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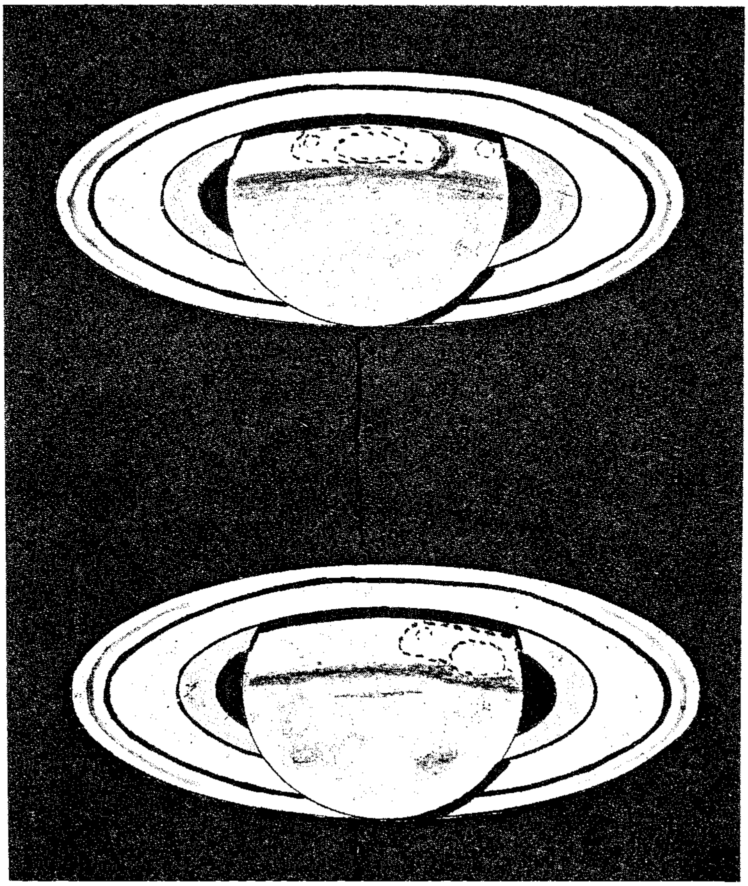

Two drawngs of Saturn by Daniel M. Troiani, showing the "Great White Oval of 1990" in the planet's Equatorial Zone, discussed on pages 24-25 of this issue. Both drawings were made on 1990 OCT 13 with a 10-inch Newtonian reflector at 374X under very good seeing and transparency conditions, have south at the top, and have their contrasts greatly enhanced. The upper view was drawn between 01h 14m-01h 19m U.T., at System I Central Meridian (C.M.) 341°, and shows the Oval on the Central Meridian with one major and three smaller light areas; Mr. Troiani interprets the shading on the right (following) edge of the large Oval as a shadow cast by the feature upon the lower cloud surface. The lower view was drawn earlier, between 00h 04m-00h 11m U.T., when the Oval was near the following limb (C.M.$_{I}$ = 301°).

THE ASSOCIATION OF LUNAR
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ALPO
Founded in 1947

IN THIS ISSUE

PLANETARY VIDEO IMAGES AND VIDEO-ASSISTED DRAWINGS

By: Daniel M. Troiani, A.L.P.O. Assistant Mars Recorder,
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ABSTRACT

Recent access to CCD equipment allows amateur astronomers to record planetary and lunar images for television display. These recordings have sufficient resolution to be useful, especially when made with large, high-precision optical telescopes and when used along with routine planetary-sketching techniques. Video-assisted drawings can help both novice and advanced observers to improve their observing skills.

INTRODUCTION

For the past several years, professional astronomers have been working with CCD's [Charge-Coupled Devices; solid-state electronic imaging arrays. Ed.] in order to produce images from telescopes. In fact, they now only rarely employ conventional film—just CCD units and computers. Accelerating advances in technology have both increased the quality and reduced the cost of these devices. Thus it was only a matter of time before amateur astronomers would be employing CCD's.

Currently, more and more amateurs are making videotapes of the Moon and planets with their own telescopes and equipment. At the most basic level, the amateur can learn how to become more proficient in the art of sketching lunar and planetary detail by recording a brief videotape during the observing session. He or she can then watch the taped display when reviewing the drawing in order to verify or to correct the positional accuracy of features and to detect details that were missed visually. Note, however, that those seriously contemplating telescopic videotaping investigate the use of professional cameras; particularly those with detachable lenses, which make them suitable for prime-focus or Barlow- or eyepiece-projection imaging.

PHOTOVISUAL OBSERVATIONS AND THE VIDEO-ASSISTED DRAWING (VAD)

A.L.P.O. Mars Recorder Donald Parker has advocated the use of photographs as an aid to drafting final drawings of Mars. This technique is called *photovisual observation.* [Brasch, 1990] This technique permits the accurate placement of the main features on the disk. One can then draw in what other features were seen visually—fine detail that the photograph would not record. Television can be similarly used, with the added advantage of being viewable immediately, producing a *video-assisted drawing* (VAD).

After making a rough drawing, one can take the videotape indoors and, with the mental image still fresh, use the tape as a guide in the placement of features in the final drawing.

When making drawings through different color filters, remember to videotape through the same filters. With Mars, for example, we use a variety of filters, but find the Wratten 47 (W47) violet as to be too dark for the common "7-LUX" cameras and a 10-inch telescope. The W21 (orange) and W23A (light red) are particularly useful for detecting Martian limb brightenings that may elude routine visual scanning. Surprisingly, we found that the best contrast was given by a combination of the W11 (green-yellow) and the W21 Filters, stacked so that light passed through the W11 first. This combination also gives a relatively-bright image. Major Martian features were nearly always more easily seen with filters, but only slightly so with the W58 (green) or W80A (light blue). Another surprise was the fact that the polar caps always appear white on the video monitor, regardless of the filter used, just as they do visually. Also, use the W23A or W25 (red) Filters to detect Martian dust storms. [Parker *et al.*, 1990] We now use red filters, not the traditional yellow, in order to detect dust storms.

EQUIPMENT AND METHODS

Observers can make interesting astronomical videotapes through their telescopes with off-the-shelf camcorders on conventional tripods. [Here, we use the term "camcorder" for a unit which combines a video camera with a video tape recorder/player. We will use the term "camera" when it does not matter whether the recorder be built-in or be a separate "VCR" unit. One important difference is that camcorders are battery-operated and completely portable; while cameras, and particularly VCR's, often require line current. On the other hand, if the camera and VCR are separate, it is possible to insert a "video enhancer" between them, which can then sharpen the image. Ed.] With one of the new varieties of video camcorders with built-in CCD, all that is required is a sizable high-resolution telescope on a clock-driven mounting. Connecting the equipment will appear more difficult than it really is; and with a little practice in getting all the elements aligned properly, the observer can obtain outstanding results on videotape. Later, the videotape can be viewed on cloudy nights. Also, for example, one can view a videotape of Mars' 24 arc-second disk when its current disk measures only 4 arc-seconds!

When we first thought of trying to capture planetary images on videotape, we were hesitant because we envisioned complex bracketing, aligning, and counterweighing in order to mate the camera system to our telescope.

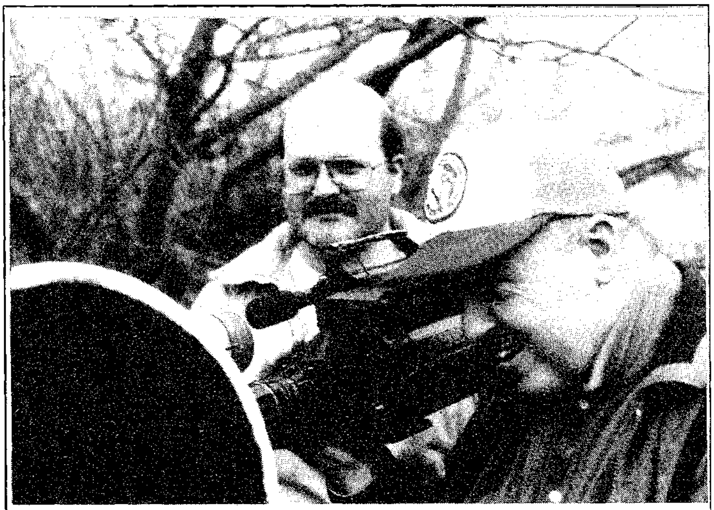

Figure 1. Hand-held afocal ("through the eyepiece") video recording technique demonstrated by Daniel P. Joyce with a 10-inch Newtonian telescope with Daniel M. Troiani looking on.

However, with only "320-line, low-definition TV," and without computer enhancement, we found that we could capture Martian features just by aiming the hand-held video camera at the telescope eyepiece (see *Figure 1* above). So much for our apprehension about afocal techniques with a camcorder—this method works well and is simple for anyone to do.

Therefore, it is possible to obtain high-quality planetary video images without mounting the camera to the telescope. The camera can be mounted on a tripod and the planet centered in the telescope eyepiece. The small, real-time monitor on the camera then becomes indispensable in keeping track of alignment, framing, and focus. For a better view, the camera may be connected to a full-size television monitor. What a difference from attempting conventional film photography and waiting around with fingers crossed to see if those exposures came out! Even seeing conditions are "averaged out" in a manner similar to visual observing because the video camera views continuously as does the eye. If a moment of excellent seeing occurs, the videotape will catch it.

Because the eyepiece is in motion with most designs of clock-driven telescopes, it would appear that a fixed, tripod-mounted camcorder would quickly lose track of the image. Actually, once well-centered in the eyepiece, any planet or lunar feature tends to remain in the video image for as long as 5 or 6 minutes before readjustment is required. In general, the eyepiece may move either away from or toward the camera with a Newtonian design, depending on tube orientation; but tangentially with, for example, a refractor or Schmidt-Cassegrain. An eyepiece diagonal will change the direction of movement of the eyepiece, but of course will laterally reverse the image. With a little practice, you can master this technique and begin to make your own planetary videotapes with a minimum of equipment.

The afocal videotaping method can be done with any camcorder, or camera with video monitor; those used by the authors were the Magnarox Model VR 9240 camcorder and the GBC black-and-white "0.2 lux" camera.

Recently there have appeared on the market some CCD camcorders equipped with color-balance sensors that may attempt to "correct" for the effects of filters, partly negating the desired effect of using filters. If such a unit does not have manual color-balance overrides, it is unsuitable for filter applications; if it does, the override should be engaged.

A remaining possible problem is vignetting, which occurs when the image occupies only the central portion of the camera's field and thus the edges are dark. This does not occur with planetary imaging as long as the planet is approximately centered in the field. With the Sun and Moon, vignetting can occur. This can be cured with the zoom lenses that most camcorders now have; simply "zoom up" to about 5 times the normal focal length, which will reduce the camera's angular coverage to the fully-illuminated portion of the field. Remember that the apparent magnification of the video image when it is viewed will be equal to the magnification used at the telescope at the time of videotaping *times* the zoom magnification of the camera.

CONCLUSION

While still not capable of resolving detail as fine as shown in modestly good visual sketches, television often makes features much more obvious than at the eyepiece. This is especially true of Martian low-lying frost or fog limb phenomena. Also, video images provide an additional dimension; quantitative information. Although visual drawings can be first-rate in a qualitative sense, they should not be relied upon quantitatively; for the determination of positions, dimensions, or albedos. Video images begin to reveal this type of information. As with visual drawing, color filters can often accentuate planetary features and offer remarkable contrast in video images.

Many of us were either born in or grew up in the video age. This began in the 1950's with "TV"; most of us became addicted to television at an early age. In the 1960's we

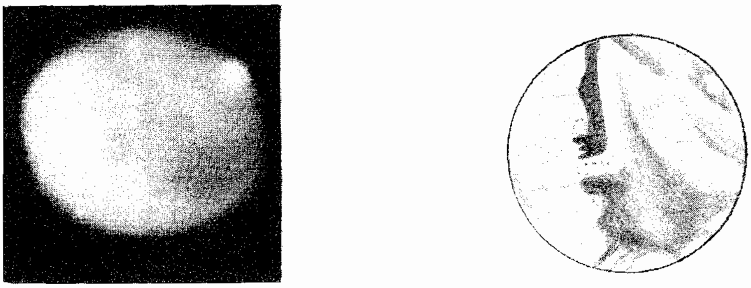

Figure 2. Video image (left) and drawing (right) of Mars, made with the aid of the video image. The video image was made with a 10-inch (25-cm.) Newtonian telescope at 260× on 1988 SEP 25, 07h 05m U.T. (Central Meridian 358°) The drawing was made by Daniel M. Troiani with the same instrument at 374× on the same date at 08h 00m-08h 20m U.T. (Central Meridian 012°-017°); Seeing 9.5 on the A.L.P.O. Scale of 0 (worst) - 10 (best); Transparency (limiting magnitude) +5.0. No filters were used for either observation. Mars' angular diameter was 24 arc-seconds at that time. South at upper right.

witnessed the advance from black-and-white to color monitors, satellite transmissions from around the globe, and images of the Moon and other extraterrestrial vistas. During the late 1970's and into the 1980's we saw the onset of personal video recorders and video cameras; these advances provided an opportunity for amateur astronomers. Most recently, highly-sensitive CCD's now allow us to videotape the Sun, Moon, and planets with satisfactory results. With such equipment now readily available and affordable, video techniques will grow in importance in amateur astronomy. The preliminary results are most exciting, particularly from the widely-observed 1987-89 Apparition of Mars. All the major albedo features on the Red Planet were prominent in the videotapes, as were dust storms and limb hazes, frosts, and fogs. The shrinkage of the South Polar Cap was well-documented during this period.

With the advent of using television at the telescope, it is more and more desirable to use large-aperture high-resolution telescopes in order to obtain planetary video images. By training more observers to sketch Solar System objects with the "VAD" technique, we could greatly increase the amount of serious useful observation. Currently, video images cannot replace the human eye for high-resolution observations of the planets; we are sure that they will sometime in the future, but for now video techniques can help you in making great planetary drawings (for an example of a video image of Mars and a drawing made with its aid, see *Figure 2* above; see also the video image of Jupiter in *Figure 3* to the right).

We want to acknowledge the fine images and the encouragement provided by David Brewer of DuBarry, Florida, and by Alan MacFarlane of Seattle, Washington [see MacFarlane (1990)]. They had very sage advice for us. It was Jimmy Carroll, our colleague from nearby Schiller Park, who first directed our attention to the advances that were being made in video astronomy, and he has since been given the title "Captain Video" for his more recent tireless efforts. The A.L.P.O. Mars Recorders Jeff Beish and Donald Parker also have encouraged us and are now using these techniques themselves. We are certain that we have not mentioned some other persons who have been in the vanguard, but we sing your praises too.

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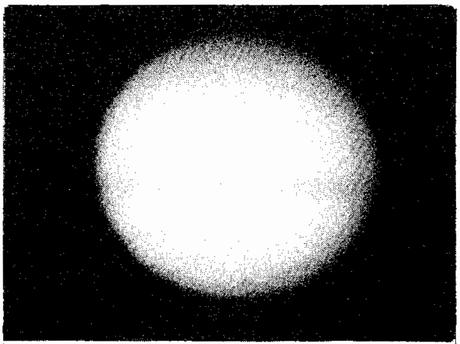

Figure 3. Video image of Jupiter taken with Donald Parker's 16-inch (41-cm.) f/6 Newtonian reflector, using a 244× eyepiece, a Magnarox VR9240 camcorder and a yellow (Wratten 8) filter. Taken 1990 JAN 30 at 05h 30m U.T. South at top.

THE INTERNATIONAL MARS PATROL IN 1987-89—PART I

By: Jeff D. Beish, Donald C. Parker, Carlos Hernandez, Daniel Troiani,
and Harry Cralle, A.L.P.O. Mars Recorders

ABSTRACT

This paper is an A.L.P.O. International Mars Patrol (IMP) report and observational summary for the 1987-89 Perihelic Apparition of Mars. The Martian South Polar Cap and Polar meteorology, as well as a description of two major dust storms that occurred on Mars, are discussed. A possible new Martian surface feature that was discovered by A.L.P.O. astronomers is described.

INTRODUCTION

The 1987-89 Perihelic Apparition of Mars will be remembered as the most popular and productive apparition in the history of the Mars Section of the A.L.P.O. We will report on the more interesting facets of this apparition, giving due credit to all those dedicated astronomers who participated and contributed observations. First, we will present the state of the International Mars Patrol (IMP) and describe the Mars Section Recorders. The 1987-89 Apparition shall be discussed in detail, with some comments on the methods and techniques of observing Mars. (This report will have to be published in at least two parts.)

We will not present individual observers' drawings and photographs in this report due to the great volume of observations that were received. However, in order to share the credit of the very successful 1987-89 Apparition; we will publish a report with at least one observation report (drawing or photograph) of each observer in the near future. [Although there may not be room in *this* Journal. Ed.]

THE INTERNATIONAL MARS PATROL IN 1987-89

The 1987-89 Perihelic Apparition of Mars has indeed proved to be a most exciting event for the planetary observer. A.L.P.O. Executive Director John Westfall predicted that, for observers in the Earth's Northern Hemisphere, Mars would be in its most favorable position since the year 1875 and would not be positioned as well until 2025–a 150-year period [Westfall, 1988]. The A.L.P.O. Mars Recorders agreed in principle with his forecast, and it appears that this proposition has been correct–Mars was truly the great astronomical show of 1987-89.

By the end of June 1989, the Mars Section had received more than 1,000 letters and postcards from interested amateur and professional astronomers located in 42 countries, regions, or United States territories: Arabia, Argentina, Austria, Australia, Belgium, Bolivia, Brazil, Canada, Mainland China, Czechoslovakia, Columbia, England, Faroe Islands, France, Germany, Greece, India, Israel, Italy, Japan, Korea, Mexico, New Guinea, New Zealand, Norway, Nova Scotia, Okinawa, Philippines, Polynesia, Puerto Rico, Romania, Rwanda, Samoa, Scotland, South Africa, Spain, Sweden, St. Croix, Taiwan, the United States, and Venezuela.

We think that the renewed interest in the Red Planet, and in planetary astronomy in general, is a direct result of the articles published in the past two years in *The Strolling Astronomer* (*J.A.L.P.O.*), *Astronomy*, *Sky & Telescope*, and The Planetary Society's *The Planetary Report*. We commend the editors of these publications for their help in making the public, and practicing astronomers, aware of the pleasure of observing the Solar System.

The massive response to the most favorable Mars apparition in over a century is largely the result of the late Charles F. Capen's efforts in establishing the IMP. Because the IMP network was already in place, there was unprecedented international cooperation. Additional support was provided by the Oriental Astronomical Association (OAA), the British Astronomical Association (BAA), the Arbeitskreis Planetenbeobachter (Germany), and the Groupement Internationale d'Observateurs des Surfaces Planetaires (GIOSP); the last a group recently founded by Prof. Jean Dragesco to stimulate international cooperation in high-quality planetary observations, and headed by noted amateur and professional astronomers from around the world.

We wish to especially to thank the members of the Planetary Society's *Mars Watch '88* Science Advisory Council; Leonard J. Martin of the Planetary Research Center at Lowell Observatory, Flagstaff, Arizona; and Prof. Phillip James of the University of Missouri at St. Louis for their help in bringing the professional and amateur planetary scientists together to record the 1987-89 Apparition of Mars. The close cooperation between amateur and professional astronomers was quite evident during January, 1989, as the world's leading Mars researchers met in Tucson, Arizona for the Fourth International Conference on Mars. Presented at this meeting were several papers by Leonard Martin, Phil James, Jeff Beish, and Don Parker–making it the first time amateurs were invited to present their work to this august body of international scientists.

THE MARS SECTION EXPANDS

As the A.L.P.O. Mars Section grows in size, so does its workload. To keep up with the growing number of letters and reports, we have asked our Executive Director, John

Westfall, to appoint two additional Assistant Mars Recorders to the Section. We have also selected Assistant Recorder Carlos Hernandez to be promoted to Mars Recorder. Carlos now resides in Woodbridge, New Jersey. In addition, we have appointed two very capable and enthusiastic Mars observers, Daniel Troiani of Schaumberg, Illinois and Harry Cralle of Bryan, Texas as acting Assistant Mars Recorders. [The addresses of all Recorders are given on our inside back cover.]

Each Recorder has areas of responsibility that suit his interest in Mars and is responsible for observations received and for corresponding with observers in specific geographic areas as follows: **J.D. Beish**–Alabama, Arkansas, Florida, Georgia, Hawaii, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia. **Harry Cralle**–Arizona, California, Colorado, Kansas, Louisiana, Missouri, Nevada, New Mexico, Oklahoma, Texas, Utah, and Wyoming. **Carlos Hernandez**–Alaska, Connecticut, the District of Columbia, Delaware, Massachusetts, Mary-land, Maine, New Hampshire, New York, New Jersey, Pennsylvania, Rhode Island, and Vermont. **Donald C. Parker**–Overseas and United States territories. **Dan Troiani**–Idaho, Illinois, Indiana, Iowa, Michigan, Minnesota, Montana, Nebraska, North Dakota, Ohio, Oregon, South Dakota, Washington, West Virginia, and Wisconsin.

1987-1989 OBSERVATIONAL SUMMARY

The 1987-89 Perihelic Apparition of Mars began with Donald Parker's observation of the Red Planet on 1987 NOV 09 (100° Ls). [Ls is the areocentric longitude of the Sun and thus measures the Martian season, being 000° at the planet's Northern-Hemisphere Spring Equinox.] The last Mars observations were made from Las Cruces, New Mexico on 1989 JUN 07 by Walter Haas and from Boynton Beach, Florida by Dan Boyer on 1989 JUN 12 (053° Ls). (See *Table 1*, pp. 6-9; the history of A.L.P.O. Mars observations for the 1969-1988 Apparitions is summarized in *Tables 2 and 3* (p. 10).

During the 1987-89 apparition, 73 percent of the Martian year, (261° Ls) was actually observed. A substantial portion of each Martian season was covered, resulting in; 100 percent (090° Ls) of the Southern Spring; 100 percent (090° Ls) of the Southern Summer, 41 percent (037°Ls) of the Southern Autumn, and 49 percent (044° Ls) of the Southern Winter (See *Figure 4*, below).

The 1987-89 Apparition was considered a perihelic apparition because opposition occurred only 30 degrees after perihelion (250° Ls). Mars reached opposition at 03h 23m U.T, [Universal Time] on 1988 SEP 28 (280°.2 Ls) and was closest to Earth at 03h 18m U.T. on 1988 SEP 22 (276°.5 Ls) with a distance of 0.39237 astronomical units (58,698,000 km or 36,473,000 miles) and an apparent disk diameter of 23.85 arc-seconds.

A total of 413 telescopes was used by IMP Mars observers this apparition, averaging 11.8 inches in aperture. Although most of the telescopes used by observers ranged between 3 and 16 inches in aperture, several astronomers employed reflectors of 20, 42, 60, and 90 inches and refractors up to 33 inches.

By June 12, 1989, 304 observers from 42 countries had contributed 7,052 Mars observations (4,813 drawings, 2,032 photographs, 16 CCD images, and 191 micrometer measurements), an indication of increasing interest in the scientific study of the Red Planet. Included in the voluminous collection of observations were several video tapes with hours of images of Mars. This was a very successful observing program indeed!

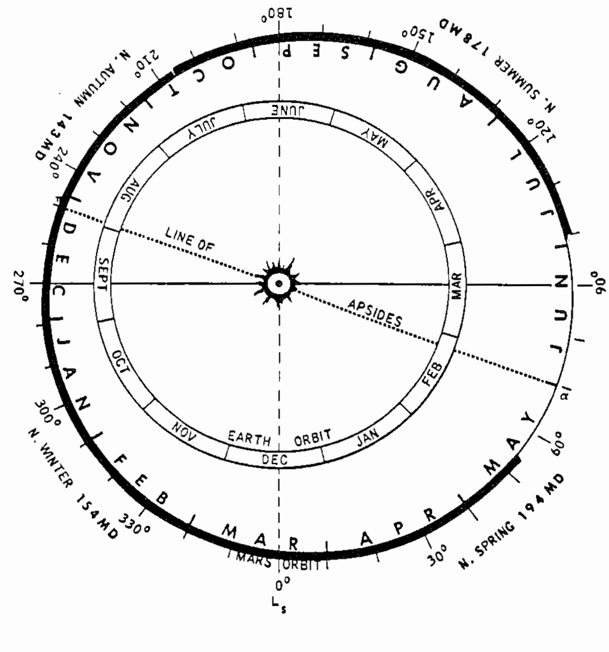

Figure 4. Seasonal observational coverage of the 1987-89 Martian Apparition by the A.L.P.O. International Mars Patrol. Mars' orbit is graduated in degrees of Areocentric Longitude of the Sun (Ls), with 0° defined as the Spring Equinox of the Martian Northern Hemisphere. "MD" stands for Martian Date.

Table 1. Contributing Observers, 1987-89 Apparition of Mars.

This table uses the following abbreviations: V, visual drawings; P, photographs; M, micrometer measurements; CASS, Cassegrain; CAT, Catadioptric; HERS, Herschelian; NEW, Newtonian; RR, Refractor; and TRIS, Tri-Schiefspiegler. Telescopes apertures are in inches.

