm.; 2)
1 = Bourgeois, J. (100 cm.; 5)
2 = Corrêa, O. (6 cm.; 9)
3 = Dalmau, F. (20 cm.; 7)
4 = Da Silva, L. (6 cm.; 3)
5 = de Pontieu, B. (11.5 cm.; 1)
6 = Filho, A. (6 cm.; 8)
7a = Gonzalez, G. (10.2 cm., 7)
7b = " " (20 cm.; 10)
7c = " " (53 cm.; 14)
8 = Haas, W. (20 cm.; 12)
9 = Langhans, T. (36 cm., 15)
10 = Luedeke, K. (20 cm.; 2)
11a = MacDougal, C. (6 cm.; 1)
11b = " " (15cm.; 21)
12 = Newbill, C. (15cm.; 15)
13 = Rousom, J. (8 cm.; 1)
14 = Teixeira, R. (11 cm.; 5)
15 = Vandenbulcke, G. (21.5 cm.; 3)
16 = Vingerhoets, M. (20 cm.; 6)
17a = Westfall, J. (9.0 cm.; 6)
17b = " " (10.2 cm.; 6)
17c = " " (25.4 cm.; 12)
17d = " " (35.6 cm.; 3)
18 = Abrahams, W. (15 cm.; 5)
19a = Bembrick, C. (10 cm.; 3)
19b = " " (25 cm.; 11)
20 = Brickell, A. (11.4 cm.; 4)
21 = Büttner, D. (6.3 cm.; 16)
22 = Hutcheon, S. (25 cm.; 10)
23a = Ives, B. (10 cm.; 7)
23b = " " (20 cm.; 2)
24 = Kerr, S. (5 cm.; 25)
25a = Kruijshoop, A. (20 cm., 14)
25b = " " (25 cm.; 1)
25c = " " (32 cm.; 1)
26a = Loader, B. (10 cm.; 3)
26b = " " (20 cm.; 18)
27 = Priestley, J. (20 cm.; 9)
28 = Smith, G. (30 cm.; 6)
29 = Aliaga, - & Villaverde, - (20 cm.; 1)
30 = Arredondo, E. (10 cm.; 12)
31 = Casado, J. (20 cm.; 1)
32 = Casajust, J. (21 cm.; 12)
33a = Casas, R. (16 cm.; 21)
33b = " " (20 cm.; 2)
34a = Gallart, C. (16 cm.; 1)
34b = " " (30 cm.; 3)
35 = Garcia, S. (11 cm.; 1)
36 = Gomez, A. (20 cm.; 1)
37 = Gomez, J. (20 cm.; 3)
38 = Gonzalez, O. (6 cm.; 6)
39 = Grados, J. (8 cm.; 6)
40 = Prat, J. (12 cm.; 7)
41 = Santacana, - & Tobal, T. (10 cm.; 1)
42a = Soldevilla, J. (16 cm.; 2)
42b = " " (20 cm.; 1)
42c = " " (26 cm.; 2)
43 = Sors, A. (13 cm.; 2)
44 = Tobal, T. (10 cm.; 1)

c. "Con." refers to observing conditions, where the first digit indicates seeing; the second, transparency; and the third, sky brightness. "0" means the condition was not perceptible, with no effect on timing accuracy; "1" indicates that the condition was perceptible, with a possible minor effect on the timing; and "2" marks a serious condition with a definite effect on the accuracy of the timing.

d. "Obser. U.T." is the observed Universal Time of the "last speck" for a disappearance, or the "first speck" for a reappearance. A pound sign indicates that the observed time falls in the previous U.T. day.

e. "Residual" is the time difference, in seconds, found by subtracting the predicted eclipse U.T. from the observed eclipse U.T. "Samp." refers to the Sampson Ephemeris, used in the Astronomical Almanac through 1986; "E-2" refers to the E-2 Ephemeris developed by Jay Lieske of the Jet Propulsion Laboratory. The E-2 Ephemeris is given in E.T. (Ephemeris Time), and a Delta-T correction of +55 seconds was used to convert it to U.T. An asterisk (*) indicates that the residual that precedes it was sufficiently different from that expected to be excluded from the regression analysis.

f. "Geometry" gives, first, the apparent distance of the satellite from the adjacent jovian limb in units of the Jovian equatorial diameter; and, second, the latitude (in degreees) of the satellite in relation to the shadow center.

[Text continued from p. 252.]

Summary and Prospects

This is the last apparition for which we will investigate the errors of the Sampson Ephemeris, which were significant for all four Galilean Satellites. Somewhat modified, it is still used in the Éphémérides Astronomiques prepared by the French Bureau des Longitudes. It was last used in the American and British Astronomical Almanac for 1986, which now uses the E-2 Ephemeris instead. The E-2 model showed no significant deviation from our timings for any Galilean Satellite.

The accuracy of our results depends on the number of timings. Thus, we always can use more timings, both visual and photoelectric, and particularly timings made before opposition as well as after. Please send in your timings as soon after the end of each apparition as possible, giving them on the forms available from this writer (address on inside back cover). Eclipse predictions for the Galilean Satellites are given for each year in the A.L.P.O. Solar System Ephemeris; the 1989 edition is announced elsewhere in this issue.

In conclusion, we are very grateful to all the observers who contributed visual and photoelectric timings of the eclipses of Jupiter's four major satellites in the 1986/87 Apparition. We hope that the present participants in our program will continue, and we also heartily welcome newcomers.

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MARTIAN SOUTH POLAR CAP MEASUREMENTS DURING THE 1985-87 APPARITION USING A MICROMETER RETICLE EYEPIECE

By: Harry Cralle, Acting A.L.P.O. Assistant Mars Recorder

Abstract. --Seasonal changes in the latitudes of the edges of the martian polar caps are chiefly derived from measurements with filar micrometers. A less expensive and relatively rapid alternative method employs a micrometer reticle eyepiece. This paper describes the application of this instrument with a portable 20.3- cm. Newtonian reflector in order to measure the recession of the South Polar Cap from L 207 to L 326 during the martian Southern Hemisphere Spring and Summer during the 1985-87 Apparition. The results indicate that this method is reasonably accurate when Mars' apparent diameter is at least 6.0 arc-seconds.

Introduction

Changes in the extent of the martian polar caps with the seasons are readily observed with moderate-sized telescopes. These polar caps consist largely of CO -ice, although the summer residual North Polar Cap is primarily water-ice [1]. Because they are relatively thin, with only a 23-53 cm. mean thickness in the case of the seasonal North Polar Cap [2], the caps undergo great changes in size during the martian year from their maximum winter extent as far as latitude 50-65 to their summer remnant above about latitude 85 [1].

The changing latitudes of the polar caps are usually determined by using data from measurements with a filar micrometer [3]. A less expensive and relatively rapid alternative method uses a micrometer reticle eyepiece [4]. This paper describes the use of such an eyepiece with a telescope of modest aperture in order to determine changes in the latitude of the edge of the South Polar Cap during the martian Southern Hemisphere Spring and Summer during the 1985-87 Apparition. [These "latitudes" are not true areogreaphic latitudes because the polar caps are eccentric with respect to their poles. Nonetheless, the values found here do define the extent of the polar caps. Ed.]

Materials and Methods

Observations were made using a portable 20.3-cm. Newtonian reflector with a 142.2-cm. focal length (f/7.0) and a 4.4-cm. diagonal. The telescope was on a clock-driven equatorial mounting which was polar aligned before each observing session. The optical alignment was frequently checked and corrected when necessary by star testing.

Measurements of the martian polar cap and north-south disk diameter were made with a Meade Model 419, 12-mm. illuminated reticle eyepiece. The normal crossline reticle was removed and replaced with a Meade No. 705A micrometer reticle, which had a central area etched with 200 equidistant lines for measurements of distances. [Note: Other firms also produce appropriate reticles, such as the Edmund N30091 and N51028 or the Bausch & Lomb 63-1057. Ed.] The L.E.D. [light-emitting diode] illuminator of the eyepiece was not used during observations because the brightness of the polar cap and the planet was sufficient to make the etched lines clearly visible. Moreover, the L.E.D.'s light appeared to reduce the clarity of the image.

A 2.4-power Dakin Barlow lens was used with the 12-mm. eyepiece, giving a magnification of 284 power. Observations were made without filters, with a red Wratten 25 (A) Filter, or with an orange W21 Filter. The filters improved the quality of the seeing and enhanced the contrast of the polar cap.

To provide data for the determination of the latitude of the edge of the South Polar Cap, I measured the number of divisions between etched lines transected by the cap across its maximum east-west extent. This procedure is clearly illustrated in reference [5]. North-south measurements were not used because of the extreme foreshortening and small apparent width of the high-latitude cap in this direction [5]. The number of divisions between etched lines transected by the north-south diameter of Mars was also measured.

Three to five replicated measurements of the polar cap and of the apparent disk diameter were made, usually during moments of better seeing, in order to increase the accuracy of the latitude determinations. An example of this procedure is shown in Table 1 (p. 259). Using the ratio of the mean cap and disk diameter measurement, as indicated in reference [5] and the erratum on p. 224 of J.A.L.P.O. for July, 1986, the latitude of the edge of the South Polar Cap was calculated for each observation date.

As the apparent disk diameter decreased after opposition and the polar cap continued to recede, the observed cap extent became about as small as an individual etched line. To continue determining the latitude of the cap, it was necessary carefully to measure the relative width of an individual etched line as compared with the width of a division between lines. This ratio was measured with a microscope and a filar micrometer. The width of each division was found to be 3.29 ± 0.34 etched lines, making the width of an etched line equal to 0.304 divisions. Hence, while the small polar cap was measured relative to the width of an individual etched line, the disk diameter was still measured relative to the width of a division between lines, as shown in the example in Table 2 below. This technique allowed polar-cap measurements with disk diameters down to 6.0 seconds of arc.

Table 1. Measurements of the South Polar Cap and Disk Diameter of Mars on 1986 AUG 31 at L_s 235°*.

