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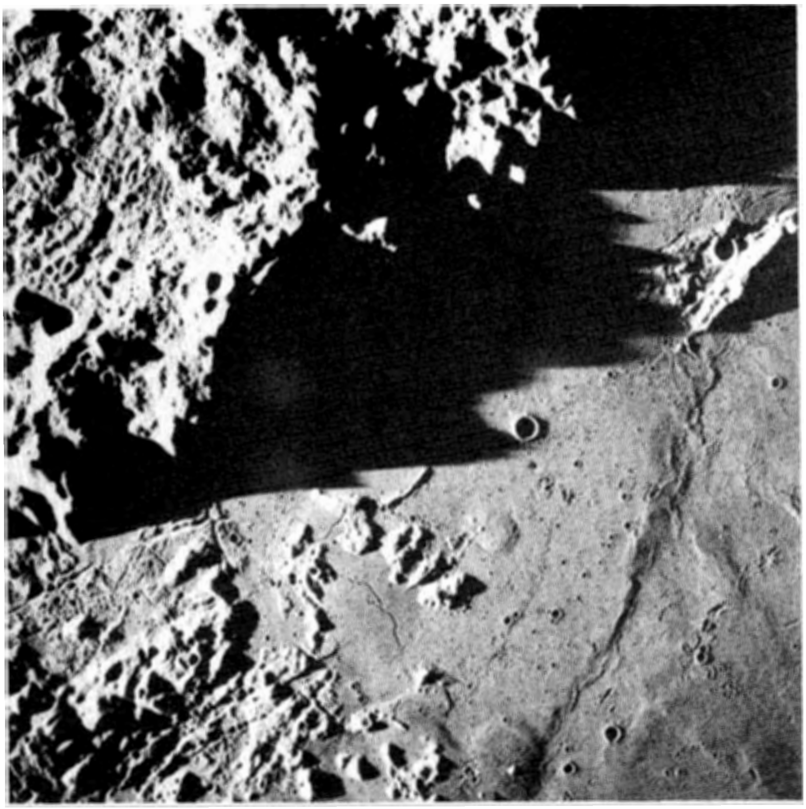

Lunar domes in Mare Imbrium, photographed by the Apollo-17 metric camera (frame AS17-1828). The two domes shown lie below the 4-km crater Huxley (itself just right of center). The Apennine mountain front is in the upper left. South at top, frame size ca. 128 km on a side. See the article on lunar domes on p. 70 of this issue.

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IN THIS ISSUE

THE APPARITION OF COMET WILSON 1987 VII

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

ABSTRACT

This report examines the 1986-87 Apparition of Comet Wilson. This comet did not become as bright as had been at first expected, but did display at least one, and perhaps two, outbursts; and its nucleus was observed to split as it was leaving the inner Solar System.

DISCOVERY

Christine Wilson, a graduate student at the California Institute of Technology, found this comet on plates that she had taken for the Second Palomar Observatory Sky Survey on 1986 AUG 05.332 U.T., using the 48-inch Schmidt telescope at Palomar Mountain. She reported the comet as being magnitude +7.5; and located at right ascension 22h 22.2m, declination +25° 11' (1950.0 coordinates). Later, prediscovery images were found on plates that had been taken at Oak Ridge Observatory on the previous night. [**1**]

This was the twelfth comet to be discovered or recovered in 1986, and thus was named Comet Wilson, 1986L. Initially, it appeared to be quite small. Charles Morris reported the coma's diameter as 0.7 arc-minutes on 1986 AUG 08, while John Bortle on AUG 12 and AUG 14 reported a 0.6-0.7 arc-minute diameter with a well-condensed inner portion only 20 arc-seconds across. [**2**]

Although the discovery magnitude, as corrected to standard aperture, was considerably fainter than reported by Wilson, actually closer to +12.0, Comet Wilson was then still 3.6 AU from the Sun and 2.8 AU from the Earth. [1 AU = 1 Astronomical Unit = 149,597,870 km.] Were the comet to behave normally, an early orbit calculation suggested that it would continue to brighten as it approached perihelion in late April, 1987, reaching magnitude +3.4 shortly after that when observable in the Southern Hemisphere. [**3**] When Comet Wilson was discovered, Comet Halley was in the solar glare and was receding from both the Sun and the Earth. Thus the astronomical world began to prepare for a year-long session of observing Comet Wilson.