Observer, Location	Observations			Telescope
	V	P	M	
M. Adachi, Japan	15	-	-	8.0 RR 12.0 NEW
B. Adcock, Australia	-	115	-	12.5 TRIS
L. Aerts, Belgium	31	-	-	11.0 CAT 12.0 NEW
A.F.A.M.(4 observers), Italy	25	-	-	3.5 RR 7.3 RR 8.0 CAT 8.3 NEW 8.5 NEW 11.8 NEW
R. Ajuria, Mexico	11	-	-	5.0 CAT 11.0 CAT
Y. Akutsu, Japan	-	118	-	10.0 NEW
R. Albertson, Fridley, MN	18	-	-	6.0 NEW
M. Alecsescu, Romania	78	-	-	6.0 CASS 8.0 CASS
M. Allen, Oak Hill, WV	-	2	-	8.0 CAT
S. Allen, Atmore, AL	30	-	-	14.3 NEW 22.0 NEW
R. Alonzi, Leavenworth, KS	10	2	-	30.0 NEW
J. Aloy, Spain	10	4	-	12.0 NEW
M. Anderson, Mission, KS	1	2	-	30.0 NEW
J. Armstrong, Villa Rica, GA	1	-	-	5.0 RR
T. Asada, Japan	-	19	-	12.0 NEW
J. Asztalos, West Allis, WI	-	20	-	12.5 NEW
R. Aubé, Canada	6	-	-	8.0 NEW
G. Austin, --	1	-	-	8.0 CAT
W. Baldwin, Jacksonville, FL	5	49	-	8.0 NEW
R. Ball, Bristol, TN	3	-	-	10.0 NEW
S. Ball, Australia	1	-	-	6.0 NEW
K. Bartholomew, Poyduas, LA	9	-	-	8.0 NEW
M. Bauchnerova, Czechoslovakia	8	-	-	6.0 RR 6.3 RR 8.0 RR 10.0 CASS
J. Beish, Miami, FL	107	12	11	12.5 NEW 16.0 NEW 18.0 NEW 20.0 NEW 23.0 RR
S. Bergeron, Canada	13	-	-	8.0 NEW
S. Bissonnette, Canada	3	-	-	8.0 NEW
T. Blazicek, Czechoslovakia (group observation)	2	-	-	6.0 RR 6.3 RR 8.0 RR 10.0 CASS
P. Bock, Sterling, PA	1	-	-	4.0 RR
R. Bolster , Washington,DC	-	21	-	12.0 RR 14.0 CAT
J. Borra, Leawood, KS	1	-	-	30.0 NEW
M. Boschat, Nova Scotia	94	-	-	3.0 RR
A. Bosselaers, Belgium	1	-	-	12.5 TRIS
M. Bosselaers, Belgium	8	-	-	12.5 TRIS
D. Boyar, Boynton Beach, FL	36	-	-	8.0 NEW
K. Brasch, Jenks, OK	28	5	-	14.0 CAT
J. Brooks, Santa Ynez, CA	8	-	-	8.0 CAT
J. Brown, Santa Barbara, CA	13	-	-	8.0 CAT
J. Brunkella, Thousand Oaks, CA	26	-	-	10.0 CAT
D. Bryant, East Falmouth, MA	5	-	-	8.0 NEW
R. Buchanan, Joplin, MO	17	-	-	6.0 NEW 10.0 NEW
R. Buggenthien, Germany	15	-	-	6.0 RR
C. Buckley, Chicago, IL	2	-	-	7.0 RR 10.0 TRIS
E. Bunn, Westford, MA	15	-	-	6.8 RR
Z. Burget, Czechoslovakia (group observation)	1	-	-	6.0 RR 6.3 RR 8.0 RR 10.0 CASS
E. Calvo, Spain	-	5	-	3.5 RR
G. Cameron, Ames, IA	5	-	-	12.5 NEW
T. Campbell, Villa Rica, GA	1	-	-	5.0 RR
G. Canonaco, Belgium	37	5	-	8.0 NEW 12.0 RR
B. Cardenas, Mexico	8	-	-	11.0 CAT
L. Carlino, Lockport, NY	5	-	-	11.0 CAT
J. Carroll, Schiller Park, IL	2	-	-	10.0 NEW
J. Caruse Harvard, MA	6	-	-	6.5 RR
D. Cautolen, France	-	3	-	39.6 NEW
T. Cave, Long Beach, CA	42	-	-	12.5 NEW 18.8 NEW
J. Cerreta, Italy	8	2	-	23.6 RR
D. Costanzo, Arlington, VA	-	1	-	12.0 RR
T. Cragg, Australia	20	-	-	12.5 NEW
H. Cralle, Bryan, TX	200	-	121	8.0 NEW
A. Crayon, Phoenix, AZ	14	-	-	8.0 NEW
S. Damiano, Italy	44	-	-	6.0 RR 12.0 CASS
E. Daniel, Coarsegold,CA	24	-	-	6.0 NEW
D. Darling, Sun Prairie, WI	9	-	-	12.5 NEW
F. Dement, Kennewick, WA	29	-	-	3.7 RR
A. Desai , India	30	-	-	8.0 CAT
K. Devadas, India	25	-	-	10.0 NEW
A. Diepvens, Belgium	8	-	-	6.0 RR
S. Dijon, France	32	-	-	8.3 NEW
M. Doka, Elizabeth City, NC	6	-	-	10.0 CAT
C. Dong hua, China	17	-	-	4.0 NEW
C. Douglas, Mission, KS	3	-	-	30.0 NEW
J. Dragesco, France (Flagstaff, AZ)	-	41	-	24.0 RR
J. Drummond, New Zealand	19	-	-	10.0 CAT
A. Durri, Netherlands	-	1	-	10.0 NEW
J. Dusek, Czechoslovakia	40	-	-	6.0 RR 6.3 RR 8.0 RR 10.0 CASS
P. Van D.Eijnde, Netherlands	2	-	-	8.2 NEW
J. Ergon, Sweden	6	8	-	10.0 NEW
C. Evans, Hampton, VA	30	-	-	6.0 RR
K. Fabian, Chicago, IL	26	-	19	8.0 NEW
N. Falsarella, Brazil	1	4	-	8.0 NEW
R. Fawcett, Scotland	1	-	-	6.0 RR
B. Flach-Wilkeb, Germany	-	29	-	12.0 NEW
D. Fischer , Germany	50	-	-	3.0 RR 8.0 NEW
P. Fischetti, San Jose, CA	3	-	-	4.5 NEW
J. Fletcher, England	10	-	-	10.0 NEW
G. Forno, Italy	14	-	-	4.5 RR
C. Franciosi, Italy	1	-	-	5.0 RR

Table 1. Contributing Observers, 1987-89 Apparition of Mars—*Continued.*

Observer, Location	Observations			Telescope
	V	P	M	
W. Frerck, Houston, TX	110	120	-	5.7 RR
				14.0 CAT
T. Fuller, Santa Barbara, CA	-	1	-	18.0 NEW
J. Gamarra, Spain	8	-	-	2.4 RR
D. Gegen, Greenville, SC	-	9	-	23.0 RR
M. Gelinas, Canada	24	6	-	6.0 RR
B. Giuseppe, Italy	16	-	-	8.0 CAT
J. Gillray, Australia	19	-	-	8.0 NEW
Q. Giovanni, Italy	45	-	-	6.0 RR
				12.0 CASS
K. Gleason, Boulder, CO	-	14	-	24.0 CASS
R. Gomien, St. Louis, MO	2	1	-	14.0 CAT
O. Gonzalez, N. Miami, FL	8	-	-	8.0 CAT
L. Goode, Paula, KS	1	1	-	30.0 NEW
R. Gordon, Nazareth, PA	4	-	-	2.5 RR
				3.0 RR
				5.5 RR
M. Goutel, Canada	5	-	-	8.0 NEW
				12.5 NEW
J. Gracia, Spain	9	-	-	12.2 RR
D. Graham, England	58	-	-	6.0 RR
				10.0 NEW
				16.0 NEW
F. Graham, E. Liverpool, OH	2	11	-	7.0 RR
I. Grant, Australia	6	-	-	8.0 NEW
H. de Groote, Belgium	-	3	-	12.0 NEW
H. Gross, Germany	16	-	-	8.0 CASS
R. Gubbels, Belgium	2	-	-	6.0 NEW
W. Haas, Las Cruces, NM	66	-	-	8.0 NEW
				12.5 NEW
D. Hanon, Ringgold, GA	-	8	-	7.0 RR
S. Haro, Mexico	8	-	-	5.0 NEW
C. Hartley, Oneonta, NY	21	-	-	16.0 CASS
E. Harvey, Australia	6	-	-	14.0 CAT
C. Haun, Morristown, TN	12	-	-	13.1 NEW
A. Havrilla, Eastlake, OH	1	-	-	16.0 NEW
A. Heath, England	27	-	-	12.0 NEW
J. Heath, Commerce, TX	1	-	-	8.0 NEW
A. Herbert, St. Peters, MO	2	-	-	5.0 CASS
H. Herman, Mequon, WI	4	-	-	4.0 RR
J. Hermans, Brillion, WI	1	-	-	5.0 HERS
C. Hernandez, Miami, FL	17	-	-	16.0 NEW
A. Herring, Anaheim, CA	17	7	-	12.5 NEW
D. Hill, Peoria, IL	3	-	-	9.0 RR
R. Hill, Tucson, AZ	10	-	-	8.0 CAT
				9.3 RR
D. Himes, Chagrin Falls, OH	13	-	-	12.5 NEW
				16.0 NEW
J. Hollan, Czechoslovakia	1	-	-	6.0 RR
(group observation)				6.3 RR
				8.0 RR
				10.0 CASS
J. Hoppe, Germany	20	-	-	3.0 RR
T. Hoppe, Stilwell, KS	1	-	-	30.0 NEW
F. Hroch, Czechoslovakia	5	-	-	6.0 RR
				6.3 RR
				8.0 RR
				10.0 CASS
T. Hudecek, Czechoslovakia	1	-	-	6.0 RR
(group observation)				6.3 RR
				8.0 RR
				10.0 CASS
T. Ishibashi, Japan	-	111	-	8.3 NEW
				10.0 TRIS

Observer, Location	Observations			Telescope
	V	P	M	
G. Johnson, Swanton, MD	2	-	-	6.0 NEW
G. Jones, Bel Air, MD	27	-	-	16.0 CASS
J. Jones, Houston, TX	8	-	-	14.0 CAT
T. Jorgenson, Neenah, WI	3	2	-	10.0 CAT
D. Joyce, Chicago, IL	12	6	-	10.0 TRIS
				10.0 NEW
N. Kanas, Kentfield, CA	3	-	-	8.0 CAT
T. Kenyon, Palmetto, FL	46	-	-	2.4 RR
				10.0 NEW
				20.0 NEW
L. Keith, Milwaukee, WI	4	4	-	12.5 NEW
C. Kirkpatrick, Santa Barbara, CA	48	34	-	16.5 CASS
F. Kline, Washington, DC	-	12	-	8.0 CAT
				12.0 RR
				14.0 CAT
				20.0 CASS
D. Klos, Brillion, WI	5	-	-	5.0 HERS
G. Knight, Canada	5	-	-	12.0 NEW
P. Koch, Las Vegas, NV	9	-	-	10.0 CASS
D. Koehler, Waukesha, WI	-	9	-	11.1 NEW
P. Kolar, Czechoslovakia	1	-	-	6.0 RR
(group observation)				6.3 RR
				8.0 RR
				10.0 CASS
A. Kruijshoop, Australia	2	-	-	12.5 NEW
J. Kuhter, La Mesa, CA	2	-	-	3.0 RR
				16.0 NEW
J. Lamb, Commerce, TX	33	-	-	8.0 NEW
J. Lauderback, South Bend, WA	2	-	-	8.0 NEW
M. Larkin, Blue Springs, MO	1	2	-	30.0 NEW
A. Larocgue, Canada	1	-	-	10.0 NEW
J. LaVigne, Naples, FL	12	-	-	16.0 NEW
M. Legrand, France	16	4	-	8.0 NEW
E. Lerner, Lawrenceville, NJ	1	-	-	6.0 NEW
F. Lewandowski, Rochester, NY	4	-	-	4.5 NEW
L. Lewis, Kerrville, TX	2	-	-	12.5 CASS
J. Lightcap, --	1	-	-	--
J. Liguori, Tiverton, RI	1	-	-	8.0 CAT
T. Lohvinenko, Canada	36	-	-	8.0 CAT
F. Van Loo, Belgium	9	-	-	10.0 NEW
C. Lower, Port Deposit, MD	6	-	-	8.0 NEW
R. Lucas, Goleta, CA	1	-	-	10.0 CAT
R. Lunsford, Chula Vista, CA	27	-	-	6.0 RR
B. Lux, McKeesport, PA	1	-	-	6.0 NEW
L. Macdonald, England	3	-	-	4.5 NEW
C. MacDougel, Tampa, FL	27	-	-	6.0 NEW
A. MacFarlane, Seattle, WA	1	4	-	11.0 CAT
R. Mallory, Huntington Beach, CA	11	-	-	6.0 NEW
J. Manifold, Louisburg, KS	1	1	-	30.0 NEW
B. Manske, Waunakee, WI	26	-	-	8.0 CAT
				17.5 NEW
R. Marcisz, Chicago, IL	2	-	-	8.0 NEW
T. Martinez, Cleveland, MO	7	3	-	30.0 NEW
G. Marzo, Belgium	1	-	-	8.0 RR
C. Massey, Glen Rock, NJ	-	2	-	12.5 NEW
N. Matsopoulos, Greece	-	30	-	25.0 RR
M. Mattei, Littleton, MA	49	-	-	6.0 RR
P. Maxson, Glendale, CA	-	12	-	14.3 NEW
R. McArthur, Andover, KS	22	-	-	8.0 CAT
R. McKim, England	35	-	-	33.0RR

Table 1. Contributing Observers, 1987-89 Apparition of Mars—*Continued.*

Observer, Location	Observations			Telescope
	V	P	M	
G. McNamara, Australia	6	-	-	16.0 NEW
J. Meadows, Memphis, TN	9	-	5	10.0 NEW
D. Means, Tucson AZ	8	-	-	5.0 RR 8.0 CAT 90.0 CASS
F. Melillo, North Valley Stream, NY	62	34	-	8.0 CAT
J. Melka, St. Louis, MO	12	15	-	8.0 NEW 24.0 CASS
M. Miller, Huntington Beach, CA	35	-	-	10.0 CAT
L. Mitchell, Houston, TX	47	-	-	8.0 NEW 10.0 CAT 12.5 NEW 14.0 CAT 16.0 CASS
I. Miyazaki, Okinawa	68	173	-	8.0 NEW
R. Modic, Richmond Heights, OH	29	-	-	8.0 NEW
J. Moll, Greenville, SC	-	21	-	8.0 CAT 23.0 RR
Y. Morissette, Canada	1	-	-	8.0 NEW
W. Morris, Manahawkin, NJ	8	10	-	6.0 NEW
M. Morrow, Ewa Beach, HI	41	-	-	16.0 NEW
P. Mozel, Canada	2	2	-	5.0 RR
T. Nakagami, Japan	-	67	-	11.4 NEW
M. Nakajima, Japan	18	5	-	8.0 NEW
F. Naud, Canada	1	-	-	4.5 CAT
R. Néel, France	44	-	-	12.0 NEW
J. Nehls, Crestwood, IL	1	-	-	5.6 RR
Z. Nesvadba, Czechoslovakia (group observation)	1	-	-	6.0 RR 6.3 RR 8.0 RR 10.0 CASS
P. Neville, England	11	-	-	8.75 NEW
G. Nichols, East Hampton, CT	11	-	-	6.0 NEW
U. Vag Nolsoe, Faroe Islands	9	-	-	8.0 CAT
C. Northam, South Africa et al(group of amateurs)	44	-	-	12.0 CASS
G. Nowak, Essex Jct., VT	20	-	-	8.0 NEW 9.0 RR
E. Ofek, Israel	4	-	-	8.0 CAT
P. Olding, England	1	-	-	3.0 RR
S. O'Meara, Cambridge, MA	14	-	-	9.0 RR 60.0 CASS
T. Osawa, Japan	16	-	-	12.5 NEW
S. Padills, Lakewood, CA	-	1	-	18.0 NEW
R. Panigoni, -	28	-	-	8.0 CAT
J. Park, Australia	4	-	-	8.0 NEW
D. Parker, Coral Gables, FL	145	156	30	12.5 NEW 16.0 NEW 18.0 NEW 20.0 NEW 23.0 RR
S. Parker, New Zealand	23	-	-	4.0 RR
C. Peterson, Sacramento, CA	5	-	-	8.0 CAT
R. Petti, South Euclid, OH	1	-	-	3.0 RR
J. Pfannerstill West Allis, WI	6	1	-	6.0 NEW 12.5 NEW
W. Piorkowski, Tinley Park, IL	-	8	-	16.0 NEW
R. Powaski, Euclid, OH	5	-	-	10.0 NEW

Observer, Location	Observations			Telescope
	V	P	M	
P. Pravec, Czechoslovakia	7	-	-	6.0 RR 6.3 RR 8.0 RR 10.0 CASS
F. Price, Buffalo, NY	14	-	-	8.0 NEW
T. Printy, Orlando, FL	6	11	-	10.0 CAT
P. Ptacek, Czechoslovakia	5	-	-	6.0 RR 6.3 RR 8.0 RR 10.0 CASS
D. Raden, Fort Meade, FL	15	-	-	6.0 RR
R. Ramakers, Genk, Belgium	-	2	-	12.0 RR
M. Regis, France	-	1	-	--
T. Rezek, Czechoslovakia	4	-	-	6.0 RR 6.3 RR 8.0 RR 10.0 CASS
K. Rhea, Paragould, AR	215	24	-	4.0 RR 6.0 NEW 8.0 NEW
R. Robinson, Morgantown, WV	25	-	-	10.0 NEW
W. Robinson, Bonner Springs, KS	4	3	-	30.0 NEW
R. Robotham, Canada	28	-	-	6.0 NEW
M. Roos, Netherlands	16	-	-	4.0 RR
J. Rogers, England	17	-	-	10.0 NEW
G. Rosenbaum, Tucson, AZ	11	9	-	5.0 RR 8.0 NEW 16.0 CASS 90.0 CASS
G. Rosenberg, San Francisco, CA	19	-	-	8.0 NEW
J. Rouse, Greenville,SC	-	10	-	8.0 NEW
R. Roye, Lakewood, CA	29	16	-	12.5 NEW 18.0 NEW
J. Sanford, Orange, CA	-	6	-	12.0 CASS
M. Santo, Italy	52	-	-	6.1 NEW 8.0 NEW
J. Saucedo, Mexico	7	-	-	8.0 RR 11.0 CAT
C. Schambeck, Germany	7	-	-	4.5 NEW
R. Schepis, Mullica Hill, NJ	17	-	-	10.1 NEW
R. Schmidt, Pittsburgh, PA	7	-	-	13.0 RR
R. Schmude, Rosenberg,TX	164	-	-	4.1 RR 6.0 NEW 14.0 CAT
K. Schneller, Euclid, OH	9	-	5	8.0 NEW
A. Schroyens, Belgium	7	-	-	6.0 NEW
G. Schwartz, Wichita, KS	11	-	-	5.0 RR
L. Scott, Tyler,TX	4	-	-	8.0 NEW
D. Searcy, Dallas, TX	-	10	-	12.0 CASS
M. Shirao, Japan	-	437	-	14.0 NEW
J. Sims, Miami, FL	12	-	-	10.0 NEW
V. Simon, Czechoslovakia	7	-	-	3.1 RR
R. Singer, Czechoslovakia (group observation)	1	-	-	6.0 RR 6.3 RR 8.0 RR 10.0 CASS
J. Skubal, Czechoslovakia	4	-	-	6.0 RR 6.3 RR 8.0 RR 10.0 CASS

Table 1. Contributing Observers, 1987-89 Apparition of Mars—*Continued.*

Observer, Location	Observations			Telescope
	V	P	M	
D. Slauson, Swisher, IA	22	-	-	4.0 RR 8.0 NEW
R. Smith Santa Ysabel, CA	1	-	-	--
B. Sobel, Tarzana, CA	4	16	-	--
M. Stangl, Austria	13	7	-	--
P. Stegmann, Fairview, NJ	8	-	-	10.0 CAT
J. Stem, Studio City, CA	11	-	-	10.0 CAT
B. Stevens, Rolling Meadows, IL	2	-	-	8.0 CASS
P. Stinissen Belgium	1	-	-	8.0 RR
J. Strakowski, -	-	6	-	14.0 CAT
S. Swagerty, Overland Park, KS	3	1	-	30.0 NEW
M. Sweetman, Tucson, AZ	31	-	-	10.2 CASS
B. Talaga, Tucson, AZ	47	-	-	8.0 NEW
P. Tanga, Italy	44	1	-	6.0 NEW
R. Tatum, Richmond, VA	4	-	-	7.0 RR 26.0 RR
G. Teichert, France	112	-	-	11.0 CAT
G. Terrence, Lima,NY	1	7	-	6.0 RR
R. Thompson, Independence, MO	1	1	-	30.0 NEW
M. Torres Colorado Springs,CO	6	-	-	8.0 CAT
R. Trembour, Willoughby Hills, OH	3	-	-	10.0 CAT
D. Troiani , Schaumberg, IL	152	23	-	10.0 NEW 24.0 NEW
R. Trother, Canada	7	-	-	12.5 NEW
A. Vargas, Bolivia	14	-	-	8.0 RR
R. Velez, Mexico	-	14	-	11.0 CAT
F. Verheyden, Belgium	6	-	-	8.0 NEW
E. Verwichte, Belgium	10	-	-	8.0 NEW
J. Vetter , Australia	33	-	-	4.0 RR
M. Vorel , Czechoslovakia	22	-	-	6.0 RR 6.3 RR 8.0 RR 10.0 CASS
G. Waffen , Broadview Heights, OH	2	-	-	5.0 RR
T. Wakugawa, Okinawa	-	27	-	10.0 NEW.
G. Walker , Macon, GA	22	6	-	5.0 RR 7.0 RR
K. Walker, Holbrook, AZ	-	4	-	16.0 NEW
F. Walter, Austin, TX	18	-	-	8.0 NEW
D. Ward, Australia	33	-	-	6.0 NEW
B. Waters, Kaihia, HI	8	-	-	8.0 CAT
K. Webb, Freeport, MI	30	-	-	8.0 CAT
K. Wehner, Kansas City, MO	1	1	-	30.0 NEW
R. Wessling, Milford, OH	3	-	-	12.5 TRIS
J. Westfall, San Francisco, CA	44	9	-	10.0 CASS
R. White, Santa Barbara, CA	3	-	-	16.5 CASS
R. White, Jr, Virginia Beach, VA	4	-	-	2.4 RR
A. Wilson, Lakeside, AZ	9	-	-	8.0 NEW
B. Wilson, Houston TX	5	-	-	8.0 NEW
Y. Marc Wisler, Netherlands	1	-	-	8.2 NEW
D. Young, Shawnee, KS	4	1	-	30.0 NEW
R. Young, Harrisburg, PA	14	-	-	12.5 NEW
H. Zeh, Temperance, MI	-	10	-	8.0 NEW
R. Ziss, Chicago, IL	32	-	-	12.5 NEW
<observer unknown>	33	1	-	8.0 CAT 12.2 NEW 12.5 NEW

Summary : 304 Observers

4813	Visual observations
2032	Photographic observations
191	Micrometer observations.
16	CCD/Video observations
7052	Total observations

Instrument

Type	Number	Percentage
Newtonians	180	43.6
Refractors	126	30.5
Catadioptrics	57	13.8
Cassegrains	41	9.9
Others	9	2.2
Total	413	100.0.

Mean Aperture: 11.8 inches (30.0 cm), weighted by number of telescopes.

DRAWINGS

This form of recording Martian detail has been much maligned in recent years, especially because improved photographic and CCD imaging techniques have become commonplace. Except in the hands of a rare few, drawings lack positional accuracy and are all but worthless for producing maps of the Martian surface. Contrary to popular belief, the A.L.P.O. Mars Section is not particularly interested in making albedo-feature maps of the Red Planet. We are better suited to conduct detailed studies of surface features and meteorological phenomena. In this context, the lowly drawing still fills several very important niches in Martian research. The human eye is a superb device for recording fine detail and minute differences in contrast–it is far superior to any film in existence. The superb CCD images that have appeared recently in *Sky & Telescope* and elsewhere reflect what a trained observer sees through a good 12- to 20-inch telescope. A number of observers, such as Richard McKim of the BAA, take advantage of this by making extremely accurate drawings of micro-morphology; detailed sketches of limited areas like Solis Lacus, the SPC [South Polar Cap], and so forth. We have found that these drawings have accurate spatial relationships, especially when combined with lower-resolution photographs to form a photo-visual observation.

Recording Martian clouds and hazes requires considerable expertise–long exposures through violet filters and large-aperture tele-

Table 2. Chronology of A.L.P.O. Mars Observations

Opposition		Span of Observation Dates		Ls Coverage		
Date (U.T.)	Ls	Begin	End	Span	Range	Actual
1969 May 31	165°	1968 Nov 22	1970 Mar 12	075-336°	261°	120°
1971 Aug 10	232	1970 Nov 29	1972 Feb 18	097-347	250	138
1973 Oct 25	307	1973 Feb 24	1974 May 19	160-050	250	163
1975 Dec 15	358	1975 Mar 18	1976 Jul 19	197-096	259	151
1978 Jan 22	037	1977 Jun 26	1978 Aug 05	286-124	198	136
1980 Feb 25	071	1979 Jun 06	1980 Oct 22	300-187	247	162
1982 Mar 31	105	1981 Jul 28	1983 Jan 01	354-258	264	194
1984 May 11	145	1983 Aug 11	1985 Mar 29	021-336	315	218
1986 Jul 10	202	1985 Sep 19	1987 Jun 22	059-038	339	240
1988 Sep 28	280	1987 Nov 09	1989 Jun 12	100-053	313	261

Table 3. Number of Observations, 1968/70-1987/89 Mars Apparitions.

Opposition Date	Number of Observers	Number of Observations				
		Visual	Photographic	Micrometric	CCD/video	Total
1969 May 31	31	415	6	0	0	421
1971 Aug 10	115	1633	345	0	0	1978
1973 Oct 25	78	1050	305	0	0	1355
1975 Dec 15	54	888	124	0	0	1012
1978 Jan 22	30	494	38	0	0	532
1980 Feb 25	41	1118	45	145	0	1308
1982 Mar 31	56	1551	143	309	0	2003
1984 May 11	57	1267	194	149	0	1610
1986 Jul 10	90	1623	555	172	0	2350
1988 Sep 28	304	4813	2032	191	16	7052
Mean	86	1485	379	97	02	1962
Total	856	14852	3787	966	16	19621

scopes. On the other hand, drawing the planet through a blue or violet filter couldn't be simpler: one only needs to position the polar caps accurately and sketch in a few dashed lines to represent atmospheric phenomena. The dark surface markings are usually invisible, so one need not be concerned with drawing their complex contours. After his analysis of several thousand IMP violet-light drawings and photographs, Beish has determined that the average amateur is able to draw Martian atmospheric features with surprising positional accuracy. During 1987-89 we had the luxury of frequently having several observers performing simultaneous violet-light drawings. In such cases drawings become extremely quantitative and provide much valuable information. In addition, more IMP astronomers are photographing Mars in blue and violet light. While we do not have more than a few dozen such photographs, they are fairly evenly spaced throughout the apparition and therefore provide excellent cross-checks for the drawings.