Observation	South Polar Cap (Maximum East-West Extent)	Disk Diameter (North-South; actually 17".9)	Ratio of Cap to Disk Diameter
1	2.5 Divisions	9.50 Divisions	0.26
2	3.0	9.75	0.31
3	2.0	10.25	0.20
4	2.5	9.25	0.27
5	2.5	10.00	0.25
Mean	2.50 ± 0.16	9.75 ± 0.18	0.258 ± 0.018

Table 2. Measurements of the South Polar Cap and Disk Diameter of Mars on 1986 DEC 03 at L_s 294°*.

Observation	South Polar Cap (Maximum East-West Extent)	Disk Diameter (North-South; actually 8".36)	Ratio of Cap to Disk Diameter
1	1.00 Line Widths	5.25 Divisions	0.058
2	1.25	5.00	0.076
3	1.50	5.00	0.091
4	1.25	4.75	0.080
5	1.25	4.50	0.084
Mean	1.25 ± 0.08 (0.38 ± 0.02 Divisions)	4.90 ± 0.13	0.078 ± 0.006

* L_s is a measure of the martian season. For the Southern Hemisphere: Spring Equinox is at L_s 180°; Summer Solstice, 270°; Autumnal Equinox; 360/000°.

Results and Discussion

The results of the measurements of the martian South Polar Cap during the 1985-87 Apparition are plotted in Figure 28 (p. 260). The latitude of the cap edge receded from about 66° S in early southern Spring (L_s 207°) to about 85° S just after the onset of southern Summer (L_s 271°). The cap edge remained at about 85° S until observations ended during southern Mid-Summer (L_s 326°).

A linear regression analysis of the recession of the southern cap from L_s 207° to L_s 271° gave a high positive correlation coefficient of +0.96 between the polar cap edge latitude and the orbital position of Mars (L_s). The analysis also showed that the South Polar Cap retreated an average of 0.28 degrees (16.6 km.) per degree of L_s advance during this period.

The pattern of the recession of the South Polar Cap during the 1986 Apparition in Figure 28 approximates previous patterns found by Viking Orbiter observations [6] and various telescopic observations summarized in reference [7]. Thus, this simple method of using a micrometer reticle eyepiece with a telescope of modest aperture in order to determine the latitude of the edge of the South Polar Cap appears to be reasonably accurate. It may be productively utilized during the present Apparition in order to examine seasonal changes in the martian antarctic.

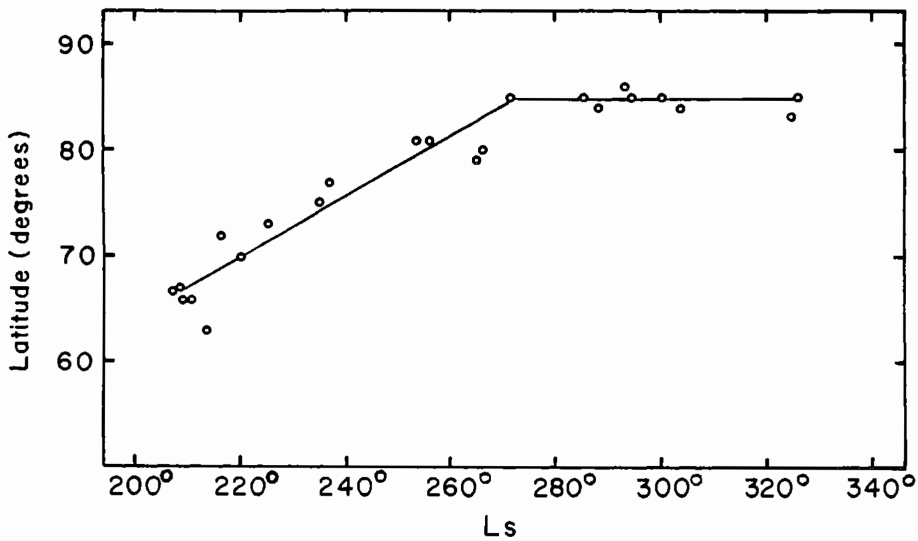

Figure 28. Graph of areocentric latitude of the edge of the South Polar Cap for the martian Southern Hemisphere Spring and Summer during the 1986 Apparition. See also text, p. 259.

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SOLAR ACTIVE REGIONS SESC 5047 AND SESC 5060

By: Randy Tatum, A.L.P.O. Solar Recorder (Monochromatic)

Solar ("Sunspot") Cycle 22 activity increased dramatically with the recent appearance of Southern Hemisphere SESC regions 5047 and 5060. ["SESC" stands for the region numbers assigned chronologically by the Space Environmental Services Center.] This preliminary report gives selected observations of these two regions, with all dates and times in Universal Time (U.T.). Directions are given in the celestial sense.

Solar Section observer Alan Daroff of Philadelphia, PA, reported that, on 1988 JUN 24, he observed a white-light flare coinciding with the intense 1B hydrogen-alpha flare of SESC 5047. Class 1 flares have H-alpha areas between 2.1 and 5.1 square degrees, while the suffix "B" indicates a bright flare. Mr. Daroff was using a 15-cm. (6-in.) refractor with a 2-power negative lens giving a focal ratio of f/30, along with a 0.5-Angstrom Daystar H-alpha filter. The refractor also has a white-light viewing port with a Herschel wedge, rotatable polarizer, and green filter.

Concerning the white-light flare, Mr. Daroff wrote:

"The Ha [sic.] flare was so bright at 1640 UT, it was saturating the CCTV [closed-circuit television] monitor and could not be viewed on screen unless the aperture was reduced to 2". When tilting the Ha filter and shifting the bandpass several angstroms to the blue side of the Ha line, traces of the flare were still visible. The view through the W.L. [white light] port showed no trace of the flare. At 1646, the Ha flare surged in brightness and appeared as two intensely bright, parallel streaks running roughly in a north-south direction. When the filter was tilted to its maximum extent, flare material was still visible! The view through the W.L. port showed two oval patches, as bright, if not slightly brighter, than the photosphere. They were located in the southern penumbral extension of [SESC] 5047. Their major axis [/sic./] ran north-south. These emission features were not visible six minutes before. Realizing I was observing a W.L. flare, I was ecstatic! After a few minutes the patches were gone. Following the flare, a long, dark surge-like eruption was observed in Ha, ejecting material towards the south pole of the sun."

Unfortunately this Recorder knows of no other observations of this white-light flare. Mr. Daroff's observation describes a two-ribbon H-alpha flare with ribbons on either side of a magnetic-polarity inversion line (neutral line). The two white-light patches were flare "footprints" where the magnetic flux loop intersects the photosphere, heating the gas into emission. It is curious that, according to NOAA (SESC), no energetic particles or geomagnetic disturbances were observed from this flare.

The ability rapidly to tune a H-alpha filter is helpful in the detection or anticipation of white-light activity. Flares are normally visible only in the high chromosphere and are caused by sources of particles in the corona above sunspot groups. Most particles are not powerful enough to penetrate to the photosphere. Hence, white-light flares occur during the impulsive phase of larger H-alpha flares [when rapid expansion and brightnening occur]. Before flares, active region filaments/prominences may become disrupted, with their absorption/emission wavelengths Doppler shifted. Although not particularly large optically, the flare of 1988 JUN 24 was impulsive in X-ray and radio wavelengths. Region 5047 continued to produce occasional flares as it crossed the west limb on 1988 JUN 26.

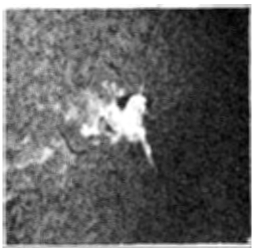


Figure 29. Hydrogen-alpha solar flare on 1988 JUN 24, 16h 50m U.T. Photographed by Robert Morris. Kodak Technical Pan 2415 Film, developed in D-19. 1/250-Sec. exposure. North at top. See also text.

Fortunately, weather conditions on 1988 JUN 24 were excellent for Robert Morris in Denver, Colorado. Mr. Morris photographed the bright flare in H-alpha light with his 10-cm. (4-in.) refractor, stopped to 5 cm. (2 in.) at f/30, using a 0.6-Angstrom Daystar Filter. Figure 29 to the left shows the flare at its brightest.

As SESC 5047 crossed the west limb, a much larger and potentially active sunspot group appeared on the southeast limb. Designated SESC 5060, this region was over three times the area of SESC 5047 and had a compact structure. It was particularly striking to the unaided eye (protected with a solar filter of course)!

Robert Morris made an excellent series of H-alpha whole-disk photographs of SESC 5060 as it transited the solar disk. Figure 30 (p. 262) was taken on 1988 JUN 28. Region SESC 5060 exhibited abundant umbral detail such as light bridges, dark cores, and veils. The greatest flare activity occurred on 1988 JUN 29 with a "2B" flare [i.e., with an area between 5.1 and 12.4 square degrees]. For comparison, the front cover of this issue shows a photograph of SESC 5060 in the far-red wing of the H-alpha filter, giving the illusion of a white-light image. It was taken by Randy Tatum with an 18-cm. (7-in.) refractor, using a 2-power negative lens to obtain an f/30 focal ratio, and a Daystar 0.5-Angstrom "T-Scanner." Note that it shows that all the sunspot umbrae were within one complex penumbra.

Figure 31, below, is a third photograph by Robert Morris, showing SESC 5060 transiting the central meridian of the Sun. As this region progressed across the Sun's disk, the preceding [right] and following [left] spots appeared to separate and to decay slowly.

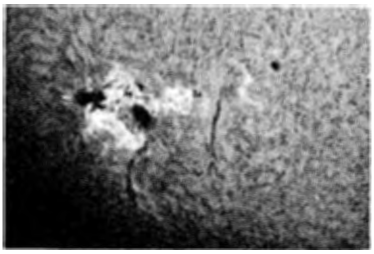


Figure 30. SESC 5060 photographed in Hydrogen alpha by Robert Morris on 1988 JUN 28, 15h 34m U.T. Kodak TP 2415 Film developed in D-19. 1/250-sec. North at top. See also text.

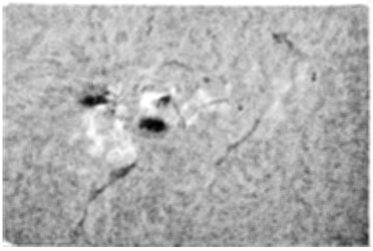


Figure 31. SESC 5060 photographed in Hydrogen alpha by Robert Morris on 1988 JUL 01, 16h 02m U.T. Kodak TP 2415 Film developed in D-19. 1/250-sec. North at top. See also text.