ORBIT AND APPARENT PATH

The orbital elements for Comet Wilson, calculated from 516 observations by T. Kobayashi, as given in *Minor Planet Circular 14903*, are [*ET* refers to "Ephemeris Time," then approximately 57 seconds later than UT]:

Date of Perihelion......	1987 APR 20.7808 ET
Distance at Perihelion............	1.199651 AU
Argument of Perihelion..........	238°.2963
Ascending Node....................	110°.9584
Inclination............................	147°.1220
Eccentricity..........................	1.000321

The comet's orbit in relation to that of the Earth is sketched in *Figure 1* (below). The orbit is slightly hyperbolic, as indicated by the eccentricity's exceeding 1.0, suggesting that the comet was making its first passage through the inner Solar System. The perihelion distance of 1.20 A.U. meant that the comet would not cross the Earth's orbit. Finally, its highly inclined retrograde orbit meant that the comet would move rapidly across the sky and spend considerable time far away from the ecliptic.

The observing conditions appeared to be favorable, especially for observers in the Southern Hemisphere. When discovered, Comet Wilson was 133° from the Sun in the morning sky, and it passed through opposition in late August, 1986. After that, the comet crept slowly across the Northern-Hemisphere evening sky, crossing the Celestial Equator on 1986 OCT 30. Useful observations ceased in late December, 1986, as the comet moved near the Sun as seen from the Earth.

In mid-February, 1987, Comet Wilson emerged from twilight in the southern morning sky, at a full 85° elongation from the Sun when it passed through perihelion on 1987 APR 20. The comet passed only 12° from the South Celestial Pole on APR 28, and four days later it was closest to the Earth at 0.62 AU. After this date, the comet was expected to dim as it moved through the southern evening sky, to be lost in the Sun's glare by mid-July, 1987. A final series of observations became possible when the comet emerged into the morning sky near the Celestial Equator in late September, where it remained for the rest of 1987.

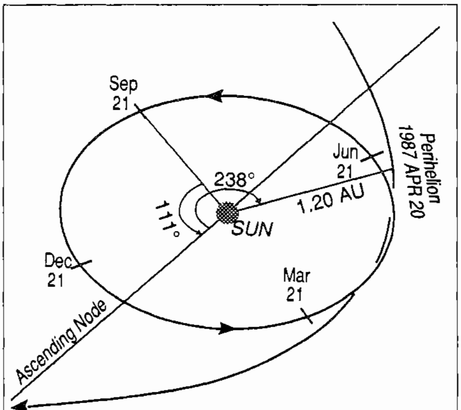

Figure 1. Sketch of orbit of Comet Wilson 1987 VII in relation to the Earth's orbit.

MAGNITUDE

A.L.P.O. members produced over 60 visual magnitude estimates of Comet Wilson's brightness, along with additional comments about the comet's appearance. Veteran A.L.P.O. comet observer Gary Kronk analyzed the magnitude data, correcting for aperture, and plotting both the *apparent* and the *absolute* magnitude.

The absolute magnitude of a comet is its magnitude if it were seen at a standard distance of 1.0 AU from both the Earth and the Sun. Because a comet is hardly ever found at that specific location, we must calculate its absolute magnitude from the following formula:

$H_0 = m - 5 \log D - 2.5\, n \log R$, where

H_0 = absolute magnitude, m = apparent magnitude, D = comet-Earth distance (AU), R = Comet-Sun distance (AU); and n = a constant for each comet, the rate of brightness change as the comet-Sun distance changes.