Under normal circumstances, Mars can be effectively photographed down to an apparent diameter of 12 arc-seconds, almost regardless of the telescope employed. Good disk and regional drawings with various filters can be obtained when the planet appears as small as 6-7 arc-seconds. While these are not of "map-quality," they effectively portray gross surface and atmospheric changes and dramatically extend the duration of the apparition.

Drawing Mars forces the observer to learn what the "normal" surface features look like. The Red Planet usually resembles its maps only in gross details; owing to frequent secular and perhaps seasonal changes, variations in axial tilt, and so forth. Therefore, astronomers must constantly keep abreast of current morphology so that they can quickly recognize sudden changes in the planet's appearance. This is especially important when these changes are due to dust storms early in the apparition. Then the practiced observer can make a real contribution to science by promptly reporting such events to those who can make detailed studies of the storm's evolution. This in fact occurred in 1987-89.

THE MARTIAN ARCTIC IN THE 1980'S

In an independent study, D. Parker, J. Beish, and C. Capen made numerous filar micrometer measurements of the retreating North Polar Cap (NPC) during the 1979-80 Apparition with some very interesting results. Some astronomers had suggested in the past that the NPC exhibits little or no variation in its rate of thaw or in the size of its summer cap remnant from one apparition to another. [Fishbacher et al, 1969] We were surprised, then, to find that the 1980 summer cap remnant (which is composed largely of water ice under a thin layer of frozen CO_2) was significantly smaller than it had been during the aphelic apparitions of the 1960's and smaller than "normal" by nearly 2° of areocentric latitude [Parker et al, 1983]. Note that the "normal" polar cap has been calculated by averaging polar cap measurements from the 1881, 1884, 1886, 1888, 1899, 1901, 1903, 1960, 1962, 1964, 1966, and 1968-70 aphelic apparitions.

When comparing similar apparitions during which the NPC was measured with identical equipment, the 1979-80 cap's edge retreated at a faster rate and by early summer was located at 4° to 6° areocentric latitude higher than the NPC remnants of the 1960's. Subsequently, measurements of the NPC over the next two aphelic apparitions gave nearly the same results during 1981-83 and, to a lesser extent, during 1983-85. The rate of regression during 1981-83 fell short of the 1979-80 rates, and the cap followed a more "normal" regression during 1983-85. Nevertheless, the trend line indicated that the NPC retreated more rapidly, even during 1983-85; and its summer cap remnant remained smaller than at any time during the 1960's.

The Martian arctic, therefore, appeared to have warmed since the 1960's. Further evidence supporting this conjecture was the reappearance of a rift in the NPC that seems to appear only when the cap is smaller than "normal". This rift is called the "Rima Tenuis" and was rediscovered by IMP astronomers in 1979 by visual as well as photographic observations. [2] The Rima Tenuis was discovered in 1888 by G. Schiaparelli and was observed during 1901, 1903, and 1918. It was not observed again until 1979 (more than 60 years later) despite intensive searches by spacecraft and large terrestrial telescopes.

The 1981-83 regression rate closely paralleled that of 1979-80, but in 1983-85 a number of unusual events were observed. After a relatively normal initial thaw, the cap abruptly stopped receding during late Martian Spring (072° Ls) and began to recondense [Parker et al, 1984]. This is not abnormal and often occurs when Mars is near aphelion. The phenomenon has been termed the "Aphelic Chill" by Professor Clyde Tombaugh and appears to be caused by arctic hazes blocking the feeble sunlight before it can reach the cap. A strong Aphelic Chill was observed during 1981-83.

What was unusual in 1983-85, however, was that the NPC remained large for an abnormally long period of time and actually showed signs of recondensation on three occasions during Martian Northern Spring until it resumed a more rapid regression in early Martian Northern Summer. The delay in cap recession lasted approximately one Martian month (030° Ls), during which at least five dust storms occurred on Mars [Martin, 1984]. It is likely that the abnormal amount of dust in the Martian equatorial region's atmosphere absorbed enough heat to delay the North Cap retreat. A fairly dense layer of dust and haze also covered the NPC during this time, which may have blocked off sunlight from the pole, slowing down the retreat. Also, it is quite possible that the dust in the polar atmosphere provided the necessary nucleus for condensation and in turn may have produced "snowfall". Most likely, the dust-laden condensates just settled to the surface to form a frost layer which added to the overall surface area of the cap. This mechanism has been suggested by observations made by the Viking spacecraft in the 1970's [James, 1979].

One other interesting result emerged from the 1983-85 Apparition–the appearance of the water-ice orographic clouds forming over the Tharsis volcanos was delayed nearly one Martian month, corresponding to the same delay in NPC recession. Our Martian Meteorological Survey had revealed that the time of appearance of the Northern Summer orographic clouds is highly predictable, so their tardiness in 1983-85 is significant. We feel that these observations have, for the first time, demonstrated a direct link between NPC recession and orographic cloud formation.

Giving further support to the evidence of arctic warming was the increase in the numbers of blue and white clouds. This increase persisted into the 1981-83 and early 1983-85 Apparitions during which the NPC again exhibited a remnant significantly smaller than normal. One may conjecture that the mechanism responsible for the apparent warming on Mars was a contributing factor in producing the high number of dust storms during the 1983-85 Apparition.

Although Mars' North Pole was tilted away from Earth throughout most of the 1987-89 Apparition (after 1988 FEB 11), the large Autumn North Polar Cap (NPC) could be seen until late June. After 1988 JUN 26, the NPC was intermittently covered by a dense cloud called the North Polar Hood (NPH). From 1988 SEP 04 onwards, the NPH appeared as a white sliver, brilliant in violet light, on the planet's north limb. As we mentioned in the previous article, the behavior and composition of Mars' polar caps are quite different, as are the appearances and times of formation of the hoods [Beish et al, 1989]. The north hood forms a dense canopy in northern autumn and persists throughout northern winter, while the south hood is more tenuous and does not form until late southern winter. (In 1987-89 it may not have formed at all!)

There were a number of papers presented at the Tucson meeting mentioned earlier which stressed the importance of the Martian polar regions as driving forces in the planet's global meteorology. These conditions appear to vary from year to year. The mechanisms of polar-climactic interactions (e.g., water transport, wind patterns, and dust storms) are only incompletely understood and require long-term studies. The 1990-91 and 1992-93 Apparitions, while not so favorable as that of 1987-89, will provide ground-based observers excellent opportunities to study polar phenomena and to provide back-up data for the planned spacecraft visits of the 1990's.

THE MARTIAN ANTARCTIC–1987-89

Mars' South Polar Cap (SPC) put on a great show in 1987-89. Because the planet's south pole was tilted earthward, astronomers had an excellent view of the cap as it thawed during Southern Hemisphere Spring. By Martian mid-May, numerous rifts were observed in the retreating cap; and by Martian late June members of the OAA noted the beginnings of the detachment of the Novissima Thyle, which would gradually shrink to become two white dots– the Novus Mons or famous "Mountains of Mitchel." This last feature was particularly prominent during the last week of August and the first week of September. Jean Dijon (Grenoble, France) reported the complete detachment of the "Mountains" (Novus Mons) from the SPC on 1988 AUG 07 (247° Ls). Located near 300°-330°W and 75°S, these two brilliant white dots could be detected with telescopes as small as 8 inches. By the time Mars made its closest approach to Earth on 1988 SEP 22 (UT Date), the SPC remnant was a tiny irregular white patch about 18° areocentric latitude in width. Observers with instruments over 10 inches in aperture often reported fine rifts crossing the SPC.

During the 1987-89 Apparition we were fortunate to have six observers performing regular measurements of the retreating SPC. In addition to the authors (Beish, Parker, and Cralle), Karl Fabian (Chicago, IL), Ken Schneller (Euclid, OH), and Jim Meadows (Memphis, TN) provided scores of quality measurements. Later these will be combined with data from the British Astronomical Association (BAA) to provide an accurate picture of the 1987-89 Martian Antarctic.

Preliminary inspection of the SPC measurements reveals an interesting phenomenon. While the SPC usually displays little of the variation seen in the NPC, in 1987-89 it did appear to halt its regression for an abnormally long time, its edge hovering near 70° areocentric latitude from mid-June through early July. This interval corresponds to the periods during which considerable dust was observed in the Martian atmosphere. Thus it appears that dust particles suspended over the South Pole of Mars absorbed enough solar energy to prevent the usual rapid spring thaw of the South Cap. The 1987-89 SPC regression is tabulated in *Table 4* (p. 13) and illustrated in *Figure 5* (below). *Table 5* (p. 13) tabulates the regression rates during 1987-89.

The edge of the South Polar Cap (SPC) had reached an areocentric latitude of approximately 82° by the time of the Martian Southern Hemisphere Summer Solstice on 1988 SEP 12. After solstice the cap continued to diminish in size at a slow rate until by October only a tiny remnant remained. This remnant persisted through late Martian Southern Summer. It was observed as late as mid-January, 1989, by Steve O'Meara with the Harvard 9-inch refractor and by Parker with 16- and 12.5-inch Newtonian reflectors. From these reports and from preliminary data from abroad, it appears that the SPC did not entirely sublime in 1987-89 but continued as an eccentrically located oval remnant whose dimensions were approximately 6° to 8° areocentric latitude. Bifilar micrometer, and reticle-eyepiece measurements by IMP astronomers consistently produced a cap remnant which was significantly smaller than that of 1986. At the Fourth International Conference on Mars held in Tucson, Dr. Kyosuke Iwasaki presented comparative measurements of the SPC obtained during the 1985-87 and 1987-89 apparitions. It was gratifying to note that our IMP data closely matched that of the Japanese professional astronomers.

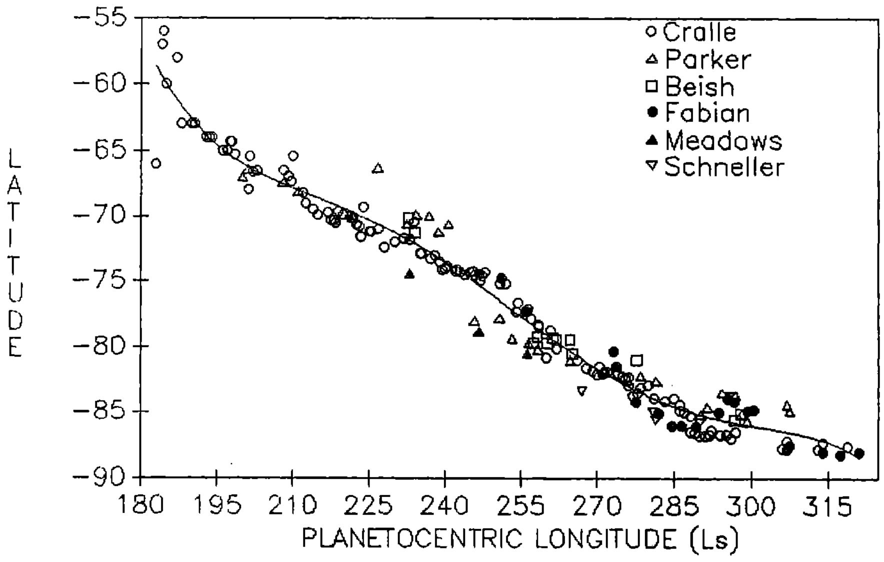

Figure 5. Graph illustrating the 1988 South Polar Cap regression for the Martian Southern Spring and Summer (Ls 180°-325°, given on the scale at bottom). The scale at the left gives the latitude of the north edge of the South Polar Cap.

Table 4. Martian South Polar Cap Edge Latitude Measurements, 1987-89.

(Ls and Latitude units are in degrees. Ls values are often rounded. All latitudes are south.)

Ls	Latitude	Ls	Latitude	Ls	Latitude	Ls	Latitude	Ls	Latitude	Ls	Latitude
183.0	66.0	212.0	68.2	233.0	71.8	248.0	74.3	267.0	83.4	289.4	86.1
184.0	57.0	212.5	69.0	233.0	74.4	250.8	77.8	268.0	81.6	290.0	85.8
184.5	56.0	214.0	69.5	234.0	70.4	251.0	75.2	269.0	81.8	290.1	85.2
185.0	60.0	215.0	69.9	234.1	71.3	251.2	74.8	270.0	82.1	291.4	84.6
187.0	58.0	217.0	69.7	234.3	69.9	252.0	75.2	270.5	81.5	293.7	85.0
188.0	63.0	217.5	70.3	235.0	72.9	253.2	79.3	271.0	82.0	294.4	83.5
190.0	63.0	218.0	70.3	235.5	72.9	254.0	77.3	271.5	81.9	296.1	83.8
190.5	63.0	218.5	70.5	236.9	70.0	254.5	76.6	272.0	82.0	296.7	85.6
193.0	64.0	219.0	69.6	237.0	73.3	256.0	77.3	273.3	80.3	296.8	83.7
193.5	64.0	220.0	69.9	238.0	73.0	256.2	77.3	274.0	82.2	297.9	85.1
194.0	64.0	221.0	69.9	238.7	71.2	256.2	80.5	275.0	82.4	298.0	85.1
196.0	65.0	221.8	70.1	239.0	73.5	256.5	77.1	275.5	82.3	299.1	84.9
197.0	65.0	222.0	70.1	239.5	74.1	256.5	79.7	276.0	82.9	300.3	84.8
197.5	64.3	222.5	70.6	240.0	74.0	257.0	77.8	276.0	82.5	306.0	87.7
198.0	64.3	223.0	70.8	240.5	73.8	257.5	79.7	276.2	83.1	306.9	87.8
198.5	65.3	223.5	71.6	240.6	70.6	258.2	79.2	277.0	83.7	307.0	87.2
199.9	67.0	224.0	69.3	242.0	74.2	258.3	80.2	277.7	81.0	307.5	84.9
201.0	67.9	225.0	71.2	242.5	74.1	258.5	78.3	278.0	83.5	307.5	87.5
201.0	66.4	225.5	71.2	243.0	74.3	258.6	78.4	278.3	83.1	309.9	84.4
201.5	65.4	226.8	66.3	244.0	74.5	260.0	80.8	278.5	82.2	313.0	87.8
202.0	66.6	227.0	71.0	245.0	74.3	260.1	79.7	280.0	82.9	313.8	88.0
203.0	66.5	228.0	72.4	245.5	74.2	261.0	78.7	281.0	83.9	314.0	87.3
208.0	66.5	229.0	71.0	245.8	78.0	261.3	79.4	281.0	85.0	319.0	87.6
208.0	67.4	229.0	62.3	246.0	74.5	262.0	79.4	281.4	85.6	321.0	88.0
209.0	66.9	230.0	72.0	246.7	74.4	263.0	80.1	281.5	82.6	324.0	85.4
209.5	67.3	232.0	71.7	246.7	78.8	264.7	81.0	282.0	85.1	324.4	85.4
210.0	65.4	232.5	70.6	247.0	74.9	265.1	80.5	284.5	86.0	331.8	85.2
211.0	68.1	232.8	70.1	247.5	74.6	266.0	81.0	286.4	86.0	335.1	85.4

Table 5. Southern Polar Cap (SPC) Regression Rates

Note: Units are in terms of Martian solar days ("sols") per degree of regression in latitude.

Southern Season (Ls°)		Apparition	
		1985-87	1987-89
		Sols	Sols
Late Winter	(Ls 150-179)	5	-
Early Spring	(Ls 180-209)	5	5
Mid-Spring	(Ls 210-239)	4	3
Late Spring	(Ls 240-269)	5	5
Early Summer	(Ls 270-299)	5	7.5
Mid-Summer	(Ls 300-330)	-	10

The "Mountains of Mitchel," so conspicuous during August, 1988, disappeared in September near the time of the Southern Summer Solstice. They were last photographed by Isao Miyazaki on 1988 SEP 11 and were last observed visually by Robert Robinson on 1988 SEP 16. The retreating South Cap did provide other entertainment, however, by displaying numerous rifts and bright projections. These were reminiscent of the SPC "outliers" described by Philip B. James (University of Missouri) in his analysis of Viking and Mariner IX photographs [James et al, 1979].

Throughout September and October, 1988, IMP astronomers reported bright spots in the SPC. Before opposition, the evening side of the cap was consistently duller than the center or the morning side. This peculiar phenomenon was reported by many of our Mars observers up to the time of opposition but was not noted after opposition. It may have been due to evening antarctic hazes or perhaps to shadows cast on the ice by the more elevated central portion of the cap.

— End of Part I —

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Due to the massive, if gratifying, observer response during the 1987-89 Apparition of Mars, this Report is too long to fit into a single issue of our Journal. The second and concluding Part will be published in the near future (the next issue if the fates are kind); and will discuss Martian Meteorology (antarctic and in general), dust storms, and surface features, for the 1987-89 Apparition.

Note that the references cited will be listed at the end of Part II.

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GALILEAN SATELLITE ECLIPSE TIMINGS: THE 1988/89 APPARITION

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

ABSTRACT

The A.L.P.O. Jupiter Section received 818 visual and 2 photoelectric timings of the eclipses of Jupiter's satellites Io, Europa, and Ganymede for the 1988/89 Apparition. For each satellite, eclipse disappearance and reappearance timings were adjusted for telescope aperture and combined for comparison with the "E-2" Ephemeris. The observed positions of Europa and Ganymede fitted the ephemeris well, but events for Io tended to be slightly but significantly later than predicted.

INTRODUCTION

The 1988/89 Apparition of Jupiter was the twelfth studied by the A.L.P.O. Jupiter Section's Galilean Satellite Eclipse Timing Program. This was our most successful apparition yet, with 818 visual and 2 photoelectric timings received. The satellites so timed were Io (*1*), Europa (*2*), and Ganymede (*3*); no eclipses of Callisto (*4*) were predicted or reported during this apparition. Visual observers timed the "first speck" visible when the satellite reappeared from Jupiter's shadow (*egress*), or the "last speck" seen when the satellite disappeared into the shadow (*ingress*). Reports for previous apparitions are listed under "References" (p. 18). [Westfall 1983-84, 1986a, 1986b, 1987, 1988, and 1989]

Table 1 (below) lists some significant dates for the 1988/89 Jupiter Apparition.

Table 1. 1988/89 Jupiter Apparition Chronology.

			d	*h*
Conjunction with the Sun	1988	MAY	02	21
First Eclipse Timing	1988	MAY	28	20
Closest Approach to Earth	1988	NOV	21	16
Opposition to the Sun	1988	NOV	23	03
Last Eclipse Timing	1989	APR	28	01
Conjunction with the Sun	1989	JUN	09	09

The *apparition* is the period between successive conjunctions, while the *observing season* covers the period of actual observation. The observing season began only 26 days after conjunction, with Jupiter 19° west of the Sun; and ended 42 days before the next conjunction, at solar elongation 31° east. During the apparition, the jovicentric declination of the Sun decreased from 3°.6 to 3°.0, meaning that only Io, Europa, and Ganymede were eclipsed.

At closest approach, Jupiter's distance from the Earth was 4.0340 A.U. (astronomical units), with an equatorial diameter of 48".80, and a visual magnitude of -2.87. Its geocentric declination at opposition was +19°.4, so this apparition favored observers in the Earth's Northern Hemisphere.

OBSERVATIONS

The timings received for 1988/89 bring our twelve-apparition total to 4353 visual and 43 photoelectric timings. Besides the timings submitted directly to the A.L.P.O. (434; 53.1 percent of the total of 818), we were fortunate to receive 206 timings (25.2 percent) by 18 New Zealand and Australian observers from the Royal Astronomical Society of New Zealand, and 178 timings (21.8 percent) by 20 Spanish observers from three groups; the Agrupació Astronòmica de Barcelona, Agrupació Astronòmica de Sabadel, and Grup d'Estudis Astronòmics. All in all, 102 individuals or teams submitted reports. The timings themselves are listed in *Table 4* (Appendix, pp. 19-23), and the observers are listed at the end of this report (pp. 23-24).

Table 2 (below and next page) gives summary statistics for the *visual* timings received.

Table 2. Summary Statistics: 1988/89 Galilean Satellite Visual Eclipse Timings.

A. By Satellite and Event Type.
(D = Disappearance; R = Reappearance)

Event Type	Number of Timings	Number of Events Total	Timed	
1D	151	106	52	(49%)
1R	261	88	71	(81%)
1	412	194	123	(63%)
2D	100	68	46	(68%)
2R	142	65	45	(69%)
2	242	133	91	(68%)
3D	92	44	33	(75%)
3R	72	43	24	(56%)
3	164	87	57	(66%)
D	343	218	131	(60%)
R	475	196	140	(71%)
TOTAL	818	414	271	(66 %)

B. By Month.
(with Solar Elongation Range)

1988	MAY	(002°E-021°W)	2	Timings
	JUN	(021-043° W)	9	
	JUL	(043-067° W)	30	
	AUG	(067-094° W)	76	
	SEP	(094-122° W)	81	
	OCT	(122-155°W)	64	
	NOV	(155°W-171°E)	87	
	DEC	(171-136°E)	125	
1988	JAN	(136-104°E)	144	
	FEB	(104-078°E)	100	
	MAR	(078-052°E)	75	
	APR	(052-029°E)	25	
Before Opposition			325	(39.7 %)
After Opposition			493	(60.3 %)

(over)

(Table 2—Continued.)

C. By Telescope Aperture.
(Truncated to whole centimeters)

5 cm.	40 timings	20 cm.	209 timings
6	63	25	65
7	25	26	1
8	17	30	12
9	3	31	3
10	46	32	6
11	41	33	4
12	15	35	13
13	31	40	34
15	111	41	12
16	53	50	9
17	1	75	1
18	2	228	1
		Total	818

Weighted by:	*Observations*	*Telescopes*
Mean	*17.9 cm.*	*19.5 cm.*
Median	*15.3*	*15.1*

As usual, more timings were made for Io than for Europa, and more for Europa than for Ganymede. This appears simply to be a result of their orbital periods increasing, and the frequency of their eclipses decreasing, outwards from Jupiter. On the other hand, there is a definite bias toward timing eclipse reappearances rather than disappearances. This bias was strongest for Io (a 1.7:1 ratio) and weaker for Europa (1.4:1). For Ganymede, more disappearances were timed than reappearances. The most likely reason for this pattern is that the disappearances of Io and, almost always, Europa are visible only before opposition, when fewer timings are made (see below).

Likewise, the distribution of timings by month follows a familiar pattern, except for the drop in October, the month before opposition, perhaps due to unfavorable weather. The period of most intense observing was the three months after opposition, when the planet was conveniently placed in the evening sky. We have an ongoing bias toward post-opposition timings, and we request participants to make more pre-opposition timings in the future, recognizing that this involves observing after midnight.

The most popular aperture continues to be 20 cm., with the median slightly less; 15 cm. with all telescopes weighted equally and when weighted by the number of observations. The range of apertures continues to be large; from 5 to 228 cm., showing that almost any telescope can be used in our program.

The geographical distribution of our contributors continues to widen, and is mapped in *Figure* 6, below. Thirteen countries on five continents contributed to the number of observers as follows: Australia, 12; Austria, 1; Belgium, 3; Brazil, 6; Denmark, 1; Germany, 3; India, 5; Italy, 6; the Netherlands, 3; New Zealand, 5; Portugal, 7; Spain, 23; and the United States, 27. However, there remain longitude gaps in our coverage; the absence of observers from France, Japan, and the United Kingdom is puzzling.

REDUCTION

The first step in reduction was to segregate the visual timings by satellites and by event type; disappearance versus reappearance. Observations were compared with the predictions of the "E-2" Ephemeris developed by Dr. Jay H. Lieske of the Jet Propulsion Laboratory. [Lieske, 1981] The predicted time of each event was then subtracted from the observed time; a positive residual meant that an event was "late"; a negative residual, that it was "early." These residuals are given in the right-hand column in *Table 4*. The next step was to correct for aperture with a linear regression model in which the dependent variable was the residual (**y**) and the independent variable was the reciprocal of the telescope aperture, measured in cm. (**x**). The form of the model is:

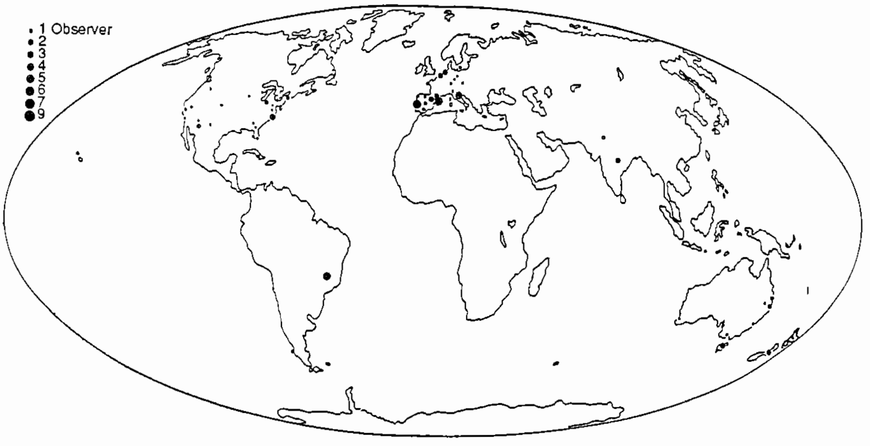

Figure 6. The geographical distribution of observers who submitted timings of Galilean satellite eclipses for the 1988/89 Apparition. Observers are grouped (see legend) when there are several near each other or when their reports are channeled through a single individual.

$$y = A + Bx,$$

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

Some timings were rejected because of extreme differences (over 2 standard deviations) from the regression model. For the 1988/89 Apparition, 96 timings (11.7 percent) were so rejected, and are shown by italicized residuals in *Table 4*. This proportion of timings rejected in somewhat high and is probably due to the fact that this was the first apparition of timing for many of the observers.