A.L.P.O. SOLAR SECTION OBSERVATIONS FOR ROTATIONS 1793 - 1797 (1987 SEP 06 TO 1988 JAN 20)

By: Richard E. Hill, A.L.P.O. Solar Recorder

The period described in this report was characterized by a mean level of activity that was higher than for any other similar period in over two years! The mean sunspot count for the five rotations was about 43, with the highest per-rotation counts for both the International (R_I) and the American (R_A) Sunspot Numbers occurring in Rotation 1794. For R_I, the highest daily counts were on 1987 OCT 15 and 16, during Rotation 1794, with a count of 101. The highest value for R_A, 97, was on 1988 JAN 15, in Rotation 1797. This was quite an improvement over the previous few years.

A graph by rotation number of sunspot numbers for the five rotations covered by this report is given in Figure 32 on page 263.

Two new terms will be used in this report and subsequent reports. A unipolar sunspot group will refer to a group that consists of a single spot or a small compact cluster of spots, the greatest extent of separation of the members not exceeding 3 heliographic degrees. A bipolar group will mean two or more main spots that are arranged in an elongated cluster greater than three heliographic degrees in length, usually with a thinly populated space between the main spot clusters. If only one main spot exists with a second clustering of smaller spots, the group must then be at least 5 heliographic degrees in length in order to qualify as bipolar. For a more in-depth description, the reader is referred to the article, "A Revised Sunspot Classification System," which is planned to appear in a future issue of J.A.L.P.O.

As with previous A.L.P.O. Solar Section reports, all dates and times are given in Universal Time (U.T.), while all directions and angular measures are heliographic unless otherwise noted and are abbreviated (e.g., N, SE, etc.). In this report, the term "group" will refer only to white-light collections of sunspots, while "region" will refer to areas of activity in all wavelengths. Regions (and groups, for the purposes of this report) are enumerated by the Space Environmental Services Center of the National Oceanic and Atmospheric Administration (SESC/NOAA) in Boulder, Colorado. All other terms and abbreviations used here are defined in The Handbook for the White Light Observation of Solar Phenomena, available from this Recorder for $US 6.00.

The seven observers who contributed to this report are listed on the following page:

Observer	Telescope Aperture (cm.)	f-ratio	Type	Stop (cm.)	Location
Garcia, G.	20	f/10	Schmidt-Cassegrain	----	Illinois, U.S.A.
Hill, R.	6	f/13	Refractor	----	Arizona, U.S.A.
Maxson, P.	28	f/10	Schmidt-Cassegrain	----	Arizona, U.S.A.
	20	f/8	Newtonian	----	" "
	15	f/13.3	Refractor	----	" "
Melillo, F.J.	20	f/10	Schmidt-Cassegrain	7.5	New York, U.S.A.
Morris, R.	5	f/30	Refractor	----	Colorado, U.S.A.
Rousom, J.	13	f/10	Newtonian	5	Ontario, Canada
	8	f/5.5	Refractor	----	" "
VanHoose, D.	11	f/8	Newtonian	----	Indiana, U.S.A.

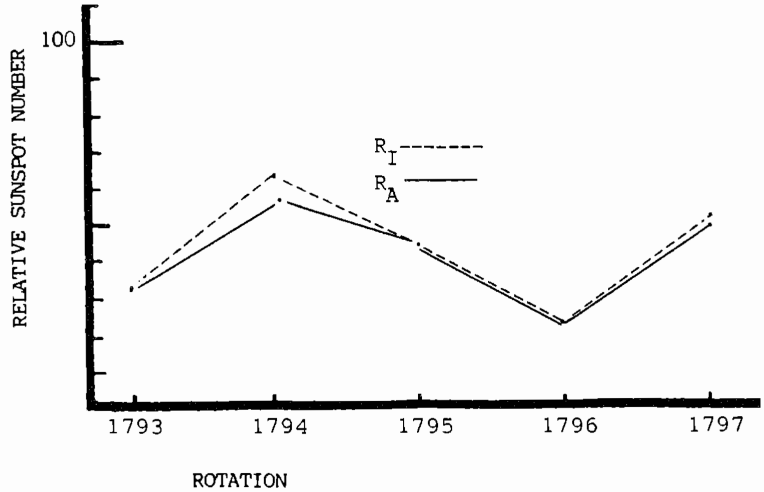


Figure 32. Graph of rotational means of R_I (the International Sunspot Number) and R_A (the American Sunspot Number) for Solar Rotations 1793-1797.

Rotation 1793 (1987 09 06.09 to 1987 10 03.36)

Sunspot Number [1,2]	Mean	Maximum (date)	Minimum (dates)
R_I	32.3	67 (09/08)	10 (09/26)
R_A	32.2	74 (09/09)	11 (09/25, 09/26)

Activity was relatively low during this rotation. There was only one significant sunspot group, SESC 4849, which came onto the disk as a bipolar group of umbral spots on 09/01. The next day, it developed penumbrae on both ends. By 09/06, Garcia, Maxson, and VanHoose observed no less than a half-dozen spots with penumbrae. One day later, the leader spot was increasing in area as the middle umbral spots began to coalesce with it, as is shown in Figure 33 (p. 264). In fact, it appears that this coalescence was the cause of the increase in area. The coalescence continued through 09/08 with some of these middle spots actually rushing into the leader! Hydrogen-alpha photographs by Morris showed this region to be fairly quiet at that wavelength. As the region left the disk on 09/10, it had some faculae but not to the degree that one would expect from a group of this size.

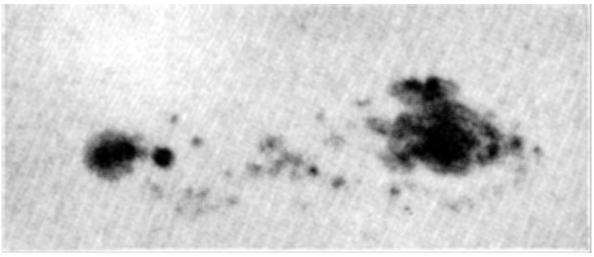


Figure 33. Green-light solar photograph by Paul Maxson on 1987 SEP 07 at 16h 02m U.T., using an 11-in. (27.9-cm.) Schmidt-Cassegrain telescope at f/38. Kodak TP 2415 Film; 1/125 sec.; W57 Filter. The sunspot group shown is SESC 4849. North at top. See also text.

Rotation 1794 (1987 10 03.36 to 1987 10 30.65)

Sunspot Number [2]	Mean	Maximum (dates)	Minimum (date)
R_I	63.6	101 (10/15, 10/16)	22 (10/24)
R_A	58.9	94 (10/15)	25 (10/24)

In terms of sunspot counts this was the most active rotation of this reporting period. Due to poor coverage for the later rotations in this period, we are unable to determine if this is true qualitatively. During this rotation, there were two regions of interest.

SESC 4860 was first caught by Hill on 09/30, one day after it had come onto the disk. It had few faculae but good penumbral development. There was little change for several days. On 10/02, the main spot was cut in two by a light bridge. Then, on 10/04, Morris managed to photograph a surge emanating from what was probably a subflare. His Hydrogen-alpha photograph appears below as Figure 34. By the next day the light bridge had closed up within the penumbra. After this date, the group diminished rapidly with the light bridge reopening and both portions of the severed spot decaying.

As SESC 4866 came around the E limb, it had few faculae as shown in both drawings and photographs. The group contained a main spot in the lead. The W portion of the main spot consisted of two large umbrae oriented N-S in a single penumbra. The E portion of this part of the main spot had no penumbrae on its W boundary; rather, the umbra bordered directly on photospheric material that was invading the spot from the N. The following portion of the main spot had at least two umbrae oriented E-W inside a poorly organized penumbra. Following this object was a slightly smaller zone of penumbral material with no umbrae apparent. This area was followed by about a half-dozen umbral spots. Bright plages following the main spot were recorded in Hydrogen-alpha. The appearance of this region on 10/11 is shown below in /Figure 35./ This region reached its maximum area and development on 10/15 as it crossed the central meridian. On its way there, it had reformed as a group of at least four umbrae [Text continued on p. 265.]

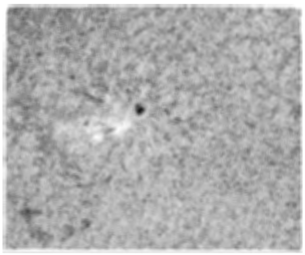


Figure 34. (To left) Hydrogen-alpha solar photograph by Robert Morris . 1987 OCT 04, 17h 14m U.T. 2-in. (5-cm.) refractor; f/30. 1/250-Sec. on Kodak TP2415 Film. Note surge emanating from subflare in SESC 4860. The subflare is the bright region near the center of this view, and the surge consists of the material being ejected from this area. North top. See also text.

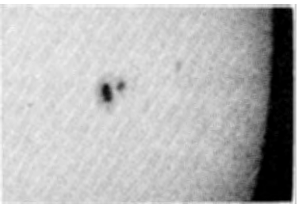


Figure 35. (To right) White-light solar photograph by Paul Maxson on 1987 OCT 11, 16h 30m U.T. 11-in. (28-cm.) Schmidt-Cassegrain at f/10. 1/1000-sec. on Kodak TP2415 Film. SESC 4866 is near the right limb. North at top. See also text.

in one penumbra, and then it was again torn apart by light bridges. As this region crossed the central meridian it consisted of a main leader spot, roughly triangular in shape, followed by four smaller spots with poorly organized penumbrae--the remnants of one spot in the process of being torn apart. There were still a number of umbral spots surrounding the group. From this impressive climax, the group began rapidly to decline. However, not all activity was over. In Hydrogen-alpha, the plage following the main spot, which previously had been a large ring, now formed an arc following the main spot and with that spot at its focus. There were also bright radial flocculi emanating from the region just following this spot, with at least three of these ray-like flocculi evenly spaced about 30° from each other. From 10/17 on, decay took place very rapidly in all wavelengths. As SESC 4866 neared the W limb, only one small spot with an umbra and perhaps two following umbral spots remained.