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

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

1988/89 RESULTS

The orbital residuals for Io, Europa, Ganymede, and Callisto for all twelve apparitions from 1976/77 through 1988/89 are graphed in *Figure 7* (p. 18). In that figure, the error bars represent a ±1 standard-error range, and a significant deviation from the ephemeris would have to be at least about ±2 standard errors. Details for the 1988/89 Apparition follow in *Table 3* (p. 17). This table gives results for each of the first three satellites in a separate column. The column is divided into four parts, "Disappearance," "Reappearance," "Orbital Residual," and "Diameter." For both disappearances and reappearances, the number of timings is given first, followed in parentheses by the number actually used in the regression analysis. The next item is the mean residual for the timings that were retained, followed by the coefficient of variation ("R-squared"), which is the proportion of the variance among the timings that is explained by the aperture model. Fourth, the two regression coefficients are given with their 1-standard error uncertainty ranges; in *Table 3*, all such uncertainty ranges are preceded by the "±" symbol. Next is the standard error of estimate for the regression model. Last are the predicted residuals for four commonly used telescope apertures.

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

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

Table 3 also shows the statistical significance of the differences of the following values from zero; "R-squared," the orbital residual (in seconds of time only), and the difference between the estimated and the standard satellite diameters. The statistical significance is shown by "-" for not significant, "*" for significant at the 5-percent level, and "**" for significant at the 1-percent level.

There are six types of events listed in *Table 3*; eclipse disappearances and reappearances for each of the three satellites. As shown by the R-square values, in all six cases the aperture-regression model significantly reduced the variance among the timings. The average uncertainty of the timings is indicated by the standard error which was roughly the same for disappearance and reappearance timings, but increased going outward from Jupiter; about ±17-19 seconds for Io, ±28-34 seconds for Europa, and ±64-70 seconds for Ganymede. This trend is not surprising because the satellites move more slowly, and Jupiter's shadow penumbra becomes broader, as one moves away from the planet. These factors also are reflected in the increasing numerical value of the B-coefficient with distance from Jupiter; this value measures the effect of aperture variations on the reported times of events.

Although there were more timings than in the previous apparition, their standard errors tended to be somewhat larger than before. This is probably due to the fact that many of the 1988/89 observers were new to the program; occasional timing errors were evident and could not always be corrected.

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

For the first time in our project, the orbital position of Io differed from that predicted by the E-2 Ephemeris, although the 73-kilometer discrepancy was significant only at the 5-percent level.

The eclipse timings of neither Europa or Ganymede differed significantly from those predicted by the E-2 Ephemeris.

The accuracy of our method of analysis is at least roughly assessed by using the A-coefficients to estimate the diameters of the satellites, and then comparing these estimates with the accurate diameters that were derived from the Voyager Missions. In the cases of Io and Ganymede there were significant differences, but of different signs. Io was estimated as slightly too small, but Ganymede was estimat-

Table 3. Galilean Satellite Timings Compared With E-2 Ephemeris, 1988/89.

Satellite:	Io	Europa	Ganymede
Disappearance			
Number of Observations	151 (136)	100 (88)	92 (82)
Mean Residual	+86.4±1.8	+92.1±4.3	+370.3±8.7
Coefficients:			
R-squared	.3871**	.3037**	.2222**
A (seconds)	+108.8±2.8	+129.0±7.0	+434.2±15.4
B	-312±34	-467±76	-929±194
Standard Error (seconds)	±16.9	±34.2	±69.6
Aperture Residual (seconds):			
6-cm.	+57±4	+51±8	+279±21
10-cm.	+78±2	+82±4	+341±10
20-cm.	+93±2	+106±4	+388±9
40-cm.	+101±2	+117±5	+411±11
Reappearance			
Number of Observations	261 (227)	142 (127)	72 (62)
Mean Residual	-83.7±1.4	-120.6±2.7	-376.0±10.1
Coefficients:			
R-squared	.2212**	.1980**	.3631**
A (seconds)	-100.3±2.4	-142.3±4.6	-451.5±15.2
B	+217±27	+307±55	+957±164
Standard Error (seconds)	±19.0	±27.7	±63.8
Aperture Residual (seconds):			
6-cm.	-64±3	-91±6	-292±17
10-cm.	-79±1	-112±3	-356±9
20-cm.	-89±1	-127±3	-404±9
40-cm.	-95±2	-135±4	-428±12
Orbital Residual			
Seconds	+4.2±1.9*	-6.7±4.2-	-8.7±10.8-
Orbital Arc (degrees)	+0.0099±.0044	-0.0078±.0049	-0.0050±.0063
Kilometers	+73±32	-91±58	-94±118
Diameter			
Seconds	209.1±3.7	271.2±8.4	885.7±21.7
Kilometers	3447±62	3059±95	6076±149
Compared with Standard	-185±62** (-5.1 %)	-67±95- (- 2.1 %)	+800±149** (+15.2 %)

ed as much too large. Ganymede's rather oblique angle of entrance and exit into Jupiter's shadow, ranging from 47°-53°, may partly explain this large discrepancy.

PHOTOELECTRIC TIMINGS

Photoelectric timings involve recording a series of brightness measures in order to determine the moment when a satellite is at one-half its uneclipsed brightness; the assumption is that then the satellite is midway though shadow ingress or egress. This halfway point is estimated by fitting a linear regression line to the brightness measurements and times near mid-event. [Westfall 1985] The removal of scattered light from nearby Jupiter is a serious problem and apparently has discouraged observers, so that only two photoelectric timings by one observer were submitted for the 1988-89 Apparition. These were of an eclipse disappearance and reappearance of Ganymede, but differed by 5 and 14 minutes, respectively, from both the E-2 Ephemeris and the visual timings, so that the photoelectric results cannot be used.

Although the above comments appear discouraging, the use of CCD cameras is growing; and at least in theory photometry using these devices should allow the scattered light from Jupiter is be better measured, modeled, and thus subtracted. Such measurements should serve not only as independent checks for the visual timings, but ultimately may provide considerably more accurate results.

IN CONCLUSION

We encourage suitably-equipped observers to use photoelectric photometers or CCD cameras to time the eclipses of Jupiter's four major satellites. However, it is clear that visual timings are at present the mainstay of our program. The more visual timings, the more accurate our results, so it is gratifying that a record number were received for 1988/89. (It already is clear that 1989/90 will be an even more extensively observed apparition.) Naturally, we hope that the present observers will continue and new ones will join us. For information on this program, please write the author, whose address is given on the inside back cover. Along with instructions, he can send you a timing report form, which should

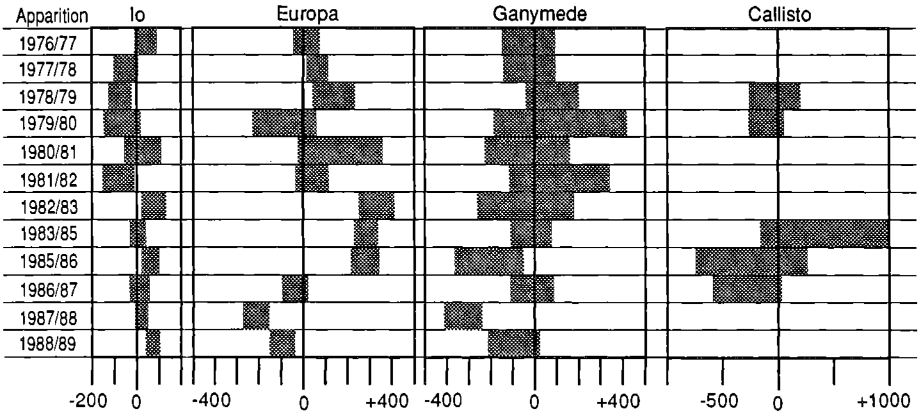

Figure 7. Graphs of deviations of the Galilean Satellites from the E-2 Ephemeris for the 1976/77 through the 1988/89 Apparitions. Units are in kilometers. The width of each bar represents ±1 standard error. Note different scale for Callisto, which was not eclipsed in every apparition.

be returned at the end of the current apparition (*not* of the calendar year). You will also need predictions of these events, which are published each year in the *A.L.P.O. Solar System Ephemeris*.

We are very grateful to the many observers who participated in our project for the 1988/89 Apparition of Jupiter. Remember that your results become more accurate as you accumulate experience. Thus we hope to hear from you again!

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APPENDIX

Table 4, beginning on the next page, summarizes the visual timings received for the 1988/89 Apparition of Jupiter. The list of observers is given on pp. 23-24. The key to *Table 4* is given below.

Key:

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

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

C. *Ob.No.:* Observer (or team) number as listed on pages 23-24. In that list, the first figure in parentheses represents the aperture of the telescope used in centimeters; the second (in italics) the number of timings submitted.

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

E. *Res.* (residual): The time difference in seconds, found by subtracting the predicted eclipse U.T. from the observed eclipse U.T. The former, originally given in ephemeris time, was converted to U.T. using an assumed ΔT correction of +56 seconds. Italicized residuals denote timings that were not used in the regression analysis.

Table 4. Galilean Satellite Eclipse Timings, 1988-89.

U.T. Date mmdd	Geometry r °	Ob. No.	Con. stb	Res. sec.
----- Io Disappearances -----				
1988				
0629	0.8+19	19	002	+63
0630	0.8+19	66	011	+92
0709	0.9+19	10	202	+56
		55a	100	+99
		101	210	+100
0722	1.0+19	67	001	+83
		32	100	+84
		24	002	+89
		97	000	+91
0725	1.0+19	52	200	+21
		101	200	+78
		56a	200	+96
		58	200	+99
0801	1.1+19	60	011	+58
		10	101	+78
		56a	100	+96
0805	1.1+19	81	000	+99
0807	1.1+19	39a	100	+75
		19	001	+83
		32	100	+100
0814	1.1+19	39	100	+87
		19	101	+95
		92a	122	+105
		24	002	+108
		32	100	+112
		96	002	+113
0817	1.1+19	56a	120	+*50*
		55a	000	+98
0821	1.1+19	61	111	+93
		81	000	+99
0823	1.1+19	19	021	+*47*
		67	100	+56
		37a	020	+78
		29	020	+79
0824	1.1+18	52	000	+70
		10	–01	+101
		58	100	+107
		55a	000	+115
0830	1.1+18	67	011	+*32*
		19a	021	+80
		13	000	+96
0831	1.1+18	66	011	+106
0904	1.1+18	42	001	+73
0906	1.1+18	39	020	+61
		67	000	+84
		24	000	+104
		13	000	+109
		37a	000	+110
		32	020	+113
0907	1.1+18	67	201	+*24*
		51	112	+76
		97	111	+77
0909	1.1+18	10	121	+72
		55a	010	+93
0913	1.1+18	30	11–	+56
		64	100	+63
		61	011	+107
0915	1.1+18	67	000	+72
		97	000	+89
		19a	101	+100
0915	1.1+18	24	000	+114
0918	1.1+18	58	200	+107
0920	1.0+18	102	000	+54
		102a	100	+106
0922	1.0+18	67	000	+80
		19a	201	+96
		13	000	+97
		37a	100	+99
		24	000	+105
0925	1.0+18	58	101	+106
0927	1.0+18	64a	000	+102
0929	1.0+18	13	100	+102
		61	101	+109
		37a	000	+115
0930	0.9+18	28	211	+78
		71	110	+89
1008	0.9+18	63	100	+96
		32	100	+97
		28a	101	+103
1013	0.8+18	25	00–	+43
1015	0.8+18	26	00–	+*17*
		78	000	+64
1016	0.7+18	28	211	+75
		66	022	+98
1020	0.7+18	78	000	+70
1022	0.6+18	61	111	+117
1023	0.6+18	62	001	+50
		51	122	+64
		67	000	+64
		39a	000	+84
		29	101	+90
		37a	001	+104
		40	001	+104
		28a	010	+105
		32	001	+107
		35	111	+124
		31	——	+*138*
1025	0.6+18	10	122	+68
1027	0.6+18	52	000	+26
		50	101	+101
		101	112	+106
		64a	001	+119
1029	0.5+18	73	000	+95
		20	000	+104
		44	001	+108
		64a	000	+113
1031	0.5+18	78	000	+54
		31	——	+56
		87	111	+71
		37a	000	+109
		32	000	+116
		35	211	+127
1101	0.5+18	51	211	+59
		88	210	+*128*
1103	0.4+18	55a	200	+66
		66	010	+92
		101	00	+123
1105	0.4+18	42	000	+90
1107	0.3+18	78	000	+38
		28	001	+55
		87	000	+80
1108	0.3+18	17	110	+60
1108	0.3+18	98	110	+82
		89	001	+87
		28a	000	+103
1110	0.3+18	66	220	+56
		82	000	+63
1112	0.2+18	10	200	-*23*
		60	0–0	+*11*
		94	000	+75
		1	200	+76
1114	0.2+18	73	022	+75
		100a	000	+105
1115	0.2+18	2	1—	-*69*
		79	211	+*15*
		81	100	+54
		47	110	+67
		36	001	+70
		37a	000	+81
		62a	000	+88
		19c	000	+94
1117	0.1+18	82	000	*0*
		17	110	+*11*
		66	010	+73
1119	0.1+18	10	101	+*3*
		66	111	+61
1121	0.0+18	42	211	+*19*
		102	000	+41
		102a	100	+90
		64b	000	+110
1123	0.0+18	68	10–	+54
----- Io Reappearances -----				
1988				
1123	0.0+18	31	——	+*387*
1124	0.0+18	28a	121	-49
		67	001	-41
		5	101	-38
		40	011	+11
		79	111	+*63*
		31	——	+*105*
1126	0.1+18	66	011	-51
1128	0.1+18	55a	100	-94
		84	201	-68
		10	120	-*13*
1130	0.2+18	100a	010	-104
		44	000	-99
		102a	200	-45
		102	100	+*4*
1201	0.2+18	44	100	-81
		79	001	-67
		67	020	-*15*
		71a	110	-*14*
1203	0.2+18	66	011	-84
		96a	100	-76
1205	0.3+18	101	100	-108
		84a	101	-100
		33	100	-84
		23	100	-82
		66	010	-73
1207	0.3+18	75	001	-114
		102a	100	-88
		42	010	-62
		102	000	-54
1209	0.3+18	31	——	-*163*

Table 4. Galilean Satellite Eclipse Timings, 1988-89—*Continued.*

U.T. Date mmdd	Geom- etry r °	Ob. No.	Con. stb	Res. sec.
-Io Reappearances—Cntd.-				
1988				
1209	0.3+18	100a	000	-113
		81	100	-76
		67	000	-66
		78	000	-65
		102a	201	-43
		102	201	-40
		59	111	-39
		42	200	*-23*
1210	0.4+18	37a	000	-111
		31	—	-94
		40	100	-85
		96	100	-85
		71a	110	-83
		79	001	-62
		62	101	-54
		67	000	*-31*
		57	100	-27
1212	0.4+18	83	110	-96
		10	–10	-86
1214	0.4+18	42	000	-83
		27	201	-53
1216	0.5+18	69	000	-96
		73	000	-95
		102a	200	-84
		59	111	-79
		78	000	-73
		37	100	-51
		42	211	*-29*
		102	200	+7
1217	0.5+18	32	000	*-150*
		31	—	*-117*
		28a	001	-114
		96a	011	-112
		37a	000	-109
		22	001	-101
		11	011	-97
		40	000	-82
		71a	110	-80
		67	000	-79
		93	001	-74
		5	001	-73
		79	101	-68
		78	001	-54
1219	0.5+18	66	111	-90
1221	0.6+18	101	222	-99
		10	102	-84
1223	0.6+18	102a	000	-95
		42	001	-93
		102	000	-42
1225	0.6+18	24	001	-102
		78	011	-50
		31	—	-34
1226	0.7+18	37a	000	-102
		80a	011	-101
		40	001	-100
		36	101	-94
		24	010	-92
		19	212	-84
		67	000	-70
		31	—	-45
		48a	212	-44
1228	0.7+18	10	000	-103
		66	010	-97
		85	100	-25
1230	0.7+18	78	000	-67
1989				
0101	0.8+18	102a	200	-95
		102	100	-40
0102	0.8+18	15	000	-108
		32	110	-104
		37a	000	-101
		17	110	-95
0104	0.8+18	85	000	*-190*
		66	010	-96
0106	0.8+18	84a	011	-110
		101	112	-109
0108	0.8+18	100a	010	-113
		77	000	-90
0109	0.9+18	19c	000	-127
		28a	100	-108
		17	210	-97
		31	211	*+106*
0111	0.9+18	85	000	-82
0113	0.9+18	55a	110	-102
		27	200	-84
		52	000	-51
0115	0.9+18	20	001	-113
		42	001	-85
0117	0.9+18	53	111	*-232*
		59a	101	-119
		100a	001	-110
		91	000	-109
		41	000	-105
		32	001	-100
		8	1—	-93
		49	000	-93
		78	111	-83
		37	001	-74
0118	1.0+18	32	001	-108
		37a	001	-106
		17	110	-104
		47	000	-84
0120	1.0+18	85	100	-82
		101	222	-82
		23	101	-55
		83	001	*-15*
0124	1.0+18	102a	100	-136
		100a	001	-112
		61	101	-108
		77	201	-104
		102	000	-95
		46	111	-85
		73	010	-78
		45	111	-71
		59a	212	-56
		8	0—	*-21*
0125	1.0+18	15	000	-109
		17	000	-90
		91	210	-90
		74	011	-74
		48	220	*-18*
		47	020	*+47*
0127	1.0+18	66	021	-107
0127	1.0+18	99	000	-38
0129	1.0+18	76	021	-107
		50	000	-104
		55	101	-81
		27	201	-79
		9	112	-47
0131	1.0+17	86	000	-106
		8	0—	-93
		42	011	-84
0201	1.1+17	18	001	-128
		74	001	-97
		79	101	-62
		31	111	-34
0205	1.1+17	66	021	-104
		55a	100	-103
		10	100	-79
		33	100	-72
		9	101	-71
0207	1.1+17	102a	100	-88
		102	000	-66
0209	1.1+17	73	000	-80
		41	000	-79
		49	000	-77
		78	000	-72
		8	0—	*-2*
0210	1.1+17	65	011	*-119*
		15	000	-114
		91	000	-112
		37a	000	-103
		17	210	-92
		6	110	-90
		98a	000	-90
		14	000	-83
		32	221	-47
0212	1.1+17	66	010	-102
0214	1.1+17	60a	000	-98
		56a	021	-87
		27	202	*-37*
0216	1.1+17	100a	001	-112
		61	101	-102
		54	001	-99
		94	000	-97
		8	0—	-92
0217	1.1+17	28a	001	-105
		32	111	-92
		71a	110	-78
		37	001	-74
		79	011	-58
0219	1.1+17	83	011	-31
0221	1.1+17	55a	010	-110
		10	011	-92
		9	101	-90
0223	1.1+17	54	000	-111
		94	010	-91
0224	1.1+17	51	221	*+69*
0228	1.1+17	66	011	-93
		50	200	-78
		52	010	*+30*
0305	1.0+17	31	111	*-136*
		40	000	-106
		19c	002	-105
		91	110	-91

Table 4. Galilean Satellite Eclipse Timings, 1988-89—*Continued.*

U.T. Date mmdd	Geom-etry r °	Ob. No.	Con. stb	Res. sec.
-Io Reappearances—Cntd.-				
1989				
0305	1.0+17	48	110	-88
		74	020	-86
		67	000	-77
		51	021	-52
0309	1.0+17	27	111	-85
		72	111	-70
0311	1.0+17	81	000	-80
		100	100	-80
		12	100	-74
0312	1.0+17	19a	101	-103
		31a	111	-95
		74	001	-87
		6	021	-82
		40	010	-82
		48	110	-78
0314	1.0+17	85	000	-64
0316	1.0+17	23	201	-55
		9	111	-54
0318	1.0+17	86	001	-101
0323	0.9+17	66	111	-88
0327	0.9+17	61	201	-97
		100a	121	-89
		81	100	-88
		8	0—	-77
0328	0.9+17	65c	110	-102
		7	000	-99
		28a	111	-98
		6	201	-72
		40	010	-72
		51	011	-71
		16	111	-63
		48	220	-49
		31	112	*+25*
0330	0.9+17	90	000	*-131*
0401	0.9+17	10	102	-70
0404	0.8+17	36a	111	-79
0419	0.7+17	54	101	-84
		73	002	-80
0420	0.7+17	15	201	-88
		47	001	-57
		65	112	-40
		38	011	*-19*
0422	0.6+17	90	000	*+43*
0424	0.6+17	55a	221	-77
		10	201	*-16*
0426	0.6+17	43	110	*+31*
- Europa Disappearances --				
1988				
0528	0.5+36	58	202	*-5*
		101	202	+30
0604	0.7+36	66	112	+50
0619	0.9+36	19	102	*-6*
0629	1.1+36	52	100	+43
0721	1.5+36	39	200	+91
		32	200	+140
0724	1.5+36	58	200	+102
		101	210	+122
0731	1.6+36	10	101	+117
		27	001	+129
0804	1.6+36	81	000	+114
0804	1.6+36	61	112	+137
0807	1.6+36	66	020	+104
0811	1.7+36	69a	000	+158
0815	1.7+36	4	220	+82
		19	001	+92
		65a	100	+99
		92	010	+121
0822	1.7+36	67	000	+101
		65	111	+113
		32	200	+126
0825	1.7+36	60	000	-8
		52	100	+40
		56a	010	+127
		101	211	+133
		58	101	+139
0829	1.7+36	37a	000	+123
		61	201	+126
		13	000	+131
0905	1.7+36	42	110	+99
0908	1.7+36	51	222	+50
0912	1.7+36	42	000	+90
0915	1.6+36	97	022	*-19*
		19a	121	+109
		37a	100	+113
0923	1.5+36	13	000	+116
		32	000	+131
		37a	000	+143
0926	1.5+36	10	002	+115
0930	1.4+36	32	000	+142
		61	102	+142
1003	1.4+36	52	000	+75
1007	1.3+36	42	000	+83
1010	1.2+36	65	010	+97
		17	010	+120
		66	011	+133
		95	100	+178
1021	1.0+36	50	000	+115
1025	0.9+35	78	000	+45
		12a	111	+111
		37a	011	+125
		35	111	+156
1028	0.8+35	66	020	+111
		55a	100	+131
1101	0.7+35	28	001	+71
		95	000	+124
1104	0.6+35	17	110	+82
		65	011	+82
		66	010	+107
1108	0.5+35	25	00–	+42
		102	000	+58
		102a	100	+103
		61	001	+131
1111	0.3+35	51	111	+89
1115	0.2+35	44	000	+116
1118	0.1+35	40	210	*-28*
		79	111	*-23*
		3	101	*+24*
		31	——	+30
		67	000	+44
		96a	001	+92
		19c	000	+127
1122	0.0+35	101	102	+98
1989				
0118	0.0+34	84a	111	+88
		101	111	+94
0121	0.0+34	31	101	*-68*
		79	221	*-19*
		18	212	+45
		32	111	+57
		37a	001	+72
0125	0.1+34	10	101	*-17*
		33a	200	*-1*
		84a	211	+65
		55a	100	+71
		101	100	+91
0129	0.1+34	30	00–	+18
0205	0.2+34	42	100	+60
0208	0.2+34	82	100	-5
0215	0.2+34	47	000	+38
		37a	100	+97
0219	0.2+34	10	102	*+5*
		60a	110	+44
		84a	102	+95
0222	0.2+34	51	221	+11
		30	00–	+12
0302	0.1+34	12	110	+55
0309	0.1+33	94	100	-12
		70	000	*+27*
0312	0.1+33	85	111	+105
-- Europa Reappearances --				
1988				
0724	0.1+36	101	100	-76
		58	000	-62
0728	0.1+36	61	101	-92
0804	0.2+36	42	011	*-23*
0815	0.2+36	24	000	-110
		65a	102	-84
		67	000	-76
		19	001	-70
0818	0.2+36	101	110	-89
0822	0.2+36	67	001	-83
		24	002	*+36*
0825	0.2+36	101	111	-139
		56a	000	-106
		58	100	-100
		52	010	*+8*
0905	0.2+36	42	001	*-37*
0908	0.2+36	19a	111	-107
		24	000	-77
		65	110	-38
		67	200	*-32*
		51	011	*0*
0916	0.2+36	32	000	-121
		37a	000	-111
		19a	101	-85
		97	000	*-17*
0923	0.1+36	37a	000	-120
		61	111	-111
0926	0.1+36	10	002	*-18*
0930	0.0+36	102a	101	-133
		69	001	-109
1129	0.2+35	65b	100	-133
		84a	201	-93
1203	0.3+35	100a	000	-142

Table 4. Galilean Satellite Eclipse Timings, 1988-89—*Continued.*

U.T. Date mmdd	Geometry r °	Ob. No.	Con. stb	Res. sec.
--- Europa Reap.—Cntd. ---				
1988				
1203	0.3+35	61	200	-132
1206	0.4+35	37a	000	-147
		35	201	-135
		31	——	-120
		40	000	-117
		80	200	-96
		89	000	-80
		67	100	-54
1210	0.5+35	84	001	-153
		102a	000	-122
		102	000	-96
1213	0.6+35	28a	111	-153
		32	000	-143
		37a	000	-143
		5	001	-120
		71a	110	-107
		78	000	-102
		96a	100	-77
1217	0.8+35	55	100	-134
		27	201	-108
		72	200	-80
1221	0.8+35	100a	022	-149
1224	1.0+35	84a	101	-157
		83a	200	-142
		66	011	-135
1228	1.0+35	59a	222	-174
		100a	000	-162
		77	000	-114
		78	000	-103
		37	000	-67
1231	1.1+34	85	100	-101
1989				
0104	1.2+34	42	001	-133
		77	121	-118
0107	1.3+34	96a	100	-164
		40	000	-150
		37a	100	-140
		36	201	-136
		19	001	-134
		48a	002	-130
		79	001	-127
		31	000	-82
0111	1.4+34	50	100	-159
		76	220	-148
		84a	102	-147
		101	202	-147
		42	200	-59
0114	1.4+34	19c	000	-176
		91	000	-162
		15	100	-150
		32	010	-147
		40	000	-131
		67	000	-77
		31	001	-45
0118	1.5+34	55a	000	-157
		10	001	-145
0122	1.5+34	32	001	-144
		73	001	-122
		15	111	-117
		30	00–	-115
		37	101	-92
0205	1.7+34	42	100	*-286*
0208	1.7+34	19c	000	-173
		28a	000	-162
		15	110	-157
		17	220	-148
		32	000	-146
		48	110	-111
		37a	000	-88
0212	1.7+34	56a	100	-155
		50	100	-139
		60a	000	-138
0215	1.7+34	15	000	-161
		37a	100	-160
		6	111	-142
		31	101	-95
		71a	110	*-14*
		47	020	*-9*
0219	1.7+33	55a	000	-141
		66	112	-136
		10	——	-112
0223	1.7+33	54	000	-144
0302	1.7+33	12	100	-117
		8	1—	*-33*
0312	1.6+33	28a	112	-161
		35	111	-161
		19c	102	-149
		6	021	-140
		40	000	-136
		37a	000	-132
		16	112	-131
		39a	000	-131
		31	011	-127
		74	002	-100
		48	110	-99
		67	000	-94
0316	1.5+33	9	102	-73
0319	1.5+33	21	110	-61
0323	1.5+33	66	111	-132
0327	1.4+32	61	201	-139
		100a	121	-139
		81	100	-138
		8	0—	-103
		78	000	-50
0330	1.4+32	90	000	*+92*
0413	1.1+32	38	001	-111
		40	210	*+75*
0417	1.1+32	52	000	*-247*
		50	200	-116
0428	0.9+31	49	000	-112
-Ganymede Disappearances				
1988				
0607	1.1+53	101	202	+*208*
		58	202	+222
0622	1.5+53	80	202	+*134*
		32	110	+*239*
0706	1.9+53	102a	002	+337
0720	2.3+53	58	102	+279
		101	002	+370
		66	210	+429
0804	2.5+53	80	211	+347
		39	100	+367
		97	000	+389
0804	2.5+53	32	100	+422
0818	2.7+53	102a	020	+390
0825	2.7+53	52	100	+234
		56a	010	+449
		101	111	+460
		58	101	+465
0909	2.6+53	39	121	+*180*
		67	000	+344
		65	010	+390
		51	011	+411
		24	000	+421
		97	000	+451
0916	2.5+53	97	000	+445
		24	000	+451
		19a	201	+462
		32	000	+468
0923	2.4+53	42	001	+405
		86	112	+493
0930	2.2+52	42	001	+449
		69	000	+466
1007	2.0+52	23	100	*-66*
		56	000	+389
		56a	000	+466
1014	1.8+52	88	110	+362
1022	1.5+52	40	000	+438
1029	1.1+52	31	——	+155
		12a	101	+430
		44	001	+444
		20	000	+448
		64a	010	+462
		61	201	+467
1105	0.8+52	42	000	+402
1112	0.5+52	1	000	+413
		55a	000	+431
1119	0.1+51	10	000	+203
		66	011	+283
1218	0.1+51	42	111	+254
		72	212	+262
1225	0.4+50	27	101	+379
1989				
0101	0.6+50	85	000	+186
0108	0.9+50	48	100	+*146*
		16	121	+317
		28a	121	+368
		40	000	+373
		37a	100	+414
		32	000	+441
0116	1.1+50	37	101	+295
		32	111	+412
		100a	001	+415
		73	000	+420
		61	101	+439
0123	1.2+50	77	000	+412
		20	000	+420
		61	201	+429
0130	1.3+49	8	0—	*-601*
		94	110	+325
		60a	000	+332
0206	1.4+49	33	210	+*100*
		10	120	+246
		55a	210	+361
		66	010	+407

Table 4. Galilean Satellite Eclipse Timings, 1988-89—*Continued.*

U.T. Date mmdd	Geometry r °	Ob. No.	Con. stb	Res. sec.
- Ganymede Disap.—Cntd.-				
1989				
0220	1.4+49	48	110	+263
		71a	110	+267
		98a	110	+359
		34	101	+401
		14	000	+411
		15	001	+423
0228	1.4+48	12	100	+335
		8	0—	+361
0307	1.3+48	94a	011	+329
0314	1.2+48	50	000	+368
		84a	222	+368
0321	1.1+47	66	212	+298
0404	0.7+47	37	110	+221
		32	110	+314
		36a	111	+316
0412	0.5+47	41	111	*+50*
		78	111	*+56*
		87	000	+254
		12	101	+269
		81	100	+291
-Ganymede Reappearances				
1988				
0713	1.0+53	58	100	-401
		52	110	-188
0720	1.2+53	66	011	-397
0728	1.3+53	97	000	-369
		67	000	*-198*
		80	001	*-72*
0804	1.4+53	81	000	-374
0811	1.5+53	69a	000	-458
0825	1.6+53	101	011	-508
		56a	000	-483
		58	100	-457
		52	010	-308
		10	121	*-182*
0909	1.5+53	19a	101	-447
		65	010	-424
		67	000	-349
		32	000	-343
		17	000	-285
0923	1.3+53	42	000	-346
1014	0.7+53	37a	100	-445
1029	0.2+52	20	000	-451
		44	001	-451
		73	000	-398
1126	0.1+52	19b	100	-421
		67	000	-346
		81	111	-248
		28	000	-210
		79	111	*-194*
		31	—	*-23*
		47	111	*+284*
1204	0.5+51	73a	000	*-490*
		30	00–	-405
		42	010	-382
		102a	100	-315
		78	000	-262
		102	000	-215
1211	0.8+51	102a	100	-340
		102	000	-318
1211	0.8+51	78	022	-121
1989				
0101	1.8+51	37a	000	-464
		19	201	-357
		48a	201	-356
		85	000	-217
0108	2.0+50	37a	100	-460
		40	010	-420
		79	111	-358
		31a	—	*+1*
0116	2.2+50	100a	001	-478
		86	111	-464
		61	221	-455
		102a	100	-439
		42	001	-398
		102	000	-370
0130	2.5+50	84a	211	-430
		10	000	-421
		27	210	-329
		60a	020	*-101*
0206	2.6+49	66	110	-424
0213	2.6+49	28a	100	-442
		32	000	-423
		79	001	-390
		37	000	-349
0220	2.6+49	30	00–	-350
0228	2.6+49	61	101	-424
		8	0—	-359
		12	210	-326
0314	2.4+48	66	012	-430
		55a	210	-372
0321	2.3+48	85	020	*+350*
0328	2.1+48	7	001	-424
		65c	111	-407
		51	011	-314

Participating Observers

1	Abrahams, W. (15; *2*)
2	Aguiar, J. (6; *1*)
3	Aliete, M. (40; *1*)
4	Aloy, J. (16; *1*)
5	Arredondo, E. (10; *3*)
6	Barbany, D. (8; *5*)
7	Baroni, S. (20; *2*)
8	Baughman, W. (25; *11*)
9	Benn, D. (10.2; *5*)
10	Blanksby, J. (15; *26*)
11	Blasco, J. (20; *1*)
12	Bock, P. (7.5; *6*)
12a	” (10.2, *2*)
13	Brás, J. (16, *6*)
14	Bril, H. (20; *2*)
15	Bulder, H. (30; *9*)
16	Busi, L. (12; *3*)
17	Büttner, D. (6.3; *11*)
18	Casajust, J. (20.7; *2*)
19	Casas, R. (16; *10*)
19a	” (20; *9*)
19b	” (40; *7*)
19c	” (50; *1*)
20	Collins, M. (20; *5*)
21	Corrêa, 0. (6; *1*)
22	Cristini, D. (12; *1*)
23	Daadler, P. (15; *4*)
24	Dalmau, F. (20; *12*)
25	da Silva, A. (11.4; *2*)
26	Del Dotore, R. (9.6; *1*)
27	Dickie, R. (20; *9*)
28	Di Luca, R. (11.4; *5*)
28a	” (35; *13*)
29	Fernandes, J. (15; *2*)
30	Filho, A. (6; *6*)
31	Gallego, P. (6; *22*)
31a	” (41; *2*)
32	Garcia, J. (40; *31*)
33	George, M. (11.5; *3*)
33a	” (25; *1*)
34	Gerritsen, A. (16; *1*)
35	Gomez, J. (41; *5*)
36	Gómez de Quiroga, T. (20; *3*)
36a	” (30; *2*)
37	Gonçalves, R. (5; *8*)
37a	” (15; *31*)
38	González, E. (20; *2*)
39	Gracias, N. (13; *5*)
39a	” (15; *3*)
40	Grados, J. (20; *17*)
41	Graham, T. (8; *3*)
42	Gray, H. (13; *26*)
43	Haas, W. (31.8; *1*)
44	Hager, T. (32; *6*)
45	Heino, M. (8; *1*)
46	Himes, D. (31.2; *1*)
47	“I.B.C. Arenal” (8; *7*)
48	Jariod, E. (16; *8*)
48a	” (20; *3*)
49	Kazmierczak, M. (25; *3*)
50	Kearney, P. (20; *8*)
51	Kerber, F. (11.4; *12*)
52	Kerr, S. (5; *13*)
53	Kimmel, A. (20; *1*)
54	Klos, D. (33; *4*)
55	Kruijshoop, A. (10.5; *2*)
55a	” (20; *17*)
56	Loader, B. (10; *1*)
56a	” (20; *10*)
57	Lopez, M. (6; *1*)
58	Lowe, D. (20; *14*)
59	Lux, B. (6; *2*)
59a	” (15; *3*)
60	MacDonald, M. (7.5; *3*)
60a	” (20; *5*)
61	MacDougal, C. (15; *20*)
62	Marques, R. (9; *2*)
62a	” (40; *1*)
63	Martinez, D. (8; *1*)
64	Means, D. (5.4; *1*)
64a	” (12.7; *4*)
64b	” (228.6; *1*)
65	Molau, S. (6.3; *8*)
65a	” (10; *2*)
65b	” (15; *1*)
65c	” (50; *2*)
66	Moller, H. (20.3; *33*)
67	Muñoz, P. (16; *27*)

(over)

Participating Observers, Galilean Satellite Eclipse Timings, 198/89—*Continued.*

68	Napoleão, T. (20; *1*)
69	Newbill, C. (15; *3*)
69a	” (18; 2)
70	Oesper, D. (31.2; *1*)
71	Olesen, J. (15; *1*)
71a	” (20; *7*)
72	Parker, S. (10.2; *3*)
73	Parmentier, R. (15; *9*)
73a	” (75; *1*)
74	Prat, J. (12; *5*)
75	Predom, C. (25.4; *1*)
76	Priestley, J. (20; 2)
77	Rose, C. (15; *5*)
78	Rowley, D. (5; *18*)
79	Ruiz, B. (11.5; *13*)
80	San Jose, J. (11.4; *4*)
80a	San Jose, J. (20; *1*)
81	Schmitt, S. (10.2; *11*)
82	Shankar, A. (6; *3*)
83	Singh, J. (6.3; *3*)
83a	” (20; *1*)
84	Smith, C. (7.5; 2)
84a	” (25; *10*)
85	Sorathia, B. (7.5; *10*)
86	Stamm, J. (20; *4*)
87	Stark, R. (20; *3*)
88	Sterzinger, P. (12.7; 2)
89	Tamburini, F. (11.4; 2)
90	Tembrey, U. (7.5; *3*)
91	Thirionet, Y. (25; *5*)
92	Torrell, S. (26; *1*)
92a	” (30; *1*)
93	Tulipani, F. (15; *1*)
94	Undermay, E. (6; *5*)
94a	” (10; *1*)
95	Vandenbulcke, G. (25; 2)
96	Vidal, J. (20; 2)
96a	” (41; *5*)
97	Vigil, E. (20; *9*)
98	Vingerhoets, M. (17; *1*)
98a	” (20; 2)
99	Wadi, P. (7.5; *1*)
100	Walker, G. (10.2; *1*)
100a	” (25; *14*)
101	Ward, C. (20.5; *22*)
102	Westfall, J. (10.2; *15*)
102a	” (25.4; *18*)

MONITORING ATMOSPHERIC FEATURES ON SATURN IN 1991

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

For observers of Saturn, the 1990 Apparition began without any extraordinary changes being noted in the appearance or brightness of the planet's belts and zones. After all, atmospheric features on Saturn are characteristically ill-defined and transient, and it takes persistence and meticulous visual monitoring to recognize any subtle variations.

However, in late September 1990, Saturn rewarded the faithful who had been following that planet. For the first time in three decades, a truly spectacular white spot appeared on Saturn's disk. [The earliest sightings known to the Editor were independently made on 1990 SEP 25 U.T. by three amateur astronomers; Stuart Wilber of Las Cruces, New Mexico; and A.L.P.O. members Alberto Montalvo of Burbank, California, and Michael Sweetman of Tucson, Arizona.] It was located in the planet's Equatorial Zone (EZ); the last similar spot in the EZ occurred in 1933. Saturn's Globe, often considered a smaller, dimmer, quiescent replica of Jupiter's, had dramatically changed, even as seen in telescopes as small as 5.0 cm. (2.0 in.)! Walter H. Haas, the Director Emeritus of the A.L.P.O. and a veteran Saturn observer, said "the bright EZ oval now present is the brightest and most conspicuous feature I have ever seen [on Saturn]." Haas has been following Saturn visually since 1935. His impression that this was the most spectacular outburst recorded in the EZ during that interval was confirmed after examining A.L.P.O. Saturn Section files dating back to 1947, along with others going much further back (e.g., B.A.A. data). Observations from individuals all over the world have been received, including comments similar to those of Haas; all witness to the fact that something really remarkable had occurred on Saturn.

This eruption of activity on Saturn, however, was not totally unexpected. [See: Frank J. Melillo, "A White Oval Watch on Saturn?" *J.A.L.P.O.*, *33*, Nos 7-9 (July, 1989), p. 138.] Visual observational records maintained by the A.L.P.O. Saturn Section show recognizable seasonal and other long-term patterns in belt and zone intensities, and the emergence of what is now called the "Great White Oval of 1990" fits into a nearly-30-year cycle of spot activity. [Possibly the same as the 29.35-year revolution period of Saturn about the Sun. Note that this feature has also been called the "Great White Spot" and the "Wilber Spot." Ed.] The historical data suggest a sequence of spreading, differentiation, and fading over several weeks following the initial observation of such spots. Preliminary results indicate that this scenario applied to the Great White Oval during much of October, November, and early December, 1990.

When discovered, the spot was centered at Saturnian System I longitude 335° (see below), with a longitudinal extent of about 20°-25°. However, by the middle of October, the spot had declined slightly in intensity, but had expanded to cover some 80° of longitude! [See our front cover for the spot's appearance at about that time.] By early November, there was additional elongation along the EZ, with the spot almost encircling Saturn. Fulfilling expectations, a variety of less conspicuous, smaller white spots appeared in the EZ between System I longitudes 30° and 70°. The emergence of these "secondary" features accompanied a noticeable darkening of other Saturnian zones north of the EZ, while the North Equatorial Belt (NEB) adjacent to the EZ did not appear so dark as it had following the beginning of white-spot activity in late September, 1990.

A full analytical report will of course be published at a much later date, once all of the observations are gathered and carefully studied. For now, it is extremely important for individuals to maintain close scrutiny of Saturn in 1991. It is reasonable to expect that additional activity will erupt in the EZ and elsewhere on Saturn when the planet will have emerged from the glare of the Sun in the predawn sky in February-March, 1991.

Individuals who are equipped with nothing more than a telescope of reasonable aperture and performance, along with a good pair of eyes, have the greatest potential for making contributions to science through systematic, simultaneous, and extended observations of variable phenomena in the atmospheres of planets such as Saturn. The typically elusive phenomena visible in its belts and zones do not photograph well, and it is the visual observer who can take advantage of intermittent periods of good seeing to record delicate details. These are the types of observations we seek in the A.L.P.O. Saturn Section. Our participants are not necessarily large in number, yet the level of dedication, stamina, and zeal of our members is unmatched; apparition after apparition, in cold and hot weather, fighting frostbite and mosquitoes. Although sometimes slow in coming, the observational rewards are usually worth the long hours of gazing through our telescopes. The events of the 1990 Saturn observing season are an example.

As an example of the need for continuous patrols, discrete detail on Saturn's Globe seldom persists for many weeks, or even many days. Because of this, there has been tremendous difficulty in establishing reliable rotation rates for different belt and zone latitudes. Thus, when long-enduring spots or disturbances appear, as with the the Great White Oval of 1990, the opportunity must be taken advantage of in order to secure accurate central-meridian (CM) transit timings of such phenomena. Any feature which can be monitored for a few days or weeks, even if the individual CM timings are uncertain by a few minutes, can still yield valuable results. Observers, through careful planning, must remain alert for such outbursts, no matter how insignificant any new detail in a particular belt or zone may at first appear.

And so, we look forward to the 1991 observing season for a possible continuation of spot activity on Saturn. Knowing how to make CM transits will be helpful, and those who are experienced in making such observations with Jupiter should have no problems in extending their methods to Saturn. The atmosphere of Saturn, as that of Jupiter, rotates in two main Systems. Long-term timings by A.L.P.O. and other observers indicate that the rotation of the EZ and nearby portions of the North and South Equatorial Belts is best described with a sidereal period of 10h 14m 13s, or 844°.0 per terrestrial day. This means that 7 rotations occur in about 71.7h, just less than three Earth days. Subsequent transits can be timed for the same feature at 3-day intervals for some time, assuming it lasts long enough. In 1980, the International Astronomical Union (IAU), in apparent ignorance of the A.L.P.O. System I that had been in use for many years, chose an even sidereal period of 10h 14m 00s, or 844°.3 per day, and IAU System I longitudes are now annually published in the *Astronomical Almanac*. The A.L.P.O. has adopted the use of the IAU System I for its *Solar System Ephemeris* in the interest of continuity and standardization.

Regions on the Globe poleward of the System I region, except the polar regions themselves, are described by "System II", which is assumed to rotate with a sidereal period of 10h 38m 25s, or 812°.0 per day. Thus, 7 rotations take 74.5h, or 2.5h over three Earth days. Note that rotational rates differ significantly between different latitudes in the System II region. The IAU has not yet implemented its own System II, but the *A.L.P.O. Solar System Ephemeris* publishes System II longitudes as well as System I longitudes.

A.L.P.O. Saturn observers, as well as others who rely on visual methods, have found many different rotational rates in the atmosphere of Saturn at different latitudes. The only way by which accurate rates can be determined is through CM transit timings of prominent features on the Globe, and the making of such timings is really very easy. Observers simply estimate, to the nearest whole minute, when a particular feature is precisely midway between the east and west limbs of the planet. Use Universal Time (U.T.), obtained by listening to a time source such as the WWV or CHU short-wave time signals and then setting a watch or a clock. CM transit timings can be made more precise by averaging these three times: 1— the final minute when the feature is on the following ("f") side of the CM; 2—the last instant when the feature is centered on the CM; 3—the final minute when the feature is on the preceding ("p") side of the CM.

Naturally, timings are useless without supporting data. All observations should include the U.T. date and time, seeing and transparency conditions, the observer's name and location, the instrument and magnifications used, and data on filters and other pertinent factors. Because most of the observations will occur as part of a routine Saturn program, most reports will be accompanied by drawings of the planet, color and intensity estimates, descriptive notes, and so forth. It is essential that such information be provided, particularly a sketch of the feature being timed. Correctly showing its appearance and location in relation to perceptible belts and zones is important, as well as how the brightness of the spot or disturbance compares with other regions. Most observers attempt to estimate, and to show on a drawing, the extent of the feature on the Globe. The A.L.P.O. Saturn Section provides complete forms for use in recording observations.

We encourage interested individuals to contact the A.L.P.O. Saturn Section [address on inside back cover] for complete details on how to carry out observations of Saturn. You should begin observing as soon as Saturn is visible in the morning sky, and continue every clear night until it fades in the evening sky in very early 1992. This will provide you with an education in visual observing, but also possibly with a few more surprises such as those that delighted observers in 1990!

METEORS SECTION NEWS

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

1991 PREVIEW

For observers who enjoy meteors in mass quantities, 1991 will be an excellent year. Both the Perseids and the Geminids reach maxima without lunar interference. The mornings of August 13th and December 14th are dates to remember this year. An observer with dark skies could possibly log 1000 meteors if he or she observed on both those mornings. A six-hour session on each morning would be required to produce such large totals. On December 14th, 1990, I observed the Geminids for seven straight hours with a thin cirrus cloud cover, but still managed to count 610 meteors, even though nearly all 5th and 6th-magnitude meteors were missed. Under perfect skies at least 700 meteors would have been seen, and probably far more. Not too bad for one night!

Other major showers that may be seen favorably this year include the Lyrids (maximum on April 22), the Taurids (November 03 and 10), and the Leonids (November 18).

Major showers that will be spoiled by moonlight include the Quadrantids, Eta Aquarids, Alpha Capricornids, Delta Aquarids, Orionids, and the Ursids. However, although the night of maximum activity may be spoiled for these showers, we urge observers to watch for activity away from the maximum in order to help us to determine the boundaries of each stream.

I wish to thank all those observers who sent in data during 1990. Each contributor will receive a copy of the 1990 A.L.P.O. Annual Review discussing the data and highlights of the past year.

Please mail all observations of the 1990 Geminids as soon as possible so that all data may be included in the Annual Review and in the next issue of *J.A.L.P.O.*

RECENT METEOR OBSERVATIONS

Table 1, below, summarizes the observations made between 1990 JUL 29 and NOV 27 that have been received at the time of writing (January 3, 1991).

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

1990 U.T.Date	Observer and Location	Universal Time	Number and Type of Meteors Seen*	Comments* (+*N* = Limiting Magnitude)
JUL 29	Roger Venable, GA	06:25-07:23	14 S. δ Aqr; 5 Per; 6 SP	+6.0
SEP 16	James Richardson, CA	06:15-08:07	1 κ Aqr; 1 S. Psc; 8 SP	+6.5
	" " "	08:07-10:07	1 S. Psc; 18 SP	+6.5
	" " "	10:07-12:40	24 SP	+6.2
17	Deborah Carroll, NC	04:00-05:00	1 SP	+4.3
	Rex Carroll, NC	04:00-05:00	1 S. Psc; 2 SP	+2.5
	Barbara Hands, NC	04:00-05:00	2 SP	+2.5
	Dennis Hands, NC	04:00-05:00	2 SP	+4.3
	Rowena Nichols, NC	04:00-05:00	1 SP	+2.5
	Debbie Olson, NC	04:41-05:00	(none seen)	+4.3
	Jim Olson, NC	04:41-05:00	3 SP	+4.3
	Deborah Carroll, NC	05:00-06:00	1 S. Psc; 2 SP	+5.1
	Rex Carroll, NC	05:00-06:00	1 S. Psc; 3 SP	+2.9
	Barbara Hands, NC	05:00-06:00	1 S. Psc; 5 SP	+2.9
	Dennis Hands, NC	05:00-06:00	1 SP	+5.1
	Rowena Nichols, NC	05:00-06:00	4 SP	+2.9
	Debbie Olson, NC	05:00-06:00	4 SP	+5.1
	Jim Olson, NC	05:00-06:00	1 S. Psc; 4 SP	+5.1
	Deborah Carroll, NC	06:18-07:18	1 SP	+5.1
	Rex Carroll, NC	06:18-07:18	1 SP	+2.9
	Barbara Hands, NC	06:18-07:18	1 S. Psc; 1 SP	+2.9
	Dennis Hands, NC	06:18-07:18	1 SP	+5.1
	Rowena Nichols, NC	06:18-07:18	1 S. Psc; 1 SP	+2.9
	Debbie Olson, NC	06:18-07:18	1 S. Psc; 2 SP	+5.1
	Jim Olson, NC	06:18-07:18	2 SP	+5.1
28	Mark Davis, VA	07:30-08:30	1 S. Psc; 1 S. Tau; 6 SP	+5.9
30	Leonard Tomko, PA	05:29-06:34	1 S. Psc	+4.0
OCT 02	Mark Davis, VA	07:55-08:55	1 N. Tau; 1 S. Tau; 5 SP	+5.8
06	Leonard Tomko, PA	05:46-07:11	1 And; 1 SP	+5.0

------------------------------ *Table 1 continues on p. 27; notes on p. 28* ------------------------------

Table 1—Continued.