Rotation 1795 (1987 10 30.65 to 1987 11 26.96)

Sunspot Number [2,3]	Mean	Maximum (date)	Minimum (date)
R_I	45.2	89 (11/23)	15 (11/13)
R_A	44.9	88 (11/23)	20 (11/13)

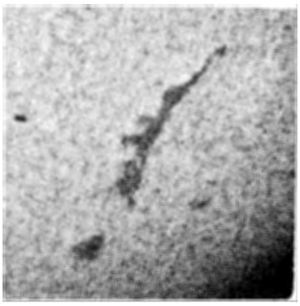
Once again, there were two regions of interest in this rotation. However, neither was covered in any great detail by the Solar Section. Although both forms of sunspot number were smaller than in the previous rotation, they were still higher than for most of the recently preceding rotations.

The first region was SESC 4875. It was first noted by Garcia on 10/25 (in Rotation 1794) as a group of three main spots with penumbrae. The middle spot of the three was the largest and was elongated N-S, with the umbra on the W side directly touching the photosphere. This aspect gave every indication that the W spot had been severed from the larger middle spot by a light bridge. To the N of the middle spot, and connected to it by a thin bridge of penumbral material, was a third, triangular spot. By 10/26, the group had changed remarkably, with only two spots that now had penumbrae, located N-S of each other. It appeared that the middle spot had overtaken the W spot by passing to the S of it. As observed in Hydrogen-alpha by Morris, the region was surrounded by a chromosphere that, for thousands of kilometers around the spots, looked like iron filings in a magnetic field that pointed radially away from the region. These were chromospheric spicules, the chromospheric equivalent of granulation. From this time until after central-meridian (CM) passage, there was a break in white-light coverage. After CM passage, there was little activity, as noted by Rousom and VanHoose. Hydrogen-alpha observations confirmed this inactivity, but showed that the radial structure in the chromosphere persisted. The position of this region corresponded closely to that of SESC 4860 of the previous rotation, but the chromospheric structure was completely different.

Maxson caught the next region, SESC 4890, in a photograph on 11/11 at 18h 15m U.T., when it was only 5 degrees from the limb. Rousom recorded nothing but a string of faculae preceding the region only three hours earlier! Hydrogen-alpha observations showed a small bright plage associated with the region. On 11/14, the group consisted of one large spot, elongated N-S with penumbrae concentrated on the E side and a light bridge almost splitting the spot from the W. In Hydrogren-alpha, the spot was followed by a bright plage ring which could also be seen as a facular ring in white light. By 11/20, the spot had divided in two; and, in Hydrogen-alpha, there was a bright rift between the spots. On the next day, Garcia showed bright flocculi dividing the spots. In white light, on the N there were now four small spots with penumbrae in an E-W row, with two more (plus a few umbral spots) in a parallel row to the S. From this time on, the region decayed rapidly and left the disk as one small spot with a penumbra surrounded by a few umbral spots.

Rotation 1796 (1987 11 26.96 to 1987 12 24.28)

Sunspot Number [3,4]	Mean	Maximum (date)	Minimum (date)
R_I	24.5	43 (12/18)	10 (12/24)
R_A	24.4	38 (12/18)	11 (12/12)



This rotation had the lowest sunspot counts of this entire reporting period, and tied with Rotation 1793 for the lowest daily count. All regions were rather inactive or decaying as they came onto the disk. Only SESC 4906 was of interest in displaying huge hedgerow prominences as it went around the W limb on 12/25, the first day of Rotation 1797. Figure 36 (to the left) shows a hedgerow prominence associated with SESC 4906. These prominences grew rapidly as dark filaments during their passage across the disk. As the region neared the W limb, the filaments underwent rapid shape changes and increased in size, finally giving quite a show.

Figure 36. Large filament, actually a hedgerow prominence, photographed by Robert Morris in Hydrogen-alpha on 1987 DEC 19, 17h 06m U.T. 2-in. (5-cm.) refractor at f/30. 1/250-sec. exposure on Kodak TP2415 Film. North at top. See also text.

Rotation 1797 (1987 12 24.28 to 1988 01 20.62)

Sunspot Number [4,5]	Mean	Maximum (date)	Minimum (date)
R_I	53.8	97 (01/14)	22 (12/26)
R_A	52.0	97 (01/15)	21 (01/03)

The counts of sunspots for this rotation were up markedly from Rotation 1796 and were the best for several rotations. During the first half of Rotation 1797, activity was low. During the last half, Section coverage was poor.

Only SESC 4912 deserves mention here. It was decaying throughout its passage across the disk. It came on as a bipolar group with penumbrae on both the follower and the leader spots. By 12/30, the follower had lost its penumbra as a dark filament formed on the following spot (as observed in Hydrogen-alpha), stretching out to the E, S of the remnants of the leader spot.

Conclusion

It should be obvious from its reports over the last several years that the A.L.P.O. Solar Section has about 15 members who regularly submit data. Different members have different times of the week, month, or year that are better for them to observe from their localities. We hope that all contributing members will make a special effort in observing and forwarding their data to the Section files. This material is being used by the professional community! We have had two data requests from NASA/Goddard this year alone, among others. One of the requests, from Drs. Drake Deming and Robert Boyle, netted the Section the following praise:

> "...this material was quite useful to us and has been mentioned in the acknowledgements section of the paper [entitled "Solar Magnetic Field Studies Using the 12 Micron Emission Lines, 1. Quiet Sun Time Series and Sunspot Slices"] which will appear in the October 15, 1988, issue of the Astrophysical Journal. The paper thanks each of the observers by name, and I am sending each [one] of the preprints."

Hearty congratulations to our observers Neal Blackburn, Gordon Garcia, Paul Maxson, and Frank J. Melillo for a job well done. Just think, it could have been you too!

References

1.) Solar-Geophysical Data (prompt reports), Part I, No. 519, Nov., 1987.
2.) ________, No. 520, Dec., 1987.
3.) ________, No. 521, Jan., 1988.
4.) ________, No. 522, Feb., 1988.
5.) ________, No. 523, Mar., 1988.

COMET CORNER

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

A Call for Observations

From time to time, I would like to write special reports on some of the brighter and more unusual comets. To do so, I shall need observations from A.L.P.O. members who give magnitude estimates, coma size, degree of condensation, and tailinformation. To better assimilate your observations, I shall need the time of observation; instrument size, type, power, and focal ratio; sky conditions; and reference star source. If possible, please use the form in the March, 1988, issue of J.A.L.P.O. (p. 175; explained on p. 176).

I am presently seeking observations of Comet Bradfield (1987s), Comet Liller (1988a), and Periodic Comet Temple 2 (1987g). Please send them to the Comets Recorder by February 15, 1989 (address on inside back cover).

Comet Finds for the First Half of 1988

As 1988 dawned, several comets from 1987 were still under wide observation. They included: Comet Bradfield (1987s), Comet McNaught ($1987b_1$), Comet Borrelly (1987p), and Comet Furuyama (1987 f_1).

The year 1988 has seen fewer comet discoveries and recoveries than 1987, but comet observers have been kept busy with at least one comet visible any night of the year. Here are the comets found and recovered so far this year:

Comet Liller (1988a) --Dr. William Liller of Chile discovered this comet on a film photograph taken 1988 JAN 11. He was using a 20-cm. (8-in.) Schmidt Camera in conjunction with the PROBLICOM survey. At that time, the comet was at magnitude 10 in Sculptor, and moving northward at a degree per day. Because Dr. Liller is a professional astronomer, but working on his own time for this find, Comet 1988a can be considered to be an amateur-found comet.

Comet Liller reached perihelion on 1988 MAR 31 at 0.85 A.U. [Astronomical Units]. It traveled north, and by April attained magnitude 6 with a tail several degrees long. Comet Liller remained a binocular object through June. I am presently seeking observations of this comet from A.L.P.O. members.

Comet Shoemaker (1988b) --Carolyn and Eugene Shoemaker discovered this comet while searching for Earth-crossing asteroids and comets with the 0.46-meter (18-in.) Schmidt Camera at Palomar Mountain. Although the comet was found on 1988 JAN 23, it was not confirmed until FEB 12. This comet was at magnitude 16 when found and did not brighten. It was closest to the Sun (at 5.0 A.U.) in March, 1987, and thus was already pulling away from us. This was the Shoemaker's twelfth comet find.

Comet Maury-Phinney (1988c) --Alain Maury and Jeff Phinney discovered this comet on photographic plates taken for the Second Palomar Sky Survey. At discovery on 1988 FEB 15, it was 3 degrees from the location of the previous (1988b) comet find, in Leo Minor. It was closest to the Sun late in 1987 at 1.9 A.U. and at magnitude 16.

Periodic Comet Hartley 3 (1988d) --Malcolm Hartley found this, his eighth comet, on plates exposed on 1988 FEB 19 from Siding Spring, Australia. We now know that it was closest to the Sun on 1987 JUL 14 at 2.4 A.U. It remained fainter than magnitude 16, but should return every 6.85 years.

Comet Levy (1988e) --David Levy of Tucson, Arizona, discovered this, his fourth comet, on 1988 MAR 19. He was using his 40-cm. (16-in.) f/5 reflector when he found this object, not far from the globular cluster M15. This discovery was David's third comet in 15 months, coming 162 search hours after his previous find in October, 1987.

When found, this comet was at magnitude 11 and more than 2.0 A.U. from both the Earth and the Sun. We now know that it was closest to the Sun in late November, 1987, at 1.18 A.U. It was discoverable, but not found, from the Southern Hemisphere in Autumn, 1987, travelling from 38 degrees south of the Sun on 1987 SEP 15 to 33 degrees south of the Sun on 1987 OCT 30. It should have brightened from magnitude 10 to 8.5 during that period. Escaping detection in the southern morning sky, Comet Levy continued northward but remained in the solar glare until shortly before its discovery.