1990 U.T.Date	Observer and Location	Universal Time	Number and Type of Meteors Seen*	Comments* (+*N* = Limiting Magnitude)
OCT 15	Mark Davis, VA	07:30-08:30	2 S. Tau; 6 SP	+5.8
	" " "	08:30-09:30	2 ε Gem; 12 SP	+5.8
16	Mark Davis, VA	07:30-09:00	1 ε Gem; 1 N.Tau; 13 SP	+5.9
20	Alton Smith, TN	04:30-05:30	8 Ori; 2 SP	(not given)
	" " "	06:30-07:30	5 Ori	(not given)
	Mark Davis, VA	07:30-08:30	2 Ori; 1 S. Tau; 1 N. Tau; 5 SP	+5.7
21	Charles Boley, AL	04:35-05:35	4 Ori; 1 SP	+5.0
	Bill Mullins, AL	04:35-05:35	4 Ori; 2 SP	+5.0
	Steve Sauerwein, AL	04:35-05:35	4 Ori; 3 SP	+5.0
	Alton Smith, TN	05:30-06:30	12 Ori; 2 δ Aur; 2 SP	(not given)
	" " "	06:30-07:30	9 Ori; 1 SP	(not given)
	" " "	08:00-09:00	11 Ori; 1 S. Tau; 3 SP	(not given)
	Phyllis Eide, HI	08:30-09:30	2 Ori; 4 SP	+6.0
	Robert Lunsford, CA	08:30-09:30	7 Ori; 2 δ Aur; 2 SP	+7.0
	Michael Morrow, HI	09:00-10:00	1 Ori; 5 SP	+6.0; 10% cloudy
	Phyllis Eide, HI	09:30-10:30	3 Ori; 1 S. Tau; 4 SP	+6.0; 60% cloudy
	Robert Lunsford, CA	09:30-10:30	4 Ori; 1 N. Tau; 8 SP	+7.0
	Michael Morrow, HI	10:00-11:00	3 Ori; 1 S. Tau; 2 SP	+6.0; 70% cloudy
	Phyllis Eide, HI	10:30-11:30	3 Ori; 1 S. Tau; 2 SP	+5.5; 60% cloudy
	Robert Lunsford, CA	10:30-11:30	8 Ori; 9 SP	+7.1
	Michael Morrow, HI	11:00-12:00	4 Ori; 5 SP	+6.0; 50% cloudy
	Robert Lunsford, CA	11:30-12:30	16 Ori; 1 S. Tau; 10 SP	+7.0
	Phyllis Eide, HI	11:30-12:45	8 Ori; 6 SP	+6.5; 30% cloudy
	Michael Morrow, HI	12:00-12:45	8 Ori; 6 SP	+6.5; 10% cloudy
	Robert Lunsford, CA	12:30-13:00	4 Ori; 2 SP	+6.6
22	Phyllis Eide, HI	08:25-09:25	1 Ori; 1 S.Tau; 1 N.Tau	+5.0; 50% cloudy
	Michael Morrow, HI	09:00-10:00	2 SP	+5.5; 30% cloudy
	Phyllis Eide, HI	09:25-10:25	2 Ori; 5 SP	+6.5
	Robert Lunsford, CA	09:47-10:47	23 Ori; 1 ε Gem; 7 SP	+6.9
	Michael Morrow, HI	10:00-11:00	2 Ori; 1 S. Tau; 7 SP	+6.5
	Phyllis Eide, HI	10:25-11:25	4 Ori; 1 ε Gem; 1 S. Tau; 8 SP	+6.5
	Robert Lunsford, CA	10:47-11:47	14 Ori; 4 ε Gem; 6 SP	+7.0
	Michael Morrow, HI	11:00-12:00	6 Ori; 2 S. Tau; 1 N.Tau; 2 ε Gem; 7 SP	+6.5
	Phyllis Eide, HI	11:25-12:05	5 Ori; 1 S. Tau; 6 SP	+6.5
	Robert Lunsford, CA	11:47-13:02	18 Ori; 2 ε Gem; 17 SP	+6.7
23	Robert Lunsford, CA	09:47-10:47	9 Ori; 1 ε Gem; 1 N. Tau; 12 SP	+7.1
	" " "	10:47-11:47	22 Ori; 1 S. Tau; 11 SP	+7.2
	" " "	11:47-12:47	21 Ori; 3 ε Gem; 1 S. Tau; 6 SP	+6.7
24	George Gliba, MD	05:40-06:40	5 Ori; 2 S. Tau; 5 SP	+5.4
	" " "	06:40-07:40	3 Ori; 2 N. Tau; 7 SP	+5.4
25	Robert Lunsford, CA	10:18-11:18	8 Ori; 4 SP	+5.2
	" " "	11:18-12:18	3 Ori; 2 SP	+5.3
	" " "	12:18-13:03	4 Ori; 2 SP	+4.8
27	Michael Morrow, HI	10:45-12:00	1 Ori; 3 SP	+5.0; 20% cloudy
31	George Gliba, MD	08:30-09:30	1 Ori; 1 N. Tau; 5 SP	+5.0
NOV 07	Leonard Tomko, PA	03:20-04:48	1 SP	+5.0
15	Mark Davis, VA	08:33-09:48	3 Leo; 12 SP	+5.8
17	Robert Lunsford, CA	10:47-11:30	13 Leo; 5 SP	+6.3; ZHR = 19
	" " "	11:42-12:42	5 Leo; 1 Mon; 4 SP	+6.4; 50% cloudy
	" " "	12:42-13:17	4 Leo; 6 SP	+6.3; 50% cloudy
18	Mark Davis, VA	06:00-07:00	2 Leo; 2 Mon; 12 SP	+5.6
	" " "	07:10-08:10	6 Leo; 3 Mon; 9 SP	+5.6
	" " "	08:30-09:00	2 Leo; 1 Mon; 4 SP	+5.6

---------------------------------- *Table 1 continues on p. 28 with notes* ----------------------------------

Table 1—Continued.

1990 U.T.Date	Observer and Location	Universal Time	Number and Type of Meteors Seen*	Comments* (+*N* = Limiting Magnitude)
Nov 18	James Richardson, CA	06:30-07:30	1 Leo; 3 SP	+4.8
	Karl Simmons, FL	09:20-10:20	7 Leo; 5 SP	+6.5
	Wanda Simmons, FL	09:20-10:20	8 Leo; 4 SP	+6.5
	Robert Lunsford, CA	11:10-12:10	11 Leo; 9 SP	+6.3; ZHR = 16
	" " "	12:10-13:30	18 Leo; 1 Mon; 7 SP	+6.3; ZHR = 23
19	Leonard Tomko, PA	03:09-04:44	(none seen)	+6.0
	Robert Lunsford, CA	10:47-11:47	1 Leo; 1 SP	+7.2; 80% cloudy
	" " "	11:47-12:47	2 Leo; 2 SP	+7.3; 70% cloudy
	" " "	12:47-13:17	(none seen)	+7.0; 80% cloudy
27	Robert Lunsford, CA	10:00-11:00	7 SP	+5.8
	" " "	11:00-12:00	4 SP	+5.8
	" " "	12:00-13:00	5 SP	+5.6
	" " "	13:00-13:17	5 SP	+5.3

*** Notes for *Table 1:*** And = Andromedid; δ Aur = Delta Aurigid; ε Gem = Epsilon Geminid; κ Aqr = Kappa Aquarid; Leo = Leonid; Mon = Monocerotid; N. Tau = North Taurid; Ori = Orionid; Per = Perseid; S. δ Aqr = South Delta Aquarid; SP = Sporadic; S. Psc = South Piscid; S. Tau = South Taurid. ZHR = Zenithal Hourly Rate.

COMET CORNER

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

COMET FINDS FOR THE SECOND HALF OF 1990

Six new comets were discovered and two returning comets were recovered during the second half of 1990, bringing the annual cometary statistics to the following:

Type of Discovery or Recovery	January-June	July-December	Total
Visual Discoveries of New Comets	2	1	3
Photographic Discoveries of New Comets	2	5	7
Recoveries of Returning Comets	4	2	6
Total Comets Found	8	8	16

In addition to several of the comets found in the last half of 1990, some other comets have been widely observed. These include Comet Austin (1989c1), which was expected to be the "comet of the year," but which barely attained naked-eye visibility. Comet Levy (1990c) did better, reaching its brightest in August, 1990. Finally, Periodic Comet Honda-Mrkos-Pajdusakova (1990f) and Periodic Comet Encke made brief bright morning appearances in the Autumn.

The comets that were discovered or recovered in the last half of 1990 were:

Comet Tsuchiya-Kiuchi (1990i).–Kiyoshi Tsuchiya photographed this comet on 1990 Jul 13.5 U.T. [Universal Time], and it was visually discovered by Tsuruhiko Kiuchi on Jul 16.5 U.T. Tsuchiya was using an f/4 camera with T-Max Film. Kiuchi used the same 25×100 binoculars that he had used to find his first comet (1990b) earlier in the year. The second find took him 47 hours in 18 sessions.

Independent discoveries of this comet were made on July 16 by both M. Zanotta of Italy (his second independent find in the past year) and by X.-m. Zhou of China. Also, William Bradfield of Australia picked it up and mistook it for a galaxy, while the writer swept to within two degrees of it on July 13 before ceasing due to moonlight!

When found, Comet 1990i was in the evening sky near the galaxy NGC 4565, at magnitude +9.0. It slowly brightened in the evening sky until it reached perihelion at 1.1 A.U. [Astronomical Unit; 1 A.U. equals 149,600,000 km.] on 1990 Sep 29, then crossed into the morning southern sky at magnitude +7. Then it slowly dimmed, remaining visible in amateur telescopes through February, 1991.

Periodic Comet Mueller 2 (1990j).–Jean Mueller, working on the Second Palomar Survey of the heavens, discovered this comet on plates taken on 1990 Sep 15, when the comet was at magnitude +17, just south of the Square of Pegasus. It was closest to the Sun at 2.08 A.U. on 1990 Nov 20, with an orbital period of 6.56 years.

Periodic Comet Holt-Olmstead (1990k).- Henry E. Holt and C. Michelle Olmstead reported their discovery of this 17th-magnitude comet on 1990 Sep 14. This comet was closest to the Sun at 2.04 A.U. on 1990 Oct 5 and has an orbital period of 6.16 years.

Periodic Comet Mueller 3 (1990L).— Jean Mueller found this comet on plate that were exposed on 1990 Sep 24. It has an orbital period of 8.65 years and had been at perihelion, 3.00 A.U., on 1990 AUG 02. While observed, it got no brighter than magnitude +17.

Periodic Comet Harrington-Abell (1990m).—Our Assistant Comets Recorder Jim Scotti recovered this comet on 1990 OCT 22 when it was at magnitude +21. H. Rickman of Pic du Midi Observatory in France picked it up on the next day. This object has a 7.6-year orbital period and is not expected to get much brighter than it was at its discovery.

Periodic Comet Taylor (1990n).—Jim Scotti also recovered this comet; on 1990 NOV 11 when it was at magnitude +19. The comet has an orbital period of 6.97 years and is not expected to get brighter than magnitude +14.

Periodic Comet Shoemaker-Levy 1 (1990o).—Carolyn and Eugene Shoemaker and David Levy discovered this comet on a plate that was exposed through the 18-inch Schmidt telescope at Palomar Mountain on 1990 NOV 15. The comet had probably been near magnitude +11 when at perihelion on 1990 SEP 19, 1.52 A.U. from the Sun, but had dimmed after that as it drew away from both the Sun and the Earth. Comet 1990o takes 17.3 years to orbit the Sun.

Periodic Comet Shoemaker-Levy 2 (1990p).—This was originally thought to be an asteroid when discovered at 16th magnitude by Carolyn Shoemaker on plates taken by herself, her husband Eugene, and David Levy in late October, 1990. Pre-discovery images were found on plates that had been taken by the Holts, C. Olmstead, and J. Brown in late September. The object reached perihelion, 1.84 A.U. from the Sun, on 1990 SEP 25. However, in mid-December the object was found to have a 29 arc-second tail! Thus the "asteroid" was declared to be a comet, with a period of 9.3 years.

PRESENT COMET ACTIVITY

During the middle part of 1991, these seven comets will be in our skies. [Not counting new discoveries! Ed.] Ephemerides of these comets are given on *Tables 1-7* to the right and on page 30.

Periodic Comet Schwassmann-Wachmann 1.—This comet will occasionally outburst to magnitude 12-14, although usually it hovers near magnitude 18. It is in a near-circular 15-year orbit more than 5 A. U. from the Sun. It will reappear in the morning twilight in June and should be monitored for outbursts thereafter. Please report all positive and negative observations to this Recorder. [*Table 1*, right]

Periodic Comet Wild 2 (1989t).—Now leaving the inner Solar System after a minimum distance from the Sun of 1.58 A.U. in December, 1990, this comet has an orbital period of 6.2 years. Its increasing solar elongation makes the coming weeks a good time in which to make magnitude estimates so that an accurate light-curve can be constructed. [*Table 2*, p. 30]

Comet Levy (1990c).—Discovered by active A.L.P.O. member David Levy in May, 1990, this comet put on a fine show late last Summer before solar conjunction. It has since entered the morning sky, underwent its second opposition since discovery, and is now dimming in the evening sky. A.L.P.O. comet observers continue to submit observations of this comet—I now have over 150. [*Table 3*, p. 30]

Periodic Comet Metcalf-Brewington (1991a).—Howard Brewington discovered this comet on 1991 JAN 07, when it was at magnitude +8 in the evening sky. When its orbit was computed, it was realized that this was the long-lost Comet Metcalf (1906 VI). Assuming that it continues its present flare activity, this comet should still be visible in our evening sky. [*Table 4*, p. 30]

Periodic Comet Machholz.—I found this comet in 1986, and it is making its first predicted return. With a high inclination and a small perihelion distance, it races in from the south, passes on the other side of the Sun, and then enters our northern evening sky. In 1986 this comet flared at least once, so it should be monitored for such behavior. This is an "annular" comet and is observable when it is all the way out past Jupiter's orbit. [*Table 5*, p. 30]

Periodic Comet Hartley 2.—This comet reaches perihelion on 1991 SEP 17 at 0.95 A.U. from the Sun. It was also discovered in 1986, and 1991's apparition will be a favorable return. [*Table 6*, p. 30]

Periodic Comet Wirtanen.—Discovered at Lick Observatory in 1948, this comet orbits the Sun every 5.5 years. It will be at perihelion on 1991 SEP 20 at 1.08 A.U. [*Table 7*, p. 30]

EPHEMERIDES

Notes: In the "Elong. from Sun" column, **E** refers to evening, and **M** to morning, visibility. "Total Mag." values are forecasts and are subject to considerable uncertainty.

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

1991		2000.0 Coörd.				Elong.		Total
U.T. Date		R.A.		Decl.		from Sun		Mag
(0h U.T.)		h	m	°	'	°		
JUN	13	03	03.8	+25	49	032	M	+17.8
	18	03	07.7	+26	07	036	M	+17.8
	23	03	11.5	+26	25	039	M	+17.8
	28	03	15.2	+26	43	043	M	+17.7
JUL	03	03	18.8	+27	00	047	M	+17.7
	08	03	22.2	+27	17	051	M	+17.7
	13	03	25.5	+27	33	055	M	+17.7
	18	03	28.7	+27	49	059	M	+17.7
	23	03	31.7	+28	05	063	M	+17.6
	28	03	34.5	+28	20	067	M	+17.6
AUG	02	03	37.1	+28	34	071	M	+17.6
	07	03	39.5	+28	48	075	M	+17.6
	12	03	41.7	+29	02	079	M	+17.5
	17	03	43.6	+29	15	084	M	+17.5
	22	03	45.3	+29	27	088	M	+17.5
	27	03	46.7	+29	38	092	M	+17.5

Table 2. Ephemeris of Periodic Comet Wild 2 (1989t).

1991	2000.0 Coörd.		Elong.		Total
U.T. Date	R.A.	Decl.	from Sun		Mag
(0h U.T.)	h m	° '	°		
APR 24	17 53.4	-18 31	124	M	+11.5
29	17 53.4	-18 27	129	M	+11.6
MAY 04	17 52.4	-18 23	134	M	+11.6
09	17 50.4	-18 19	139	M	+11.7
14	17 47.6	-18 17	145	M	+11.8
19	17 44.0	-18 15	150	M	+11.9
24	17 39.8	-18 15	156	M	+12.0
29	17 35.2	-18 15	162	M	+12.1

Table 3. Ephemeris of Comet Levy (1990c).

1991	2000.0 Coörd.		Elong.		Total
U.T. Date	R.A.	Decl.	from Sun		Mag
(0h U.T.)	h m	° '	°		
APR 24	08 17.9	+13 53	090	E	+11.7
29	08 18.5	+14 41	085	E	+12.0
MAY 04	08 19.6	+15 21	080	E	+12.1
09	08 21.1	+15 56	076	E	+12.3
14	08 22.9	+16 27	071	E	+12.5
19	08 25.1	+16 53	067	E	+12.7
24	08 27.5	+17 15	063	E	+12.8

Table 4. Ephemeris of Periodic Comet Metcalf-Brewington (1991a).

1991	2000.0 Coörd.		Elong.		Total
U.T. Date	R.A.	Decl.	from Sun		Mag
(0h U.T.)	h m	° '	°		
APR 24	04 55.3	+12 48	042	E	+10.9
29	05 07.9	+13 10	040	E	+11.0
MAY 04	05 20.3	+13 29	038	E	+11.1
09	05 32.6	+13 44	036	E	+11.2
14	05 44.7	+13 55	035	E	+11.4
19	05 56.6	+14 03	033	E	+11.5
24	06 08.4	+14 08	031	E	+11.6
29	06 19.9	+14 09	029	E	+11.7

Table 5. Ephemeris of Periodic Comet Machholz.

1991	2000.0 Coörd.		Elong.		Total
U.T. Date	R.A.	Decl.	from Sun		Mag
(0h U.T.)	h m	° '	°		
JUN 18	03 33.6	-28 16	061	M	+12.9
23	04 11.7	-23 41	055	M	+12.4
28	04 49.8	-18 01	048	M	+12.0
JUL 03	05 27.0	-11 25	040	M	+11.4
08	06 02.7	-04 07	031	M	+10.8
13	06 37.4	+03 49	022	M	+9.8
18	07 14.5	+12 54	012	M	+8.2
23	08 11.6	+24 10	004	M	+6.7
28	09 23.3	+28 46	016	E	+8.9
AUG 02	10 29.4	+28 00	026	E	+10.2
07	11 29.0	+24 32	034	E	+11.1
12	12 19.9	+19 42	042	E	+11.8
17	13 01.6	+14 32	048	E	+12.4
22	13 35.5	+09 41	052	E	+13.0
27	14 03.2	+05 24	055	E	+13.5

Table 6. Ephemeris of Periodic Comet Hartley 2.

1991	2000.0 Coörd.		Elong.		Total
U.T. Date	R.A.	Decl.	from Sun		Mag
(0h U.T.)	h m	° '	°		
JUL 13	00 51.8	+20 44	090	M	+12.1
18	01 15.1	+23 08	089	M	+11.8
23	01 40.9	+25 28	087	M	+11.4
28	02 09.4	+27 37	085	M	+11.1
AUG 02	02 40.5	+29 28	083	M	+10.8
07	03 13.9	+30 53	080	M	+10.5
12	03 48.8	+31 45	077	M	+10.3
17	04 24.5	+32 00	074	M	+10.0
22	04 59.8	+31 37	072	M	+9.9
27	05 33.8	+30 40	069	M	+9.7

Table 7. Ephemeris of Periodic Comet Wirtanen.

1991	2000.0 Coörd.		Elong.		Total
U.T. Date	R.A.	Decl.	from Sun		Mag
(0h U.T.)	h m	° '	°		
JUL 18	03 47.7	+10 38	058	M	+12.0
23	04 06.6	+11 53	058	M	+11.8
28	04 26.3	+13 05	058	M	+11.6
AUG 02	04 46.7	+14 13	058	M	+11.4
07	05 07.8	+15 16	057	M	+11.1
12	05 29.6	+16 12	057	M	+11.0
17	05 51.8	+17 01	056	M	+10.8
22	06 14.5	+17 42	055	M	+10.6
27	06 37.5	+18 13	055	M	+10.5

A.L.P.O. SOLAR SECTION OBSERVATIONS FOR ROTATIONS 1824-1828 (1989 DEC 29 TO 1990 MAY 15)

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

ABSTRACT

This report summarizes A.L.P.O. Solar Section observations for Rotations 1824-1828, particularly in terms of the morphology and development of sunspot groups. Twenty-one observers in six countries contributed visual drawings and integrated-light and Hydrogen-α photographs. Solar activity tended to decrease in this period; except for Rotation 1824, the rotational means were slightly less than those for the previous reporting period (Rotations 1818-1823).

INTRODUCTION

This reporting period witnessed a general decline in activity after its first rotation. However, the first rotation showed activity greater than did the last rotation of the previous reporting period (Rotations 1818-1823).

The Relative American Sunspot Number, **RA**, was higher than the International Number, **RI**, for most of the period, for both daily and rotational means. Sunspot numbers and other solar activity are aggregated by Rotation Number by the Solar Section, rather than by calendar month, as is common elsewhere. There appears to be no good reason to use calendar months (other than the excuse, "we've always done it that way"), which vary from 28 to 31 days in length, while there is every reason to use a system based on the heliographic coordinate system. Thus, at the inception of our Section in 1982, we decided to use solar rotations as the observing-period unit. This has worked well and has received support from some members of the professional community, giving us every reason to continue this policy.

The mean rotational **RI** for this period was 144.8, with a low mean of 122.9 for Rotation 1825 and a high of 177.6 for Rotation 1824. The mean five-rotation **RA** was 146.9, dropping to a low of 128.0 in Rotation 1825 following a high of 172.0 for Rotation 1824. The highest daily **RI** was 264 (on 1989 DEC 30 in Rotation 1824), while the lowest was 57 (on 1990 FEB 17; Rotation 1825). The highest daily **RA** was 269 (on 1990 FEB 24, in Rotation 1826), while the lowest was 48 (1990 FEB 17 in Rotation 1825). *Figure 8* (p. 32) graphs the rotational means for both forms of Sunspot Number.

The terms and abbreviations used in this report are explained in the two books: *The A.L.P.O.S.S. Monochromatic Handbook*, (available from Co-Recorder Randy Tatum for $US 6.00; 1108 Ocala Road, Richmond, VA 23229); and *The New Observe and Understand the Sun* (available for $US 5.75 from the Astronomical League Sales, Four Klopfer Street, Pittsburgh, PA 15209). Sunspot classification is explained in "A Three-Dimensional Sunspot Classification System" (*J.A.L.P.O.*, *33*, Nos. 1-3, Jan., 1989, pp. 10-13) and in the Astronomical League book mentioned above.

The times used in this report are all Universal Time (U.T.) Directions are abbreviated (e.g., N, SW) and are heliographic as are angular dimensions. "Preceding" means west and "following" east. "Groups" are white-light visible collections of sunspots, while "Regions" are the magnetically associated areas around groups. Active regions are enumerated in this report with the prefix **AR**, and are designated as such by the Space Environmental Services Center (SESC) of the National Oceanic and Atmospheric Administration (NOAA) in Boulder, Colorado.

Twenty-one observers from six countries contributed observations to this report. Although the number of contributors is less than in the previous reporting period, it is still a gratifying number. The observers who left were all in the United States, so we retained sufficient longitude spacing for a potential of 24-hour coverage.

Table 1. Observers Contributing to This Report.

	Telescope			
Observer	cm.	f/	Type	Location
Alexescu, M.	6	12	Refr.	Romania
Bartell, W.	6	16	Refr.	B.C., Can.
Clement, D.	8	15	Mak.	Louisiana, USA
Dragesco, J.	36	10	S.-C.	France
Garcia, G.	20	10	S.-C.	Illinois, USA
Garfinkle, R.	25	10	S.-C.	California, USA
Gelinas, M.A.	15.2	12	Refr.	Quebec, Can.
Glaser, P.	20	10	S.-C.	California, USA
Hill, R.E.	6	13	Refr.	Arizona, USA
Kavanagh, O.	20	10	S.-C.	New Jersey, USA
Luciuk, M.	20	10	S.-C.	New Jersey, USA
Maxson, P.	15	6	New.	Arizona, USA
Melillo, F.J.	20	10	S.-C.	New York, USA
Rousom, J.	13	10	New.	Ontario, Can.
Ryder, J.	15	?	Refr.	Qld., Australia
Tao, Fan-Lin and Chang, Grace	13	?	Refr.	Rep. of China
Tatum, R.	18	15	Refr.	Virginia, USA
Timerson, B.	18	8	New.	New York, USA
VanHoose, D.	11	7.8	New.	Indiana, USA
Viens, J.F.	11.5	7.9	New.	Quebec, Can.

Notes:"cm." is the aperture of the telescope in centimeters; "f/" is its focal ratio; "Mak." is Maksutov; "New." is Newtonian; "Refr." is refractor; and "S.-C." is Schmidt-Cassegrain.

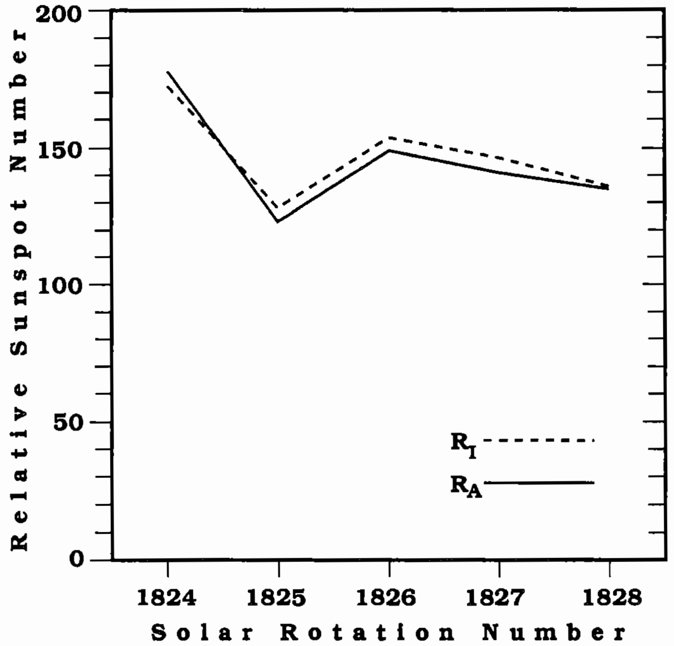

Figure 8. Graph of rotation means of RI (Relative International Sunspot Number) and RA (Relative American Sunspot Number) for Rotations 1824-1828.

Rotation 1824 [1,2]
(1989 DEC 29.73 to 1990 JAN 26.06)

Sunspot Number	Mean	Maximum (Dates)	Minimum (Date)
RI	177.6	264 (DEC 30)	125 (JAN 09)
RA	172.0	235 (JAN 24)	117 (JAN 09)

This reporting period began with its highest activity levels. However, while this rotation's activity was numerically high, none of the groups seen exceeded 1000 millionths of the solar disk in area (the standard practice is to report areas in terms of millionths of the disk), with none of the groups being reported as naked-eye. [2,3]

Two of the largest regions, **AR 5862** and **AR 5864**, were in view soon after the rotation began. Garfinkle's drawing of AR 5862 on 1989 DEC 29 showed three major spots arranged in a roughly equilateral triangle with its base oriented E-W and one spot to the N. The next day, Glaser and Maxson both observed that the following spot was breaking up and that it was followed by some small umbral spots that would later become AR 5864. The photographs taken by Glaser and Maxson also showed the leader spot to contain several umbrae in a round penumbra. They showed the N spot actually to consist of two spots; one round with penumbra, and a smaller spot with a rudimentary penumbra to the N of that one.