Periodic Comet Finlay (1988f) --Alan Gilmore and Pam Kilmartin of Mt. John Observatory in New Zealand recovered this comet on 1988 APR 21 at nuclear magnitude 17. Its orbital period is seven years, and it is unfavorably placed on this visit. It is not expected to get brighter than magnitude 13, and even then it will remain within 40 degrees of the Sun.

Comet Shoemaker-Holt (1988g) --Carolyn and Eugene Shoemaker and Henry Holt discovered this comet with the 46-cm. (18-in.) Palomar Schmidt on 1988 MAY 13. This was the Shoemakers' thirteenth comet in the five years that they have been conducting their asteroid and comet search. At its discovery, Comet 1988g was at magnitude 12 in the morning sky, near M15. It continued to dim as it left the inner Solar System.

Shortly after its orbit was determined, it was discovered that this comet shares the same orbit as Comet Levy (1988e), with 1988e preceding Comet Shoemaker-Holt by 76 days. It is now believed that both comets came from the same parent comet, the split-up occurring many years ago. Levy's comet was about two magnitudes brighter than 1988g (assuming standard distances from both the Earth and the Sun), so it may have been the larger portion. It is not known if any other portions of the parent comet exist.

Comet Shoemaker-Holt-Rodriquez (1988h) --Eugene Shoemaker reported that his wife Carolyn discovered this comet on photographs taken on June 11 and 12 by Henry E. Holt, Henry R. Holt (his son), and graduate student Tim Rodriquez. This is the fourteenth comet bearing the Shoemaker name. Carolyn (credited singly for two "Shoemaker" comets; her husband assisted with the rest) now has more than half the record of 26 comets named after Pons. She also has the greatest number of comets named for a living astronomer.

When found, this comet was in the morning sky not far from M27, and faint at magnitude 14. The orbit computation shows that the comet will be closest to the Sun in June, 1989, at 2.47 A.U. By then it might brighten to magnitude 10 in the deep-southern morning sky.

Ephemeris for Periodic Comet Temple 2 (1987g)

Finally, below is an ephemeris for Periodic Comet Temple 2. This Fall, it will be located in the evening southern sky, visible to observers in both the Northern and Southern Hemispheres. This comet may be brighter than these predictions indicate. Please send your observations to the Comets Recorder.

1988 Date	1950.0 Coordinates		Elongation	Total Visual
(0h U.T.)	Right Ascension	Declination	From Sun	Magnitude
	h m	°	°	
OCT 21	19 35.4	-30 52'	83	+ 9.7
OCT 26	19 54.5	-30 40	86	9.9
OCT 31	20 13.3	-30 16	82	10.1
NOV 05	20 31.8	-29 42	81	10.3
NOV 10	20 49.8	-28 58	80	10.5
NOV 15	21 07.3	-28 04	79	10.7
NOV 20	21 24.3	-27 04	78	10.9
NOV 25	21 40.7	-25 57	77	11.2
NOV 30	21 56.6	-24 45	76	11.5
DEC 05	22 11.9	-23 28	74	11.7
DEC 10	22 26.7	-22 08	73	12.0
DEC 15	22 40.9	-20 45	72	12.2
DEC 20	22 54.6	-19 21	70	12.5
DEC 25	23 07.9	-17 55	69	12.7
DEC 30	23 20.8	-16 29	67	13.0

[After this report was submitted, Mr. Machholz himself discovered Comet 1988j Machholz on 1988 AUG 06.5, using his 5-in. (12.7-cm.) 27X home-built binoculars, observing from Loma Prieta near San Jose, California. At that time the comet was near the Taurus-Orion-Eridanus border. It brightened to near naked-eye visibility before its perihelion passage on 1988 SEP 17. As of this writing (OCT 07), the comet has not been recovered after perihelion passage, which was only 0.17 astronomical units from the Sun, and may not have survived. Ed.]

These notes are intended to describe the visibility of Solar System objects and events, both for serious observations and as of general interest. For more detailed information, consult such sources as the 1988 and 1989 editions of the A.L.P.O. Solar System Ephemeris. All dates and times below are in Universal Time (U.T.); found by adding 10 hours to Alaksa-Hawaii Standard Time, 8 to PST, 7 to MST, 6 to CST, and 5 to EST. Directions are abbreviated.

Planetary Visibility. --Probably the most readily observed planets during this period will be Mars and Jupiter. Mars will be conveniently placed in the evening sky throughout this period, decreasing in brightness from stellar magnitude -1.8 to +0.5. Although continuously receding from Earth, its disk will be large enough (10 arc-seconds) for successful photography with moderate-size telescopes until late December. Visual observers will be able to draw a disk over 6 arc-seconds in diameter until early March, 1989.

In the beginning of this period, Jupiter will rise after sunset and reach its peak altitude (transit) after midnight. The Giant Planet reaches opposition to the Sun on 1988 NOV 23, after which it will dominate the evening sky. Also, Jupiter is becoming better placed for Northern-Hemisphere viewers, and will be at declination 19°.4 N at opposition, when its magnitude will be -2.9 and its equatorial diameter 48.8 arc-seconds.

Saturn, Uranus, and Neptune will be evening objects this Fall, best seen shortly after evening twilight ends. They will be drawing closer to the Sun, all reaching conjunction in late December (1988 DEC 26 for Saturn, DEC 22 for Uranus, and DEC 31 for Neptune). Sometime in January, these three outer planets will be recoverable in the pre-dawn sky.

The most spectacular object in the morning sky will be Venus, easily seen throughout this period as it gradually approaches the Sun (Venus' elongation will drop from 36° W in early November to 16° W at the end of January). Again throughout this period, Venus will show a gibbous phase, growing from 79 percent to 96 percent sunlit as its disk diameter shrinks from 13.8 to 10.3 arc-seconds. Venus also will be able to help observers to make initial recoveries of Saturn, Uranus, and Neptune in the morning sky because it passes all three of them in mid-January, 1989. Specifically: Venus passes just 0°.5 N of Uranus on 1989 JAN 12, 0°.6 S of Saturn on JAN 16, and 0°.9 S of Neptune on JAN 19. Venus, at magnitude -3.9, will be about 20° W of the Sun at this time, and her three conjunctions with the outer planets are plotted in Figure 37 below.

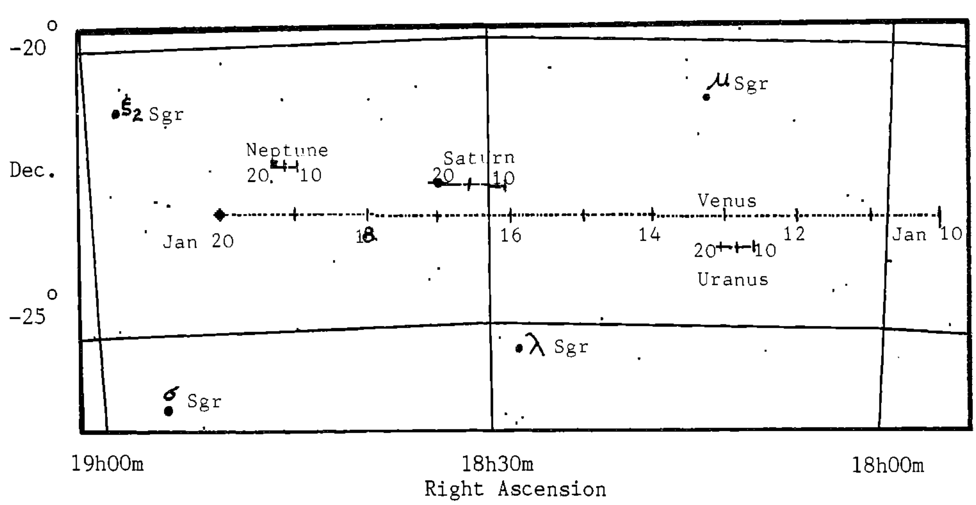


Figure 37. The apparent paths of Venus, Saturn, Uranus, and Neptune between 1989 JAN 10 and JAN 20, with ticks at 1-day intervals for Venus and 5-day intervals for the other three planets. Apparent celestial coordinates are plotted. The limiting stellar magnitude is about +7. Sky map generated by the "Voyager" program, produced by Carina Software.

The remaining bright planet, Mercury, will be in the predawn sky in November (its greatest elongation west, at 18°, a favorable elongation, was on 1988 OCT 26). Its next visibility period will be the period around 1989 JAN 09, the date of its greatest elongation east, 19° from the Sun. Also, on 1989 JAN 09, at about 05h, the Moon will pass 1°.7 S of Mercury. This January evening elongation will be moderately favorable.

The Moon. --New Moons occur, and hence lunations begin, on 1988 OCT 10.9, NOV 09.6, DEC 09.2, and 1989 JAN 07.8. Although there are no lunar or solar eclipses during these three months, and no occultations of bright planets, the Moon will pass through the Pleiades star cluster three times: 1988 NOV 23 12h, 100-percent illuminated, visible from W North America and E Asia; DEC 20 20h, 93-percent sunlit, seen from Europe and E Canada; and 1989 JAN 17 03 h, 77-percent illuminated, visible from N North America. Also, the Moon occults the bright star Regulus on 1988 NOV 03 03h (N Europe, W Asia), NOV 30 11h (North America except NE Canada and SW United States; West Indies, N South America), DEC 27 20h (Asia, Indonesia, NE Australia), and 1989 JAN 24 04h (E North and Central America, West Indies, W and S Africa). The Moon also occults Antares on 1988 NOV 11 08h (S Africa, SE Australia, New Zealand) and 1989 JAN 05 01h (Madagascar, New Zealand).

Meteors. --Below are the names, dates of maxima, and age of the Moon for the regular meteor showers during this period:

South Taurids	1988 NOV 02	22 days
North Taurids	NOV 12	2
Leonids	NOV 17	7
Geminids	DEC 14	5
Ursids	DEC 22	13
Coma Berenicids	1989 JAN 03	25
Quadrantids	JAN 04	26

Thus, the Moon will be too near New Phase to interfere with observers of the North Taurids and Quadrantids, and will have set for the morning skies for the Leonids and Geminids. This last is fortunate, because the Geminids, with zenithal rates up to 75 per hour, and a duration of 2.6 days, might be the major shower of the year. The Leonids (15 per hour) and Quadrantids (40 per hour; 1.1-day duration) are also well worth watching from dark-sky locations.

BOOK REVIEWS

Coordinated by J. Russell Smith

The Birth of the Earth. By David E. Fisher. Columbia University Press, 562 W. 113th Street, New York, NY 10025. 1987. 270 pages. Price $24.95 cloth (ISBN 0-231-06042-4).

Reviewed by Rodger W. Gordon

The Birth of the Earth is an interesting book which not only covers the subject of its title, but in addition explores the Solar System and cosmology. Approaching these subjects from both an historian's and a scientist's point of view, the author makes this volume come alive with sometimes amusing anecdotes of the discoveries and the discoverers. One of the more amusing stories concerns the young German physicist Fritz Houtermans in the early 1930's, who hit upon the idea of how the Sun shines while lying arm-in-arm with a young girlfriend at night in a Bavarian forest. Unfortunately, this flash of inspirational genius was totally lost on his companion!

This book is actually a small compendium of today's cosmological and terrestrial history. Fisher's text joins seemingly remote disciplines which, taken together, present a very broad but up-to-date view of today's thinking. Through 26 chapters, the author delights in telling of each important milestone, yet makes the pertinent facts in each step come alive. Many of today's scientific books that are intended for a general audience are merely repetitions of facts, leaving the reader with no idea of how these facts (or theories) came to be. Fisher does not fall into this trap, and indeed makes this work a scientific detective story. He has an innate ability to weave the tale of the discovery with that of the discoverer so that one gains some human insight into both. Almost everyone who reads science articles has heard of Harold Urey's contributions; but after Fisher is done, we know something of the man as well as of his accomplishments.

The Birth of the Earth is rather expensive for 270 pages, but I think that it is well worth this price. The title itself may scare off some readers or may turn others away, thinking that it is about the Earth only. This is not the case; and, if the book is brought out in paperback, a more useful title might be something like "The Birth of Cosmology." This book deserves to have a wider audience than it probably will have. Fisher has shown that science writing need not be dull or stifling. If you are looking for a reading treat on a rainy night, try this!

Discovering the Universe. By William J. Kaufmann, III. W.H. Freeman and Co., 41 Madison Avenue, New York, NY 10010. 1987. 381 pages. Illustrations, glossary, index. Price $24.95 paper (ISBN 0-7167-1784-0).

Reviewed by Ken Thomson

An introductory science course can have a profound influence on a student's future attitude toward the sciences in general. Discovering the Universe is intended to serve as the textbook for such a course.

Considerable effort has been expended in order to assemble a package that will keep the student's interest and attention while it teaches a broad range of astronomical and physical topics. An easy-to-read narrative style is used. New concepts are embedded in the text in boldface type, and one-sentence summaries are frequently placed in the margins throughout each of the 19 chapters. Photographs and other illustrations, frequently in color, are interspersed throughout the text. Each chapter ends with a concise summary that is followed by a set of review and discussion questions and a bibliography of easy-to-read journal articles and books. Also, there are Appendices that tabulate Solar System and stellar data, an 11-page glossary, and a good index.

The student reader need have no mathematical experience beyond simple algebra; graphs and explanatory text abound. The indispensable physics that must be taught is related to ordinary terrestrial phenomena whenever possible.

The author asserts that the material may be covered in as few as ten weeks, but the sheer wealth of information and concepts makes a full semester's study more realistic. Whatever plan is chosen, there are several "ancillaries" available, such as an Instructor's Manual and a Computerized Test Bank for the IBM-PC.

It is unfortunate that the author appears to be resigned to the virtual obliteration of the night sky by city lights and smog. The crude star charts, four reproductions from the Griffith Observer, are in keeping with this pessimism. Because astronomical societies that arrange field trips to dark-sky sites can be found in many urban areas, inclusion of a better set of charts and a discussion of the celestial coordinate system would have been in order.

The Search for Extraterrestrial Intelligence: Listening for Life in the Cosmos. By Thomas R. McDonough. John Wiley & Sons, Inc., 605 Third Avenue, New York, NY 10158. 1987. 244 pages. Illustrated, index. $19.95 cloth (ISBN 0-471-84684-8).

Reviewed by Frederick Pilcher

The Search for Extraterrestrial Intelligence (SETI) requires understanding life as we know it, an astronomical perspective, and the human as well as the historical and instrumental means for the search. This book introduces all these subjects at a level that is especially suitable for the non-technically oriented beginner, and includes a chapter-by-chapter listing of suggested readings needed to pursue further almost any topic about which the reader hungers to know more.

Chapter 1, "The Nature of the Search," is a short overview. Chapter 2, "Aliens in History," begins with the Earth-decentering cosmologies of Copernicus, Giordano Bruno, and Galileo, then proceeds through Leeuwenhoek's microscopic world of flea eggs and "animalcules" to the debate on Darwinian evolution between Thomas Huxley and Bishop Wilberforce. A very negative view of the opposition of the Church to the new thinking is oversimplified, and does not do justice to the complexity of the real issues. Chapter 3, "Aliens in Science Fiction," briefly traces the evolution of this literary form and its impact on human thought from Mary Shelley's Frankenstein through the great science fiction movies of the second half of the Twentieth Century. These works have inspired some famous scientists toward their careers.

The interstellar origins of heavy atoms and quite possibly of the molecular precursors of life are explained in Chapter 4. In six all-too-brief pages of Chapter 5, we learn of the detection by IRAS of dust clouds around stars. Miniscule Doppler shifts in stellar spectra caused by hypothetical planetary companions are mentioned, but not the technology currently under development for the actual measurement of these meter-per-second velocities. Chapter 6, "Exploring the Solar System," is an up-to-date account of planetary exploration by spacecraft, even including the Voyager-2 Uranus flyby.

Chapter 7 finally brings us to SETI itself, with Frank Drake's equation to estimate the number of inhabited worlds in the universe. Besides searching for messages from others, we are broadcasting our own presence to them. In Chapter 8, we learn of Drake's coded message to the cosmos, the messages aboard the Pioneer and Voyager spacecraft en route to the stars, and even prime-time commercial television shows which are inadvertently disclosing our more somber sides to the universe! Chapter 9, "False Alarms," describes the discovery of pulsars, and in considerable detail explains how a nonintelligent origin for the initially mysterious beeps was deduced.

In Chapters 10 through 12, we learn that Senator Proxmire delayed funding for NASA's SETI program, but that investigations proceeded in other countries. Private funding from the Planetary Society and science-fiction movie producer Steven Spielberg enabled Paul Horowitz to construct and operate META, with a 131,000 ultra-narrowband channel analyzer and an otherwise-discarded 84-foot radio telescope.

Chapters 13, "Interstellar Travel," and 14, "UFO's and Other Evidence," disappointed this reviewer as portraying both topics much more positively than the best current observational evidence justifies. Chapter 15, "Scientists Against SETI," rather incompletely lists arguments by Michael Hart and Frank Tipler that we are alone in the universe. We are told that there are many physical laws which, if only slightly different, would preclude life as we know it, and therefore that the universe was designed for us. However, we are not told what these laws are. Counter-arguments to these views balance this terse chapter.

The longest chapter is number 16, "The Future," which is admittedly very speculative. Questions about the impact on our civilization of the discovery of extraterrestrial intelligence very properly provide guidelines for the reader to ponder. The positive achievements of non-discovery in a dedicated search, which is likely for some time to come, merit far more space than the half page they are given.

The Search for Extraterrestrial Intelligence provides the reader with a non-technical, but often succinct, explanation of a multifaceted subject and should stimulate his thinking. There is a rich variety of illustrations. Numerous cartoons and personal stories add warmth and humor to the purely scientific topies. Misprints are very few. The beginner, while not told everything about the subject, will find here a rich introduction.

The Wonderful Apparition: The Story of Halley's Comet. By Richard B. Peterson. Published by Lighthouse Writers Guild; distributed by Univelt, Inc., P.O. Box 28130, San Diego, CA 92128. 1985. 195 pages. Illustrations. Price $18.95 cloth (ISBN 0-935125-00-0).

Reviewed by James V. Scotti

You may be saying, "Oh no, not another book about Comet Halley." Admittedly, that was exactly my opinion upon receiving this book. There certainly has been an explosion of literature about the most famous comet of all. This book, however, stands apart from the crowd. Many of the other books intentionally described tHis comet in the 1985-86 Apparition only, scarecely even mentioning any previous apparitions of Comet Halley. This book approaches the comet from an historical perspective, describing it as it appeared throughout the history of man. The book traces the research into the comet's past motions as it was carried out by astronomers beginning with the initial recognition of periodicity by Sir Edmond Halley, through John Hind, A.C.D. Crommelin, and many others. The book then looks at the contemporary events with each appearance of the comet from the first recognized appearance through its 1910 Apparition. Only in the end does the author succumb to the temptation of describing how this comet should have appeared as it passed perihelion in 1986.

For the most part, this book is very well written and is even entertaining . To be objective, I find the book does suffer from some flaws. First, the binding on the copy that I received is less than perfect. Some of the printing in the first part of the book is slightly skewed with respect to the pages. I think that the book could have waited to be published until after the 1986 Apparition; and therefore the descriptions of how the comet should then have appeared could have been replaced with a concluding chapter which could have put the recent apparition into the same historical perspective as the previous appearances, thus improving the continuity of the work.

As a whole, I must recommend this book to all comet enthusiasts, and to any other astronomers with an historical bent.

<u>Webb Society Deep-Sky Observer's Handbook. Volume 6. "Anonymous Galaxies."</u> By Webb Society Staff, Edited by Kenneth Glyn Jones. Enslow Publishers, Inc., Bloy Street and Ramsey Avenue, Box 777, Hillside, NJ 07205. 1987. 160 pages. Illustrated. Price $14.95 paper (ISBN 0-89490-133-8).

Reviewed by Howard W. Williams

With the publication of this volume the amateur deep-sky observer is introduced to what must be the ultimate in astronomical adventure and discovery. "Anonymous Galaxies" are objects which are "unknown" even to that comprehensive compilation, the New General Catalog, with its two Index Supplements. In order to observe and identify objects which have eluded the acuity of William and John Herschel and their successors in visual discovery, the modern amateur observer needs to extend his ability and his instruments to the limit. Nevertheless, the opportunity for successful work in this field, if exacting, is also virtually limitless; and it is the purpose of this book to explain and demonstrate how that success can most efficiently be achieved.