On the last day of 1989, the leader spot of AR 5862 was a group of umbrae forming a "W" in a single penumbra, with a few tiny umbrae surrounding it. The N spot had four umbrae in one penumbra with a tiny spot N of that, while the following spot held only a few small umbrae in one penumbra. By that date, AR 5864 had grown to one large spot with three small umbrae on its leading side.

New Year's Day, 1990, found the leader spot of AR 5862 to be large, nearly circular, and located slightly to the preceding side of the center of a fairly symmetrical penumbra. The N spot was then largely unchanged, while the follower was still breaking up, then consisting of a few umbrae in a rudimentary penumbra. In AR 5864, the leader spot was by then the largest in the region, and appeared to have moved W through the small spots during the preceding 24 hours. These small spots now followed the group.

On 1990 JAN 02, Luciuk and Rousom recorded a most interesting day as AR 5862 crossed the central meridian. The leader spot in that group was then elongated E-W, followed closely by a tangle of umbrae and disorganized penumbra. Oddly enough, despite this sudden change in the leader, the N spot and follower were largely unchanged! In AR 5864, the leader was the size of the N spot in AR 5862, and was followed by a small spot with a rudimentary penumbra. The previous following spots were gone, but both observers recorded several radial dark streaks to the NE. These were delicate structures, intermediate between photospheric and penumbral brightness. The author recently (Rotation 1840) observed a similar feature, when the dim or shaded area was unmistakably seen in a 7.5-cm. heliostat. However, when a 5-inch aperture was used the area was resolved into a field of several dozen pores! A H-α (monochromatic Hydrogen Alpha light at a wavelength of 6562.8Å) photograph would have been very useful here. I am uncertain what these features were, but they were not detached penumbra. Because each of the two observers showed these features without the other's knowledge, the features' existence is virtually certain. This points out the necessity of simultaneous observations.

Both regions were clearly on the decline by 1990 JAN 03, when the lead spot in AR 5862 was the largest spot in either group. It was still elongated E-W and was followed by about a half-dozen umbral spots. Both spots to the N were reduced in size, with the northernmost one without a penumbra. The follower then held only a few umbral spots.

This reduction continued on the next day, but on JAN 05 there was significant change in AR 5864. By then, it held two leader spots oriented N-S. The N leader was a fairly circular spot with a penumbra only on its N side. The S leader contained about four umbrae in one disorganized penumbra with a tail to the NE. Both spots had a line of umbral spots, some with rudimentary penumbrae, and had bits of penumbrae trailing off to the NE.

Both regions remained much the same on 1990 JAN 06, with the exception that the follower of AR 5864, formerly just some umbral spots, now had developed into two larger spots; with penumbrae located at the ends of the tails of the leaders, and aligned N-S as were the leaders. This region was near the limb on JAN 07. Meanwhile, AR 5862 had become just two round spots with radially symmetrical penumbrae. The leader spots of AR 5864 had merged and were followed by four spots with rudimentary penumbrae in a NE line. These were followed closely by the now-merged follower spots, surrounded by a single penumbra. JAN 08 was the last day of observation, when only AR 5864 could clearly be observed. It then had a leader that was three collections of spots, each in its own penumbra.

Rotation 1825 [2,3]
(1990 JAN 26.06 to FEB 22.40)

Sunspot Number	Mean	Maximum (Dates)	Minimum (Date)
R_I	122.9	211 (JAN 27)	57 (FEB 17)
R_A	128.0	213 (JAN 29)	47 (FEB 17)

Rotation 1825 had the lowest mean sunspot numbers of this reporting period. Although the maximum sunspot numbers dropped only slightly from the previous rotation, the minima accounted for the abrupt drop in sunspot number. In Rotation 1824 there were no days when either the American or International Sunspot Number fell below 115. However, in Rotation 1825 over half the days were below that value. The largest sunspot group of this rotation, **AR 5900**, actually came onto the disk in the previous rotation, and was nearly on the central meridian as this rotation opened. This grand region requires a description; because it was visible for one day longer in this rotation than is the previous one, its entire history is covered here. [3,4]

As AR 5900 came onto the disk it was hardly noticed because the disk was then covered with groups. Garfinkle recorded this region first, on 1990 JAN 20 when it was on the limb. By the next day, it could be seen as a large group of two large umbrae and several smaller umbrae, all within one irregular penumbra. Our first photographic observations of it came on JAN 22, and showed the group as several large umbrae in one penumbra, with smaller spots detached to the N and E. Following this were some smaller umbrae in one penumbra, with a few umbral spots between the leader and the follower.

By JAN 25, the region was well away from the limb. The leader then held four large umbrae and a few smaller ones, aligned E-W in one penumbra. To the E the penumbra was a jumble of penumbral fragments and umbral spots followed by detached spots, some with and some without penumbrae, along with more penumbral fragments scattered throughout. The follower consisted of two large umbrae in a penumbra, all amounting to about one-fourth the area of the leader. There was a tail of penumbra outside the N edge of the follower, containing three or four small umbrae, pointing toward the leader. A H-α photograph by Glaser showed this entire region to be surprisingly quiet. There was a large, N-S arcing filament preceding the region, with some plage between the leader and the follower spots, but it was not particularly bright.

AR 5900 was relatively unchanged on JAN 26, although its increased area then made the region visible to the naked eye. Many observers submitted data for JAN 27, when the leader appeared to be in the process of splitting up, with a light bridge in the middle of the four largest umbrae. There were fewer detached spots to the N and S than previously, but there was a N-S arc of umbral spots in rudimentary penumbrae following. The follower was much the same as before, with its "tail" reduced in extent. Garcia noted the reduced size of the group, compared with the previous day.

There was a great deal of change by JAN 28. In fact, AR 5900's contribution to the sunspot count made it double for some observers! The leader was nearly bisected with detached spots and penumbral bits on all sides but the leading one. The spots in the middle of the group were moving E and were merging with the follower. The follower itself showed the greatest change. Its "tail" had developed into three parallel branches of umbrae in strings of penumbrae, all connected to the main following spot on its NW edge. The main follower consisted of two umbrae in a radially symmetric penumbra. Around the entire group, the photosphere was distinctly brighter than normal.

There are no data in our files for JAN 29. On JAN 30, the leader was a smaller collection of about four umbrae in each of two penumbrae, with some small spots to the N and S. The follower contained a half-dozen umbrae in a large penumbra with a penumbral extension toward the leader, and projections of penumbrae to the NW and SW. Many smaller spots with and without penumbrae could be seen in the surrounding area. The group had noticeably contracted in size and in spot numbers on the last day of January. The "tail" on the follower had reformed. The region began to leave the disk on the next couple days as it experienced further reduction and dissolution.

Rotation 1826 [3,4]
(1990 FEB 22.40 to MAR 21.72)

Sunspot Number	Mean	Maximum (Date)	Minimum (Dates)
RI	148.5	249 (FEB 24)	71 (MAR 09)
RA	153.2	269 (FEB 24)	85 (MAR 10)

Except for the sudden, temporary decrease of the previous rotation, and the rise during Rotation 1826, this reporting period showed a steady decline. Rotation 1826 had activity levels that were higher than for Rotation 1825, but were significantly below Rotation 1824. [4,5]

Oddly, though, the most impressive region of this rotation, **AR 5947**, was the reduced remnant of the **AR 5900** of Rotation 1825. Having left the disk then near the beginning of February, it reappeared, as one might expect, on 1991 FEB 19. It was first observed photographically on the limb by Luciuk, appearing as a collection of spots in a rudimentary penumbra with few faculae. It was preceded closely by two other regions.

On FEB 20, three main collections of spots could be seen. The leader was the largest, composed of at least two umbrae in a rudimentary penumbra. It was followed by two collections of spots oriented in a N-S line, composed of small umbrae in a rudimentary penumbra, wreathed in faculae connecting this region with †he two to its W. On the next day, the leader was more nearly circular, with a fairly symmetrical penumbra surrounding the entire umbral collection. The collection to the N consisted of three large umbrae, of which the follower had a smaller penumbra surrounding four or five small umbrae. This penumbra was quite disorganized and fragmented.

Our only observation on FEB 22 was a H-α photograph by Dragesco, indicating that the leader spot may have rotated some 90 degrees counterclockwise. The follower appeared to consist of three spots with one or two umbrae each, within penumbrae whose character could not be judged. There was great change over the next 24 hours, when a white-light photograph by Maxson showed the entire group within one chaotic penumbral mass. The leading portion of the mass consisted of a half-dozen umbrae within a penumbra that was fragmented on its E side. The following portion had many umbrae, arranged approximately N-S with rudimentary and fragmented penumbrae surrounding it and connecting it with the leading portion. Surprisingly, the region was rather unremarkable in H-α light!

On FEB 24, the group was much the same; the only changes being a loss of penumbra on the leading edge of the leader spot and the detachment of a leading umbra that had moved W of the group. One day later, the penumbra was becoming more organized. The detached umbra in the lead was then split into two small umbrae. The leader itself consisted of four main umbrae that were arranged E-W with a penumbral tail at the N following edge, connecting to the follower. This behavior was similar to that exhibited by this group's ancestor, AR 5900. The follower was an arc of umbrae; first aligned E and then curving N on the following end, all within one penumbra. To the N was a detached piece containing six small umbrae, aligned E-W in a rudimentary penumbra.

Hill reported the group as visible to the naked eye on FEB 26. The leader was largely unchanged, but the follower was then breaking up. A light bridge cut the follower into two parts, one on the E and the other on the W. The W portion, between the leader and the E follower, was nearly entirely penumbral, while the E part had several umbrae in a rudimentary penumbra. There were also some detached small spots to the N and S. The previous detached spot to the N was rapidly dissolving and only a small penumbral piece was left.

FEB 27 saw little change in the leader, but the follower continued to break up. A day later, the leader had been invaded by a light bridge and was much reduced. The follower then consisted of one spot with a large umbra and several smaller umbrae in one penumbra, fully as large as the leader, surrounded by many small umbral spots, spots with penumbrae, and pieces of penumbra. From this point on, until it left the disk on MAR 04, AR 5947 continued to decay. The large spots diminished in size and became more nearly circular, while other spots continued to break up and dissolve.

Rotation 1827 [4,5]
(1990 MAR 21.72 to APR 18.01)

Sunspot Number	Mean	Maximum (Dates)	Minimum (Dates)
RI	140.3	230 (MAR 24)	77 (APR 10 & 12)
RA	146.1	234 (MAR 23 & 24)	85 (APR 10)

Activity continued to decline in Rotation 1827, although activity levels were still above those of Rotation 1825. No groups attained an area greater than 1000 millionths of the solar disk, although several groups grew large enough to be seen with the suitably-filtered naked eye. The region highlighted here is **AR 5984**, one of the three largest of the rotation. It appears that this region is the probable third rotation of old AR 5900 of Rotation 1825 and AR 5947 of Rotation 1826. That does not mean that these were the same sunspots as previously, but rather the same region from which the sunspots were born. Clearly, this area was quite a hotspot! [5,6]

As with its previous incarnations, AR 5984 came onto the disk at the end of the previous rotation. Garfinkle and Maxson both showed the region on MAR 18 as a lone spot in an area of massive faculae. On the next day it could be seen that this region was trapped amongst three other regions, one preceding and two following. AR 5984 then consisted of two main spots, arranged N-S and about 10 degrees apart, with pores and umbral spots between them.

We received no data for MAR 20, but fortunately the region developed slowly. On MAR 21, the S portion consisted of two umbrae in a rudimentary penumbra. To the N was a collection of tiny umbral spots also in a rudimentary penumbra. Following these was a cluster of umbral spots and pores. In H-α, the region had a very complex structure with bright arcs and a circular bright patch in a large circular swirl to the N of the sunspot group. Unfortunately, observers did not adequately cover this H-α feature, as interesting as it was, so we have no further idea as to what its connection with AR 5984 may have been.

Many observers contributed to our white-light coverage on MAR 22, when the entire region was a mass of umbrae in rudimentary penumbrae, surrounded by pores and umbral spots. There were two major collections, but no longer oriented N-S. To the SW of the center of the region was one large penumbra enclosing a half-dozen umbral spots, while to the SE were 10 to 12 umbrae in a rudimentary penumbra with an extension to the E consisting of umbral spots and pores.

A clear leader spot had developed by MAR 23, which was the previous SW collection that now contained 6 to 10 umbral spots in a rudimentary penumbra, followed by two collections of a half-dozen umbral spots to the NE and the SE. The follower, which was the previous SE collection, now contained two spots with their own rudimentary penumbrae in an E-W line. Between and slightly S of these two spots was one small umbral spot with a small rudimentary penumbra on the W side. All this detail was now followed by detached penumbrae containing two very small umbral spots. Some very rapid changes were taking place on this day. Only seven hours after the previous description, Maxson observed that the spots between and S of the leader and follower had moved E and had nearly merged with the follower. All the spots had developed more penumbra, which was rapidly becoming organized. The detached penumbra E of the follower had formed several distinct spots.

On MAR 24, the leader had become more nearly circular, with 2 to 3 umbrae in a symmetrical penumbra followed to the NE with a line of 6 to 8 spots that connected the SE edge of the leader to the NW edge of the follower. The follower itself was a chaos of umbral spots and disorganized penumbrae. The detached piece was now one umbra with a rudimentary penumbra on the W side. A H-α photograph by Melillo showed a bright plage just to the E of the leader along a line connecting the leader and the follower. This could well have been the magnetic neutral line between the two different polarities of the region and thus a good site for flares. All other regions of the disk were very quiescent.

AR 5984 was one long jumbled string of umbrae and penumbrae on MAR 25. The leader consisted of 4 to 6 umbrae in a rudimentary penumbra forming a N-tending arc. Following this was a middle cluster of umbrae with rudimentary and fragmentary penumbrae continuing all the way back to the follower collection. The follower was also a collection of umbrae arcing to the N; but on its following side, the opposite from the leader, it held many umbral spots and pores, with penumbral fragments scattered around them. The previous detached spot was by then just one small part of this general chaos. *Figure 9*, on p. 36, shows the appearance of AR 5984 on this date. In H-α light, Clement caught a flare at 17h 10m U.T., along the line passing through the middle spot, connecting the leader and follower portions, which is shown on *Figure 10* on p. 36. However, by 18h 00m U.T., Melillo recorded only a plage in that location.

With such strong and dynamic activity taking place, it is a real pity that we have no data for the next day. On MAR 27, the following spot had become the largest of the group. The leader spot contained one circular spot with a penumbra on its leading side. In the middle were 6 or 7 spots with rudimentary penumbrae. The follower was a large triangular spot with 4 umbrae in a line parallel to the NW side of this triangle. This very interesting region began leaving the disk on MAR 28. Some decay was beginning with both the leader and the follower becoming more nearly circular with smaller umbrae and more organized and symmetric penumbrae. Unlike its appearance when on the E limb, there were now few faculae in AR 5984.

Although it was not connected with AR 5984, it is interesting to note the passage of a very large quiescent filament that came onto the disk near the N pole on APR 05 and took 10 days to cross the disk. It displayed large prominences on both limbs. Many observers photographed or noted it; and Melillo took a spectacular high-resolution H-α photograph of it on APR 11, when it spanned about 40 degrees, reproduced as *Figure 11* on p. 37.

Rotation 1828 [5,6]
(1990 APR 18.01 to MAY 15.25)

Sunspot Number	Mean	Maximum (Dates)	Minimum (Date)
Ri	134.9	214 (APR 22)	59 (MAY 02)
Ra	135.4	218 (APR 18)	55 (MAY 02)

The final rotation of this report saw the second-lowest activity levels of the period. Sunspot groups tended to remain small, often not developing past Modified Zurich Class C [C; a bipolar group with penumbra on one end of the group; length under 10°]. However, there was one remarkable region whose area exceeded 1000 millionths of the Sun's disk. [6,7]

AR 6022 came onto the disk in its N Hemisphere, five days before this rotation began. It was seen by a number of observers on 1990 APR 13 as three large spots near the NE limb, with bright faculae surrounding it. One spot was in the lead, with the other two

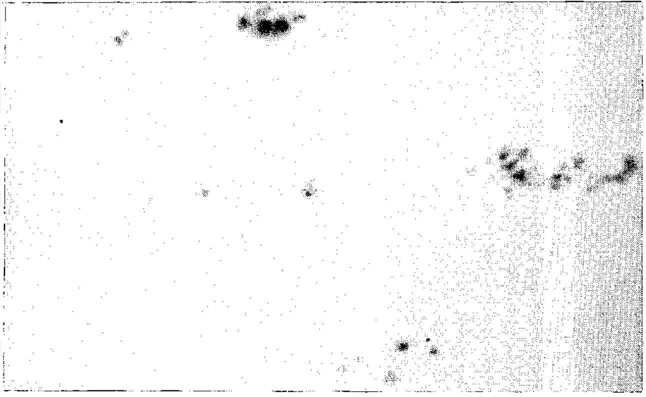

Figure 9. Solar Activity Region 5984, photographed in white light by Mike Luciuk on 1990 MAR 25, 13h 55m U.T. with a 20-cm. Schmidt-Cassegrain reflector at effective f/60. 1/1000-second exposure on Kodak TP2415 Film. North at top right.

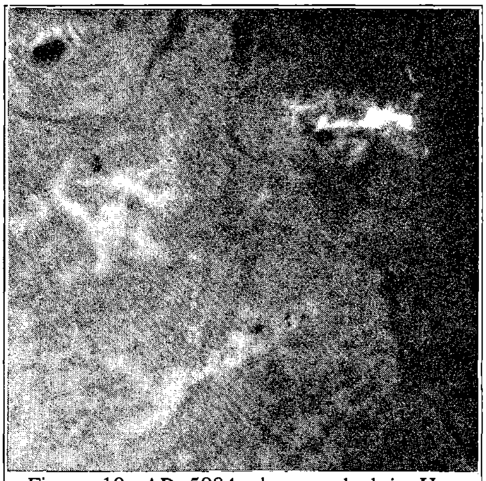

Figure 10. AR 5984 photographed in H-α light by Donald M. Clement on 1990 MAR 25, 17h 10m U.T., using a 15-cm. refractor, stopped to 6-cm. aperture with a 366-cm. focal length. Daystar © H-α 0.68Å Filter, central bandpass; 1/250-second exposure on Kodak TP2415 Film. Note the flare at center right, and compare with Figure 9 above. North at top.

aligned N-S and following. On the next day, the leader was seen to be one umbra in a penumbra elongated E-W. The S following spot was in the form of several umbrae in a chaotic penumbra, while the N follower was a circular umbra within a circular penumbra. By APR 15, the leader had become four umbrae in a row, with fragmenting penumbrae to their N and S only. The follower was by then one large spot with two large umbrae, aligned N-S in one organized penumbra. To the W of this were some detached spots, while the entire region was wreathed in bright faculae.

There was little change visible in white light on APR 16, but a H-α photograph by Melillo showed this region to be the brightest area on the disk! Again, on APR 17 a white-light drawing by Bartell showed virtually no alteration. However, there was some change by the next day, when the leader had diminished, had become more nearly circular, and had most of its penumbra to its N. The follower still consisted of two large umbrae, aligned N-S with several smaller umbrae in one well-organized penumbra. In addition, there were some small spots and pores between the leader and the follower. In H-α, a bright line could be seen running from the leading edge of the N spot to a point due S of the leader. This was reminiscent of the situation in AR 5984 on MAR 24-25. While all the above was taking place, the large N-Hemisphere quiescent filament was making a second pass across the disk, causing the H-α appearance of the Sun to be most interesting!

On APR 19, the leader of AR 6022 had lost its penumbra, but otherwise the region appeared largely unchanged in white light. A filament was seen to have formed along the edge of the bright line that connected the leader and the follower. This would have been an excellent site for flares. By the next day, the leader spot was quite small. The N umbra of the following spot had rotated around the S umbra, falling behind, while the penumbra had developed projections to the E and W. Even though this region was by then only one day from the central meridian, faculae could still be seen around all the spots and trailing off to the W limb!

On APR 21 the leader spot was all but gone. The follower was now aligned E-W, with an organized penumbra that had a ragged boundary. A series of H-α photographs by Garcia showed filament arcs rising up out of the S umbra and extending to beyond the boundary of the white-light group. At 19h 06m U.T. on that date, Garcia caught a flare along the former bright line, which could still be seen even though the lead spot was almost gone. Indeed, the leader spot had disappeared completely by the next day, although the follower remained unchanged. Also on APR 22, Melillo photographed the large quiescent filament, which by then was a splendid prominence on the limb. This photograph appears on the next page as *Figure 12.*

The last changes to the region that were noted were on APR 23. The group was then near the limb; comprising three umbrae, two leading and one following, in a massive chaotic penumbra. Observations on the next day showed only that this group was on the limb and was breaking up.

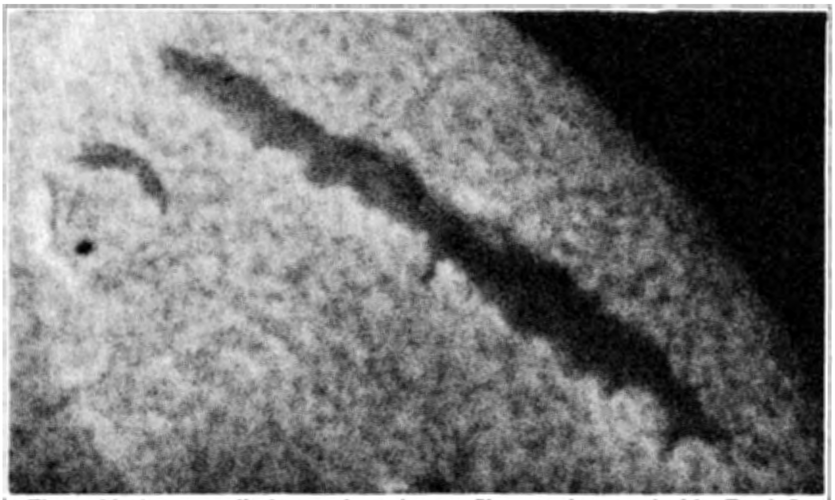

Figure 11. An unusually large solar quiescent filament photographed by Frank J. Melillo on 1990 APR 11, 21h 50m U.T. 20-cm Schmidt-Cassegrain at effective f/30. 0.6Å-bandpass H-α Filter and Kodak TP2415 Film with a 1/2-second exposure. Activity Region 6012 at lower left. North at top.

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3.) ________, No. 547, March, 1990.
4.) ________, No. 548, April, 1990.
5.) ________, No. 549, May, 1990.
6.) ________, No. 550, June, 1990.
7.) ________, No. 551, July, 1990.

Figure 12. The solar prominence photographed here by Frank J. Melillo on 1990 APR 22, 16h 00m U.T., is the same feature that appears as a filament on Figure 11, above. 20-cm. Schmidt-Cassegrain telescope with a 7.6-cm. off-axis stop at effective f/30. Photographed with a H-α 0.6Å filter and Kodak TP2415 Film with a 1-second exposure. North at top.

INDEX TO VOLUME 34 OF *THE JOURNAL OF THE ASSOCIATION OF LUNAR AND PLANETARY OBSERVERS (THE STROLLING ASTRONOMER)*

By: Michael Mattei

[*Editor's Note:* Some years ago, the A.L.P.O. published an index after every volume of this Journal was published. Thanks to the generous effort of Mr. Mattei, we hope here to reinstitute this useful practice. We welcome readers' suggestions on the contents and format of this index.]

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SUBJECT INDEX

THE INTERNATIONAL SOLAR SYSTEM OBSERVERS' FUND (ISSOF)

By: Paul H. Bock, Jr., Acting Coordinator, ISSOF

[The A.L.P.O. hears frequently from enthusiastic amateur observers who, for reasons beyond their control, are unable to obtain the equipment, the documentation, or both, necessary for them to contribute scientifically useful observations to us. Mr. Bock has generously established the special fund described below in order to assist these individuals. Ed.[

The Association of Lunar and Planetary Observers is pleased to announce the creation of the *International Solar System Observers' Fund* (ISSOF), a service similar in function to the ongoing Foreign Membership Fund (see p. 46). However, while the latter is concerned with supplying complimentary memberships to deserving observers outside the United States, ISSOF will concentrate on providing resources to individuals or groups worldwide who wish to contribute to A.L.P.O. programs, but who lack suitable equipment, observing aids, or both. The activities of the new fund will be coordinated by: Paul H. Bock, Jr., RR1, Box 347, Hamilton, VA 22068 (telephone: 703-882-4745).

As with the Foreign Membership Fund, ISSOF must be supported by contributors. However, the recent assignment of non-profit status to the A.L.P.O. will provide tax benefits to contributors, so donations will be solicited from commercial equipment manufacturers and suppliers as well as from A.L.P.O. members. An additional benefit to commercial contributors will be free publicity received through the mention of their assistance in the *Journal, A.L.P.O.*

One of the goals of ISSOF is to establish an inventory of equipment for use by Solar System observers worldwide, and to that end we request the following specific types of items:

1. Binoculars
2. Small telescopes
3. Mountings and tripods
4. Eyepieces, Barlow lenses, and star diagonals
5. Mirror kits
6. Planispheres and star charts
7. Handbooks
8. Magazines and periodicals

A computer inventory will track contributions by type, donor name and address, declared value; and recipient, when issued. The inventory will assist individuals and groups in selecting the resources required as well as in tracking contributions to the A.L.P.O.

Individuals who wish to contribute money should send checks or money orders payable to "A.L.P.O." to Executive Director Westfall. Those wishing to contribute equipment or supplies should write to Mr. Bock, who will forward the necessary forms to be completed and returned with the equipment. A signed copy of each form will be returned to the donor to serve as proof of contribution.. Donors are responsible for determining the assessed value of donated materials and services, and the Coordinator's signature merely acknowledges that the material was received by the A.L.P.O. All contributed material will be maintained in inventory until issued.