The book is divided into three parts. The first part describes in detail the older visual catalogs and atlases and the many modern photographic catalogs and atlases upon which the search for "Anonymous Galaxies" must be based. The second part is the catalog with its detailed locating diagrams, which covers the original observation of 165 galaxies. Many of these are listed in one or the other of the specialized catalogs, but some are "unlisted;" truly anonymous galaxies of which the authors of this book can claim unique "discovery." In the third part are appendices, with the object of encouraging more interest in this new form of exploration of the deep skies. The Webb Society has initiated the formation of an Anonymous Galaxies Club, details of which are given in Appendix 1. Any observer who wishes to contribute the results of his explorations in this field is welcome to take up membership in what is likely to be a very prestigious band of enthusiasts.

The book mentions that the observation of anonymous galaxies is not an easy program to carry out. However, to the visual astronomer who seeks a challenge which will require all his observing skills, coupled with dark skies and the pushing of his telescope to its limits, it can be both fulfilling and exciting, with the additional thrill of original visual discovery.

<u>Meteorites and Their Parent Planets.</u> By Harry V. McSween, Jr. Cambridge University Press, 510 North Avenue, New Rochelle, NY 10801. 1987. 249 pages. Illustrations, including photographs, and graphs; Appendix, Glossary, Index. Price $24.95 cloth (ISBN 0-521-32431-9).

Reviewed by Clifford Holmes

The final paragraph of this book sums it up: "The topics in this chapter have not been treated in many non-technical publications, and the technical literature makes for difficult reading. However, the references below contain a wealth of information for the serious reader." (p. 220)

This was a difficult book for me personally to jump right into and enjoy, and maybe that is not the purpose of the book. The text is highlighted on almost every page in heavy black type with the names of meteorites or chemical processes and geologic terms, all very helpful. The intricate descriptions of various meteorite types and subclasses is very complete and detailed. The lay reader will have to read right over some of these portions, but the serious reader or the student of meteors and meteorites will comprehend and fully enjoy the text.

A good case is made for the idea that some meteorites come from asteroids, planetesimals, the Moon, and even possibly from Mars. I will let the reader decide these matters for himself.

The Appendix and the Glossary are well done and most helpful. I am a popularizer of astronomy and will share some of the ideas from this book with the groups I work with because, although we all cheer and wow when we see a meteor flash through the sky, we rarely think of its origin.

NEW BOOKS RECEIVED

Notes by J. Russell Smith

Astronomy Projects for Young Scientists. By Necia H. Apfel. Arco Publishing, Inc., 1 Gulf & Western Building, New York, NY 10023. 1984. Price $5.95 paper (ISBN 0-668-06006-9).

After an "Introduction" are the following chapters: "Building a Theodolite," "Sundials," "Telescope Making," "The Construction and Use of a Spectroscope," "Building a Planetarium," "Model Construction," "Observing the Sun," "Observing the Moon," "Observing the Planets," "Measuring the Earth's Circumference," "Comets and Meteors," "Tiny Particles," "Variable Stars," "The Timing of Occultations," "'Star Gauging' the Milky Way," "Blinking," "Additional Ideas," and "Contests and Competitions," followed by an Appendix and an Index. If you want a book on this subject that is well worth the price, get this one.

Light from the Depths of Time. By Rudolph Kippenhahn. Springer-Verlag, 175 Fifth Avenue, New York, NY 10010. 1986. 280 pages. Illustrated, Index. Price $19.95 paper (ISBN 0-387-17119-3).

This book's contents are: "Introduction," "Anatomy of the Milky Way," "Speeding Up the Milky Way," "Plumbing the Depths of the Milky Way," "The Island Universe Debate," "The Universe is Expanding," "The Big Bang in Flatland," "Expansion and Gravity," "The Realm of the Nebulae," "The Radio Sky," "The Mysterious Quasars," "...and There Was Light," and "The Intelligent Universe," followed by the Appendices and a suitable Author and Subject Index. If you are interested in this subject, I believe that you would like to have this book; I heartily recommend it.

Cosmology--The Structure and Evolution of the Universe. By G. Contopoulos and D. Kotsakis. Springer-Verlag, 175 Fifth Avenue, New York, NY 10010. 1987. 250 pages. Illustrations, Index. Price $32.50 paper (ISBN 0-387-16922-9).

The contents of this book are as follows: "Our Galaxy," "Galaxies and Clusters of Galaxies," "Distribution of Matter in the Universe," Introduction to the Study of the Universe," "General Theory of Relativity," "Relativistic Cosmology," "Other Cosmological Theories," "The Beginning of the Universe," "The Evolution of the Universe," "The Physics of the Universe," "Cosmological Problems," "References," and "Further References for the Figures," which are followed by a Name Index and a Subject Index.

First Light: The Search for the Edge of the Universe. By Richard Preston. Little Brown and Co., 200 West Street, Waltham, MA 02254. 1987. 272 pages. Price $18.95 cloth (ISBN 0-87113-200-1).

The contents are as follows: "Big Eye," "The Shoemaker Comets," "Gadgeteers," "Discoveries," and "Credits." There are no illustrations and no index, but I recommend this book for the advanced student.

NOTICE: A.L.P.O. DUES INCREASE

Effective January 1, 1989, the dues for A.L.P.O. membership will increase for the first time since 1982 . This measure was passed at our recent Business Meeting in Council Bluffs. (The full minutes of this meeting imediately follow this notice.)

The new rates are as follows:

United States, Canada, and Mexico . . .	$14.00 for 1 year
	$24.00 for 2 years
All other Countries	$16.00 for 1 year
	$29.00 for 2 years

(There will be no discounts for subscription agencies.)

Please note that the new rates are per year, and that we plan to publish one volume, in four issues, per calendar year. Volume numbers will in the future correspond with calendar years, with Volume 33 being published in 1989. Because one volume has previouslyly taken about 18 months to be published, this rate increase is more significant than it might at first appear.

There are four reasons for this increase. First, expenses have exceeded revenue, particularly after the recent postal rate increase, and the organization is currently in debt to the Director. Next, we hope to increase services, such as: a regular 48-page Journal, a regular Section Directory supplied to all members, improved training aids for new members, achieving legal incorporation, and providing at least a partial compensation to our volunteer staff for their expenses. Third, by having a conqseuential increase now, we hope to avoid another dues increase for some time to come. Finally, we note that, even after this increase, the cost of belonging to the A.L.P.O. is much less than the dues required by other, comparable organizations.

Note that these new dues will not go into effect until January 1, 1989 (at 00h 00m U.T. to be precise!). Until then, all members have the opportunity to renew their memberships, either for a 6-issue or a 12-issue period, at the previous rates. Naturally, existing memberships will continue for the number of issues previously guaranteed.

MINUTES OF THE 1988 A.L.P.O. BUSINESS MEETING

By: Phillip W. Budine (Appointed Recording Secretary)

The 1988 A.L.P.O. Business Meeting was held as part of "ALCON-ALPO-Omaha-88," where we held our 38th Convention, meeting with the Astronomical League on the campus of Iowa Western Community College near Council Bluffs, Iowa. The Business Meeting was called to order at 1:10 P.M. CDT on July 28, 1988, by John E. Westfall, A.L.P.O. Director, with 16 other A.L.P.O. members attending. A report on the remainder of the Convention will appear in a future issue. The order of business follows.

I. A.L.P.O. STATUS REPORTS.

A. Financial. Director Westfall reported the following data, which are current to July 22, 1988, and are rounded to the nearest dollar.

San Francisco Bank Account . . .	$ 1552.
Las Cruces Bank Account.	1376.
Subtotal	2928.
Owed to Director	- 192.
Total.	2736.

Director Westfall noted that each issue of the Journal, A.L.P.O costs approximately $1350; $750 for printing and $600 for postage.

B. Membership. Director Westfall reported the following data, which are current to July 22, 1988.

Issue Number and Date	Number of Members (Subscribers)
32, 3-4 (July, 1987)	671
32, 5-6 (Oct., 1987)	670
32, 7-8 (Mar., 1988)	680
32, 9-10 (Aug., 1988)	702

Thus, over the last year, we have gained 31 members; a 4.6-percent increase. The current membership comprises 539 in the United States (76.8 %), 3 in Mexico (0.4 %), 23 in Canada (3.3 %), and 137 in other countries (19.5%).

C. Journal; reported by Director Westfall.

Issue	Pages	Interval Since Previous Issue
32, 5-6	48	3 months
32, 7-8	44	5 months
32, 9-10	48	5 months
Mean	46.7	4.3 months

In the future, we plan to maintain a consistent 48 pages per issue.

D. Introduction of new Membership Secretary. Director Westfall introduced our new Membership Secretary, Harry D. Jamieson, whose primary duties are maintaining membership records, acknowledging membership payments, providing mailing labels, and recruiting new members.

E. Annual Section Directory. Director Westfall noted that the Membership Secretary will issue the Section Directory to all new members. This annual publication lists the A.L.P.O. Sections' staff, projects, and publications. In the future, Mr. Jamieson will be responsible for updating this publication. [Westfall will prepare the 1988/89 Edition of the Directory, which should be available by the time that this issue is printed.]

F. Foreign Membership Dues Fund. Director Westfall noted that this fund totaled $64.00 as of July 22, 1988. [It was $88.00 as of September 25, 1988. Ed.] This fund is to provide dues for worthy potential members who live in nations where American dollars are unobtainable.

G. Hubble Space Telescope Amateur Proposals. Director Westfall noted that 47 amateur proposals had been received by the A.L.P.O. by July 22, 1988. Amateur HST proposals are apportioned to each amateur group, and the A.L.P.O.is tied for the largest number received. After the Challenger disaster, the proposal deadline was extended to the first Space Shuttle launch. In Westfall's opinion, amateur HST time will probably be limited to a few hours per year. Recorder Olivarez commented that the Section Recorders should have access to the data received. Westfall replied that this would be possible one year after an observation, when the data enter Public Domain.

II. 1989 A.L.P.O. MEETING SITE AND DATES.

Director Westfall noted that the A.L.P.O. had one official invitation and one pending invitation. The definite invitation was to meet with the Astronomical League on July 21-23, 1989, at Spokane, Washington. The tentative invitation was to meet with the Western Amateur Astronomers at one of three sites: (1) July 21-23, 1989, at Spokane, Washington, with the Astronomical League; (2) Pasadena, California, in conjunction with the August 24, 1989, Voyager-2 flyby of Neptune; (3) in Mammoth, California.

Recorder Parker moved that we accept the pending invitation of the Western Amateur Astronomers, unless they decide on the Mammoth, California, site. The motion was seconded by Membership Secretary Jamieson and then passed unanimously. [For more recent information on our 1989 meeting, check the Announcements section in this and subsequent issues. Ed.]

III. STAFF CHANGES.

Mars Recorder Donald Parker stated that Carlos E. Hernandez had been appointed as Acting Assistant Mars Recorder, with the approval of Director John Westfall, in order to help with the great influx of inquiries and observations during this apparition. Recorder Parker submittted Mr. Hernandez' name for official approval. Recorder Phillip Budine moved to accept Mr. Hernandex as Assistant Mars Recorder. This motion was seconded by Paul Stegmann and then passed unanimously.

Director Westfall stated that David Levy had telephoned him and had said that he regrettably had to resign as Recorder for the Comets and Meteors Sections because of many other demanding time commitments. With the approval of Director Westfall, David Levy had appointed Donald E. Machholz as Acting Recorder of the Comets Section and John W. Griesé, III as Acting Recorder of the Meteors Section. James V. Scotti will continue as an Assistant Recorder of both Sections, and David Levy would serve as an Assistant Meteors Recorder. Director Westfall asked for approval of these positions.

Director Emeritus Haas moved for Donald Maccholz as Comets Recorder; this action was seconded by Recorder Olivarez and passed. Derald Nye moved to continue Acting Recorder Griesê as the Acting Recorder for the Meteors Section for one more year; this motion was seconded by Membership Secretary Jamieson and then passed unanimously.

IV. MEMBERSHIP DUES INCREASE.

Director John Westfall stated that it will be necessary to increase membership dues because of postage and printing cost increases. If approved, the announcement could be made in the Volume 32, Nos. 11-12 issue of the <u>Journal, A.L.P.O.</u> The proposed rates listed below (p. 278) were discussed:

		Present Rate	Proposal No. 1	Proposal No. 2	Proposal No. 3 (Approved)
North America:	1-Vol.	$12.00	$15.00	$20.00	$14.00
	2-Vol.	$21.00	$26.00	$35.00	$24.00
Other Countries:	1-Vol.	$14.00	$18.00	$23.00	$16.00
	2-Vol.	$25.00	$31.00	$42.00	$29.00

[Note that "North America" means the United States, Canada, and Mexico; and that "Proposal No. 3" specified four <u>Journal</u> issues per subscription period, rather than the present six. Ed.]

In the discussion of the above proposals, Recorder Parker moved for a Volume consisting of four issues, published over a one-year (12-month) period. This plan was seconded by Recorder Budine and then passed unanimously. Membership Secretary Jamieson moved that Proposal Number 3, with a base North American rate of $14.00 per year, be adopted. This was seconded by Recorder Budine and passed by a vote of 13 for and 3 against (Director Westfall abstaining).

It was moved by Director Westfall that we discontinue the policy of giving discounts to subscription agencies, such as are sometimes used by institutions and foreign members. This motion was seconded by Membership Secretary Jamieson and then passed unanimously.

An open discussion followed regarding the utilization of the expected additional income received by the A.L.P.O. One topic was the possibility of producing video tapes to be used by the Lunar and Planetary Training Program, suggested by Membership Secretary Jamieson. The Recorder of the Lunar and Planetary Training Program, Jose Olivarez, will look into the possibility and the costs involved. Other ideas for promoting Solar System observation and the A.L.P.O. were discussed, such as posters and emblem items (banners, stickers, T-shirts, and so forth). There was no further action at this time.

V. A.L.P.O. SOLAR SYSTEM EPHEMERIS.

Director Westfall reported that 93 copies of the A.L.P.O. Solar System Ephemeris: 1988 had been sold as of July 22, 1988, while 15 free copies had been distributed to contributors and reviewers. [As of October 9, 1988, the number sold had risen to 111. Ed.] The 1988 edition is 100 pages in length in a 5.5X8.5-inch format.

Director Westfall stated that the current $6.00 charge for North American purchasers will suffice for 1989, but that the "overseas" charge should be raised from the current $7.00 to $8.50 in order to cover air mail postage. A motion to this effect was made by Recorder Budine, seconded by Membership Secretary Jamieson, and unanimously passed.

A final comment by Director Westfall, who edits the Ephemeris, is that it will be necessary for someone else to take on the tasks of producing and distributing the Ephemeris for the 1990 and later editions because these tasks currently take too much time away from editing the Journal.

VI. OPEN DISCUSSION.

Director Westfall brought up some ideas that we could give some thought to, regarding the future of the A.L.P.O.:

1. Reproduction of back issues of the Journal. A complete set could be produced in microfiche at a cost of about $150-200 per copy.
2. Should the A.L.P.O. incorporate? The advantages would be lower mailing costs; the ability to accept donations, bequests, and grants; and income-tax deductions for expenses incurred by the staff. He is consulting with an accountant, and estimates the approximate cost of incorporation as $500. We would need a Board of Directors that would have to meet at least once a year. Director Westfall will investigate further this possible future decision.

With no further business, Director Westfall adjourned the 1988 A.L.P.O. Business Meeting at 3:37 P.M., CDT, on July 28, 1988.

ANNOUNCEMENTS

Recent Section Staff Changes. --Several staff changes were noted in the Minutes of our 1988 Business Meeting (p. 277) and are also reflected in the listing on the inside back cover of this issue. We should also mention the appointment of Daniel M. Troiani and Harry Cralle as Acting Assistant Mars Recorders; note that Mr. Cralle has an article on pp. 256-260 of this issue. Both persons will help with the enormous workload that the Mars Section is experiencing in this very busy apparition. Both new Recorders can be contacted at: A.L.P.O. Mars Recorders, P.O. Box 97-0469, Miami, FL 33197-0469.

Address Changes. --Two existing staff members have moved recently. One is Lunar Recorder Jim Phillips, M.D., who is now located at 101 Bull Street, Charleston, South Carolina 29401. Also, Solar Recorder Randy Tatum has moved to 1108 Ocala Road, Richmond, Virginia 23229. Both new addresses are shown in the listing in the inside back cover of this issue.

1989 Solar System Ephemeris. --We expect that the A.L.P.O. Solar System Ephemeris: 1989 will be available by the time that you receive this issue, and are now accepting orders. The format is similar to the 1988 edition, with the addition of a table of major occultations of stars by planets. Further information on our publications and on how to order them is given in our publications advertisement at the bottom of this page.

Lunar Transient Phenomenon. --Dr. H. Varvoglis, of the University of Thessaloniki, has recently forwarded a report of a bright flash in Palus Somni that was photographed from Greece on 1985 MAY 23. A full report should appear in a forthcoming issue of Icarus. He, and we, urge lunar observers to monitor this region at every opportunity in order to detect and confirm any possible repetitions of this event. Send both positive and negative observational reports to Lunar Recorder Winifred S. Cameron (address on inside back cover).

Book by A.L.P.O. Recorders. --Two A.L.P.O. Recorders have had a book published recently which fills a long-term need for both novice and advanced lunar and planetary observers; the title is Introduction to Observing and Photographing the Solar System, published by Willmann-Bell, Inc., P.O. Box 35025, Richmond, Virginia 23235. The current price is $US 19.95. The three authors are non-member Thomas A. Dobbins, Mars Recorder Donald C. Parker, and our late Mars Recorder Charles F. Capen. We heartily recommend this work as a source for observing methods: visual, micrometric, and, especially, photographic.

1989 A.L.P.O. Convention. --Our plans for our 39th Convention, in 1989, are described in the Minutes of our Business Meeting in this issue (p. 277). It now appears very likely that we shall meet with the Western Amateur Astronomers in Pasadena, California, at the time of the Voyager-2 flyby of Neptune, and shall be able to watch the incoming imagery. Tentatively, the Planetary Society will host a "PlanetFest" on the one or two days before before the flyby date of Thursday, August 24, 1989, and the W.A.A.-A.L.P.O. sessions will follow the flyby on August 25-26 (Friday and Saturday). Much or all of the above is subject to change, but we will keep you posted in subsequent issues.

Astronomical Society of the Pacific Centennial Meeting. --The A.S.P .has announced that its 100th-anniversary meeting, to be called, "Universe'89," will be held in Berkeley, California on June 21-25, 1989. Note that this date will not conflict with our 1989 Convention, and that the A.S.P. meeting should be of interest to many A.L.P.O. members. For example, there will be three symposia, including one on "The Evolution of Planetary Systems." Included are tours of astronomical faciliities in the Greater San Francisco Bay Area. Besides poster papers, there will be talks on the history of astronomy, non-technical papers, and an exhibit of astronomical instruments, books, software, and other items. Don't forget the Centennial Banquet! For more information, write: Berkeley Meeting Information, A.S.P. 390 Ashton Avenue, San Francisco, CA 94112.

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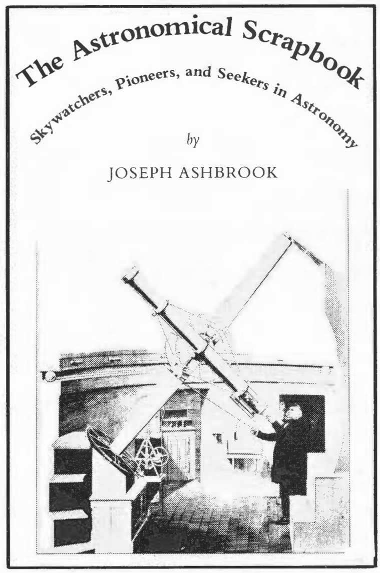

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