COMING SOLAR-SYSTEM EVENTS: MARCH - MAY, 1991

WHAT TO LOOK FOR

The purpose of this column to alert our readers about upcoming events in the Solar System; giving the visibility conditions for major and minor planets, the Moon, comets, and meteors. You can find more detailed information in the 1991 edition of the *A.L.P.O. Solar System Ephemeris*. (See p. 48 to find out how to obtain this publication.) Celestial directions are abbreviated. All dates and times are in Universal Time (U.T.). For the time zones in the United States, U.T. is found by adding 10 hours to HST (Hawaii Standard Time), 9 hours to AST (Alaska Standard Time) or HDT (Hawaii Daylight Time), 8 hours to PST or ADT, 7 hours to MST or PDT, 6 hours to CST or MDT, 5 hours to EST or CDT, and 4 hours to EDT. Note that this addition may put you into the next U.T. day!

THE PLANETS: JUPITER, AND VENUS PROMINENT, SATURN ON THE WAY UP

Venus and Jupiter are clearly the most obvious and conveniently-observable planets this season. First, **Venus** is now comfortably high above the western horizon during evening twilight. Between MAR 01 and JUN 01, the planet's elongation from the Sun increases from 28° to 45° as it approaches its Greatest Elongation East of 45°.4 on JUN 13. During this period, its disk diameter gradually grows from 12 to 21 arc-seconds; the planet's phase diminishes from 88 to 56 percent illuminated, even while its magnitude brightens slightly from -4.0 to -4.2.

Jupiter, in the constellation Cancer, is in the evening sky throughout our period, although its equatorial diameter shrinks from 44 to 34 arc-seconds. Dropping in brightness from magnitude -2.5 to -1.9, it remains second in brightness only to Venus. Besides monitoring the continuing major activity in the revived South Equatorial Belt, check the now-fading Red Spot. (A recent unconfirmed report is that it may have vanished entirely!). The unusual *mutual events* of the Galilean satellites are continuing; see below (pp. 43-44).

Saturn is now becoming easily observable in the southern predawn sky, finally moving out of Sagittarius into Capricorn. The Ringed Planet is brightening and growing in apparent size as it approaches its opposition on JUL 27. The Rings continue well-presented, inclined about 19° to our line of sight. As we go to press, two ovals have been reported in the planet's Equatorial Zone, so continue to monitor Saturn for unusual activity.

Uranus and **Neptune** remain somewhat west of Saturn, in Sagittarius, and therefore are morning-sky objects; they will reach opposition on JUL 04 and JUL 08, respectively. **Pluto**, however, reaches opposition on MAY 10, at magnitude +13.6, and thus is visible with a 8-10 inch telescope under dark skies.

Mercury has an evening-sky apparition that is very favorable for Northern-Hemisphere observers, being over 15° from the Sun between MAR 19 and APR 04. Its Greatest Elongation East is 18°.8, on MAR 27, and theoretical time of *dichotomy* (half-phase) is on MAR 25. The next, morning apparition, is best seen from south of the Equator; from APR 25 - JUN 04; with a Greatest Elongation West of 26°.2 on MAY 12 and a date of dichotomy of MAY 18.

Mars, moving from Taurus into Gemini and then into Cancer, is now sinking in the west in the evening. In early April, its disk diameter shrinks below 6 arc-seconds; too small for much detail except for dedicated observers with large instruments. For such souls, we point out that Mars' North Pole is turned increasingly toward our view during this period, and limb hazes and clouds may be in evidence as the North Polar Cap retreats.

Two of the brightest **minor planets** reach opposition in our period, perhaps bright enough to be seen with the naked (but much above-average) eye under very dark skies. Their 10-day ephemerides are given in the 1991 *A.L.P.O. Solar System Ephemeris*, but their opposition circumstances are summarized below:

	Opposition Data		
Minor Planet	1991 Date	Stellar Magnitude	Declination& Constellation
2 Pallas	MAR 02	+6.7	5°S Leo
1 Ceres	APR 21	+7.0	3°N Virgo

THE MOON

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

New Moon	First Quarter	Full Moon	Last Quarter
MAR 16.3	MAR 23.3	MAR 30.3	APR 07.3
APR 14.8	APR 21.5	APR 28.9	MAY 07.0
MAY 14.2	MAY 20.8	MAY 28.5	JUN 05.6

The three lunations above are Numbers 844-846 in Brown's series.

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

South	East	North	West
MAR 19	MAR 30	MAR 31	APR 12
APR 15	APR 26	APR 28	MAY 10
MAY 12	MAY 22	MAY 25	JUN 07

Lunar E and W directions above follow the usage of the International Astronomical Union, with Mare Crisium near the *east* limb. Particularly good views of the Moon's north polar region can be had between MAR 29-APR

03 (APR 04 marks the lunar northern Summer Solstice, with the Sun 1°.55 north of the Moon's Equator) and APR 25-30. The NE limb can be seen favorably on MAR 31-APR 02 and APR 29-MAY 01, with the SW limb well-presented on APR 10-13 and MAY 07-12.

OCCULTATIONS

Two major, and eight minor, planets will occult stars in the interval of interest, as shown in the table below which lists the date, occulting object, visual magnitude of planet/star, and *possible* zone of visibility for each occultation.

MAR 27.60. **187 Lamberta**, 11.4/8.6. New Guinea, Australia.
MAR 28.71. **30 Urania**, 12.1/7.0. SE Asia, S USSR, Indonesia.
MAR 30.25. **2 Pallas**, 8.0/8.9. E No. & W So. America.
APR 01.00. **96 Aegle**, 11.8/9.2. S Africa, So. America.
APR 02.88. **624 Hektor**, 14.6/8.2. W Australia, S Africa.
APR 04.78. **VENUS**, -4.0/7.9. E & Central Europe, N Africa.
APR 11.14. **4 Vesta**, 8.4/9.1. NW & Midwest United States.
APR 13.80. **19 Fortuna**, 11.8/10.5. N Europe, SW USSR.
MAY 02.81. **19 Fortuna**, 12.2/8.5. E Europe, SW USSR.
MAY 05.46. **15 Eunomia**, 10.6/8.5. N Australia.
MAY 12.86. **MERCURY**, 0.6/11.0. Central Australia.

Two occultations of Mars by the Moon happen during our time period, the first on **MAR 22**, 17h, when the +0.9-magnitude planet is 83°E of the Sun, and visible from the NE United States, E Canada, N and Central Europe, and W and central Asia. The second occurs on **APR 20**, 00h, when the magnitude of Mars is +1.2 and it is 70°E of the Sun. The latter event can be seen from southern South America.

Also, there will an occultation of the +1.2-Mag. star **Antares** on **APR 04**, 03h, visible from Europe and SW Asia. This will be the last occultation of Antares until 2005 JAN 07.

The series of passages of the Moon across the **Pleiades** open star cluster (M45) also ends; with the event of **MAR 21**, 00h, 25-percent sunlit Moon; visible from E North America. **APR 17**, 07h, 8-percent phase; from the W Pacific Ocean.

COMETS

Several telescopic comets will be present in the sky; including Periodic Comet Wild 2 (1989t), Comet Levy (1990c), and Periodic Comet Metcalf-Brewington (1991a). For more information, see the article by Don E. Machholz, "Comet Corner," on pp. 28-30 of this issue.

METEOR SHOWERS

(Contributed by Robert D. Lunsford, A.L.P.O. Meteors Recorder. For more information see "Meteors Section News" on pp. 26-28)

Watch for the annual **Virginid complex** beginning on MAR 12. There are many radiants that appear in Virgo during both March and April. None produce more than 5 meteors per hour and most are barely detectable.

The **Lyrids**, one of the major annual showers, reaches maximum on Monday morning, April 22nd (local date). These medium-swift meteors are best seen between midnight and dawn, when the first-quarter Moon will have set this year. Recent rates for this shower, as seen under dark rural skies, have been between 15 and 25 meteors per hour.

GALILEAN SATELLITE MUTUAL EVENTS

Jupiter's four Galilean satellites continue to eclipse and occult each other, as described in "The Mutual Antics of the Galilean Satellites" on pp. 189-190 of the November, 1990, issue of this Journal.

For more information, consult the above article. In summary, these phenomena occur during a period every six years when the Sun and the Earth cross Jupiter's equatorial plane and thus the orbital planes of the Galilean satellites. These events are fascinating to watch, even in a small telescope. For example, you can make a series of drawings, or estimate the amount of light loss in magnitudes by comparing satellites in the same way as that used for variable stars. With a medium-size telescope, the satellites can be photographed in a few seconds' exposure, which should be done at regular intervals while the event goes on. One can videotape an event with a sensitive video camera and a telescope of at least 8 inches (20 cm) aperture, and carefully time the event by recording WWV short-wave time signals on the audio track.

Photoelectric measurements of the light changes during an occultation or eclipse are probably the most useful amateur observations. Here, a frequent series of measurements is needed, each ideally timed to 0.1-second accuracy. It is of course important carefully to measure and to correct for the considerable scattered light from the nearby disk of Jupiter.

Occultations of Io by Europa are being monitored by the "International Jupiter Watch," in order to map Io's volcanic activity. To take part, you need to conduct event photometry in the **V** or **B** bands; ideally both so as to get time-dependent (**B-V**) differences. Such measures allow us to map the extent of "resurfacing" on Io caused by the volcanic ejecta.

Predictions for the events for March-May, 1991, are listed on the next page. Future issues of this Journal will continue this listing in this column. See also the appropriate annual volumes of the *A.L.P.O. Solar System Ephemeris*.

The other aspect of communication is to let people know your results; and, depending on the form of observation, it should be sent to the following persons:

—The A.L.P.O. will be happy to receive drawings, photographs, and visual photometry, which should be sent to: John E. Westfall, A.L.P.O., P.O. Box 16131, San Francisco, CA, 94116.

—(B-V) photometry of occultations of Io by Europa should be sent to Westfall at the above address, who will make them available to the International Jupiter Watch.

—Reports on single-color photometry and copies of video tapes (VHS format) of all events should be sent to both:

Fred Franklin,
Center for Astrophysics, 60 Garden Street
Cambridge, MA 02138.

Dr. Jean E. Arlot, Bureau des Longitudes;
77, avenue Denfert-Rochereau;
75014 - Paris, France.

Schedule of Galilean Satellite Mutual Events, March - May, 1991

The condensed table below gives: First the date (mmdd, in Universal Time). Next is the form of event, where the satellites are numbered 1 for Io, 2 for Europa, 3 for Ganymede, and 4 for Callisto. The occulting or eclipsing satellite is given first, followed by "O" for occultation or "E" for eclipse, then by the occulted or eclipsed satellite; finally by "P" for partial, "A" for annular, or "T" for total. Then follow the Universal Times of the event's beginning and end, each given as hhmm. The next set of two digits is the percentage maximum light loss ("DL"). Finally is given the apparent distance from Jupiter's center in Jovian equatorial radii ("R"). *Italicized events are not recommended for photoelectric photometry but may be observed visually.*

U.T. Date	Event Type	U.T. Begin	U.T. End	DL	R
1991					
0301	4E2P	1612	1645	79	09
0302	4E2P	0500	0528	08	03
0302	2O1P	1844	1852	31	06
0302	2E1A	2001	2009	61	05
0306	2O1P	0749	0756	27	06
0306	2E1A	0912	0919	60	05
0309	2O1P	2055	2101	24	06
0309	2E1A	2222	2229	59	05
0310	2E4P	0337	0349	25	04
0313	2O1P	1000	1006	20	06
0313	2E1A	1132	1139	57	05
0316	2O1P	2306	2311	17	05
0317	2E1A	0042	0049	55	05
0317	*4O3P*	*1822*	*1920*	*00*	*12*
0317-0318	4O3P	2150	0214	11	10
0318	*3E2P*	*1626*	*1630*	*01*	*05*
0318	4E2T	1938	1947	36	07
0320	2O1P	1211	1216	14	05
0320	2E1A	1352	1359	52	05
0320	*4E3P*	*2301*	*2316*	*01*	*14*
0324	2O1P	0118	0122	12	05
0324	2E1P	0301	0308	49	04
0325	3E2P	1939	1945	13	05
0327	2E4P	1151	1159	08	02
0327	2O1P	1424	1428	09	05
0327	2E1P	1610	1617	46	04
0328	*1E2P*	*2306*	*2310*	*20*	*01*
0329	*1E3P*	*0613*	*0622*	*01*	*04*
0331	2O1P	0330	0334	07	05
0331	2E1P	0520	0526	42	04
0401	*1E2P*	*1213*	*1217*	*27*	*01*
0401	3E2P	2252	2300	45	06
0403	2O1P	1637	1641	05	05
0403	2E1P	1828	1834	38	04
0404	4E1P	1353	1529	21	05
0405	*1E2P*	*0120*	*0124*	*34*	*01*
0405	1E3P	1041	1108	09	03
0405	*4E1P*	*1346*	*1350*	*00*	*04*
0407	2O1P	0544	0548	04	05
0407	2E1P	0737	0743	33	04
0408	*1E2P*	*1427*	*1431*	*38*	*01*
1991					
0409	3E2P	0207	0215	78	06
0410	2O1P	1851	1854	03	05
0410	2E1P	2046	2051	29	04
0412	*1E2P*	*0333*	*0338*	*50*	*01*
0412	3O4P	1004	1112	11	05
0413	1E4P	1605	1611	07	07
0413	2E4P	2111	2118	03	09
0414	*2O1P*	*0759*	*0802*	*02*	*05*
0414	2E1P	0954	0959	25	04
0415	3E4P	0121	0145	43	19
0415	*1E2P*	*1640*	*1645*	*56*	*02*
0416	3E2P	0522	0531	97	07
0416	*3E1P*	*1209*	*1211*	*00*	*03*
0417	*2O1P*	*2107*	*2109*	*02*	*05*
0417	2E1P	2302	2307	21	04
0419	*1E2P*	*0547*	*0552*	*64*	*02*
0420	4E3P	2306	2316	03	11
0421	*2O1P*	*1015*	*1017*	*01*	*05*
0421	2E1P	1210	1216	16	03
0421	4E1P	1848	1856	52	02
0422	4E2P	1323	1330	03	05
0422	*1E2P*	*1854*	*1900*	*71*	*02*
0423	3E2P	0838	0847	91	07
0423	3E1P	1452	1457	04	03
0424	*2O1P*	*2323*	*2325*	*01*	*04*
0425	2E1P	0118	0123	12	03
0426	*1E2A*	*0802*	*0807*	*80*	*02*
0427	*1E3P*	*1700*	*1702*	*00*	*07*
0428	*2O1P*	*1232*	*1234*	*01*	*04*
0428	2E1P	1427	1431	08	03
0429	*1E4T*	*2052*	*2102*	*52*	*02*
0429	1E2A	2109	2114	85	02
0429	2E4A	2202	2236	47	02
0430	3E2P	1155	1203	65	07
0430	3E4P	1531	1542	18	09
0430	3E1P	1738	1744	20	04
0501	*2E4P*	*0410*	*0412*	*00*	*14*
0502	*2O1P*	*0140*	*0142*	*01*	*04*
0502	2E1P	0335	0338	04	03
0503	1E2A	1016	1022	87	02
0504	*1E3P*	*1949*	*1953*	*01*	*06*
0505	*2O1P*	*1449*	*1451*	*02*	*04*
1991					
0505	*2E1P*	*1642*	*1646*	*02*	*03*
0506	*1E2A*	*2324*	*2329*	*85*	*02*
0507	3E2P	1512	1520	39	08
0507	3E1P	2025	2032	43	04
0508	4E1P	0116	0132	47	06
0508	*4E1P*	*1041*	*1103*	*81*	*01*
0509	4E1A	0330	0342	78	04
0509	*2O1P*	*0357*	*0400*	*02*	*04*
0509	*2E1P*	*0550*	*0553*	*01*	*03*
0510	4E3A	0431	0455	66	14
0510	1E2A	1231	1237	81	02
0511	1E3P	2236	2242	06	06
0512	*2E3P*	*0427*	*0431*	*00*	*08*
0512	2O1P	1707	1709	03	04
0512	*2E1P*	*1858*	*1900*	*00*	*03*
0514	1E2P	0139	0144	75	02
0514	3E2P	1830	1838	12	08
0514	3E1P	2316	2324	66	05
0516	3E4A	0047	0102	64	04
0516	2O1P	0616	0618	04	04
0516	*2E1P*	*0805*	*0807*	*00*	*03*
0517	1E4P	0610	0619	36	07
0517	1E2P	1447	1452	68	03
0519	1E3P	0122	0128	17	05
0519	2E3P	0742	0748	05	08
0519	201P	1925	1928	06	04
0519	*2E1P*	*2113*	*2114*	*00*	*02*
0521	1E2P	0355	0400	61	03
0521	*3E2P*	*2150*	*2155*	*01*	*08*
0522	3E1P	0211	0220	88	05
0523	2O1P	0835	0838	08	04
0524	1E2P	1703	1708	56	03
0525	*4E3T*	*1823*	*1836*	*51*	*01*
0526	1E3P	0406	0412	29	04
0526	2E3P	1056	1104	20	08
0526	2O1P	2144	2148	10	04
0528	1E2P	0611	0616	49	03
0528	*3O2P*	*2143*	*2146*	*01*	*07*
0529	*3E2P*	*0112*	*0114*	*00*	*08*
0529	3E1P	0512	0523	98	06
0530	2O1P	1054	1058	13	03
0531	1E2P	1919	1925	43	03

BOOK REVIEWS

Edited by José Olivarez

Observing Variable Stars. By David H. Levy. Cambridge University Press, 32 East 57th Street, New York, NY 10022. 1989. 198 pages. Price $19.95 (ISBN 0-521-32113-1).

Reviewed by John W. Griesé, III

For some time now, there has been a need for a good, basic, yet complete introduction to variable-star observing. This book fills that need and does it well. I'm certain that most readers of *The Strolling Astronomer* are already well acquainted with David Levy's writing. This new book is delightful, and I learned a few new facts by reading it. How many of you know that the Julian Day has nothing to do with the Julian Calendar? See page 35 of this book for that one. The work is well researched, thought out, and executed.

First, the sky is discussed. I liked one interesting aspects of the sky charts—they cover major portions of both northern and southern skies. Thus Southern-Hemisphere observers are not left out. After this, the reader is introduced to stellar brightness, color, and distance. Then, before introducing the family of variable stars, Levy discusses how to train your eyes for observing them. Also, sufficient "variables" are provided for a year-round observing program. Lastly, he covers the sociology of variable-star observing and introduces the reader to John Goodricke and Leslie Peltier. outstanding observers from the past.

Why would A.L.P.O. members read a book about variable stars? Because their love for observing and witnessing what the sky has to offer is shared by variable-star observers. Levy is well acquainted with the romance of observing and does a fine job describing the human experience. [Also, let's not forget that variable-star observing techniques are often transferable to estimating the magnitudes of asteroids, comets, and planetary satellites. Ed.]

For me, variable stars are old friends, each with a unique personality. It is the same for David Levy; and this book is an invitation to come in, meet, and get to know this family of stars.

The book is written for beginners. I had to remind myself of that frequently because each aspect of variable-star observing is covered in great detail. I don't always agree with David's observing style, or his guide as to how often a particular star should be observed; but these are minor complaints. There are some errors in the book but none are due to the author. For example, page 121 lists the dwarf nova star SS Aurigae as having a period of 558 days between outbursts. The error originated in the *General Catalog of Variable Stars*; the correct value is more like 56 days.

For those of you who have not yet been introduced to variable stars, enjoy this introduction. For those already acquainted with "variables," give yourself a few cloudy nights with this delightful book!

The Practical Astronomer. By Brian Jones. Simon & Schuster, Rockefeller Center, 1230 Avenue of the Americas, New York, NY 10020. 1990. 160 pages. Price $24.95 cloth (ISBN 0-671-69304-2).

Reviewed by Craig MacDougal

Beginners in astronomy can choose from many books. Some beginners' books have so much information that they are overwhelming, while others are so simplified that nothing is ever really explained. *The Practical Astronomer* attempts to walk that fine line between too much and too little information. For the most part it succeeds.

The format is slightly different from other beginner's books. It starts with the usual brief physical descriptions of everything from minor planets to clusters of galaxies. These descriptions are at most two pages for each type of object, and are very up-to-date. Later in the book, though, we return to the Solar system in order to find out how to *observe* each object. Once again, we start close to home and move out to the deep sky. The observing techniques described appear to draw heavily upon the experience of the *British Astronomical Association.* Any beginner who absorbs the information here will feel right at home in the B.A.A. or the A.L.P.O. Between the two jaunts through space, there is a good section on choosing binoculars, and plans for building a Dobsonian telescope and an observatory to put it in.

The writing is clear and concise throughout. Now and then, a section is so concise that pertinent information gets left out, but never so extremely concise that this is a hindrance. Occasionally, a new term shows up without explanation, only to be defined a few pages later. We *are* warned in the Foreword that not everything will be understood on the first reading. Also, the ten-page set of diagrams explaining the celestial sphere and coordinate systems are the clearest that I've seen. There are also a number of beautiful photographs.

There are some problems with this book. The star charts given in the last part are too small and crowded to be of much use. There are monthly descriptions of interesting things to look for. However, you need somebody else's charts to find these interesting objects. Fortunately several good star atlases are recommended elsewhere in the book. A more serious problem is that there are photographs with no captions, and captions with no photographs. Several photographs are rotated 90° or 180° compared with what the caption says. One photograph of the Moon is reversed left-to-right. One hopes that these problems will be cleared up in the next printing. Once the editing is improved, I can heartily recommend this book as a gift to that budding astronomer that you know. It is indeed a *practical* book.

ANNOUNCEMENTS

Correction to A.L.P.O. Board of Directors List.—In the previous issue, the Editor *thought* that he gave a complete list of our Board of Directors, as approved at our initial Board Meeting in St. Louis on August 2, 1990. Unfortunately he forgot to include long-term member and Jupiter Recorder **Phillip W. Budine**, who was indeed appointed to our Board at that meeting. We apologize to Mr. Budine, who has been added to the Board of Directors list on the inside back cover.

New Expiration Notice Policy.—Up to now, if a person's A.L.P.O. membership has expired, we have mailed him or her an additional issue of the *Journal, A.L.P.O.*, accompanied by a second renewal notice. Starting with the next issue, *members will no longer receive any issues after their membership expires*; instead they will receive a final reminder as a separate letter. Naturally, if they then renew promptly, they will receive the current issue and avoid any interruption of coverage.

!991 A.L.P.O. Convention.—As was announced in the previous issue, the 41st annual convention of the A.L.P.O. will be held as part of the Symposium for Research Amateur Astronomy in La Paz, Baja California Sur, Mexico, on July 8-12, 1991. Note that La Paz will experience 382 seconds of totality during the solar eclipse on July 11th! Very few registrations or hotel accommodations still remain available; if you wish to attend, write *very soon* to: Symposium for Research Amateur Astronomy, P.O. Box 16542, San Francisco, CA 94116 (FAX Number: 415-731-8242).

A.L.P.O. Benefactors.—If every member paid only the minimal dues required, the A.L.P.O. could not operate in its present form. We continue to be in debt to those generous members who voluntarily pay more; either contributing $20 per year and thus becoming *Sustaining Members*, or contributing $40 or more and being designated *Sponsors*.

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Again, our thanks to these individuals. Note that any contribution (including regular dues) in excess of $11 per year may qualify as a deduction for United States members.

Foreign Membership Fund.—Thanks to the generous donations of its members, the A.L.P.O. maintains a small fund to furnish complimentary memberships to deserving foreign amateur astronomers who, for one reason or another, cannot obtain the American currency necessary for dues payment. However, this fund has become *too* small of late; i.e., $17. Donations of any amount are very welcome; they should be payable to "A.L.P.O.", annotated "Foreign Membership Fund", and mailed to: A.L.P.O., P.O. Box 16131, San Francisco, CA 94116, U.S.A.

New Section Publications.—Just released are two attractive and informative A.L.P.O. Section publications.

The first is the *A.L.P.O. Minor Planets Section Procedures Manual* (January, 1991), with 16 pages about asteroid position measurement and photoelectric photometry. It is available from Derald Nye, 10385 East Observatory Drive, Tucson, AZ 85747, for $3.00 domestic and $5.00 for foreign air mail.

Likewise, just published is the *A.L.P.O. Solar Section Catalog of Data.* Its 49 pages include general articles on solar observing and observers besides the catalog itself. To order this, send $5.00 to: Paul Maxson, 8839 N 30th Avenue, Phoenix, AZ 85051

Observation Scheduling Service.—Daniel Klos, an active member, can now provide to inquirers site-specific particulars for observing the phenomena of Jupiter's satellites. This takes the form of a schedule of events visible under a dark sky from your location, giving both local time and Universal Time, with the altitude and azimuth of Jupiter, accompanied by an observing form. To obtain an individualized schedule, send Mr. Klos a self-addressed stamped envelope with a note giving your latitude, longitude, time zone, and whether your area observes Daylight Saving Time when it is in effect. He also requests a $1.00 donation so that one day he may purchase a computer co-processor and thus provide such services yet more efficiently! Mr. Klos' address is: W404 County K, Brillion, WI 54110.

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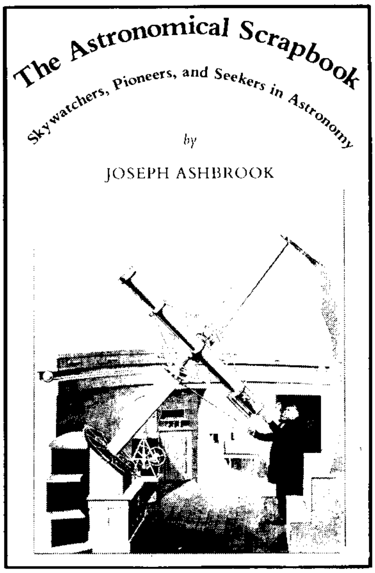

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