In the case of Comet Wilson, some surprising results appeared. Kronk writes:

> "It would seem an unusual brightness change had occurred by the time this comet left the sun's glare in February 1987. At that time the comet's absolute magnitude was about one magnitude brighter than what it had been in the previous summer and autumn." [4]

Had this brightness surge continued, this comet would have reached apparent magnitude +3 by perihelion. Kronk found that it did not:

> "However, as the comet continued to head toward its April 20 perihelion passage, its sharp rise to maximum APPARENT brightness was coincidentally paralleled by a steady decrease in ABSOLUTE magnitude. By the time the comet reached its maximum APPARENT magnitude of about 4.8, the ABSOLUTE magnitude was slightly fainter than the value it had previously been in the previous summer and autumn." [5]

Kronk also suggested that there was another outburst near the end of 1987, but insufficient data were available to study this possible event in detail.

Regarding the brightness behavior of Comet Wilson, *Figure 2* (below) shows the apparent magnitude of this comet, corrected to standard aperture [67.8 mm; comets tend to appear dimmer in actual magnitude as aperture is increased], in terms of the date of observation. It is clear that the comet was brightest near the perihelion date of 1987 APR 20.

Figure 3 (at the top of the next page) shows the data of *Figure 2* converted to absolute magnitude by means of the formula above. From these data, Gary Kronk determined a mean absolute magnitude of +5.18±.05, with a value of **n** of 3.0 for the 17-month span of observation. This absolute magnitude is about one magnitude brighter than for the average comet, while the **n** value is slightly lower than is typical for comets new to the inner Solar System.

Finally, *Figure 4* (next page) shows the absolute magnitude restricted to the time span of February-July, 1987. For this period, the **n**-value was 1.6. The mean absolute magnitude was +5.59, but it is clear that the comet decreased markedly in intrinsic brightness after mid-April.

THE SPLIT OF THE NUCLEUS

On 1988 FEB 14, when interest in Comet Wilson had wound down, Karen Meech of the Institute of Astronomy, University of Hawaii, reported a "possible split nucleus." Using CCD [Charge-Coupled-Device] images from the 2.2-meter telescope at Mauna Kea Observatory, she found a secondary nucleus, fainter than magnitude +15.3, located 9 arc-seconds away from the main nucleus, which was at magnitude +14.6. [6]

Subsequently, Z. Sekanina of the Jet Propulsion Laboratory of the California Institute of Technology calculated that the nucleus had split on 1987 AUG 31±7 days, at which time the comet was 2.3 AU from the Sun but lost in the solar glare. [7]

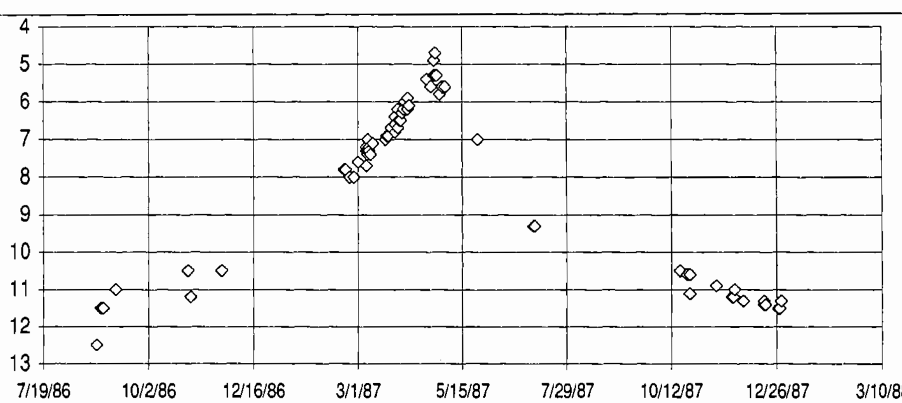

Figure 2. Apparent visual magnitude of Comet Wilson 1987 VII (vertical scale) as a function of date of observation, corrected to standard aperture. Diagram prepared by Gary Kronk.

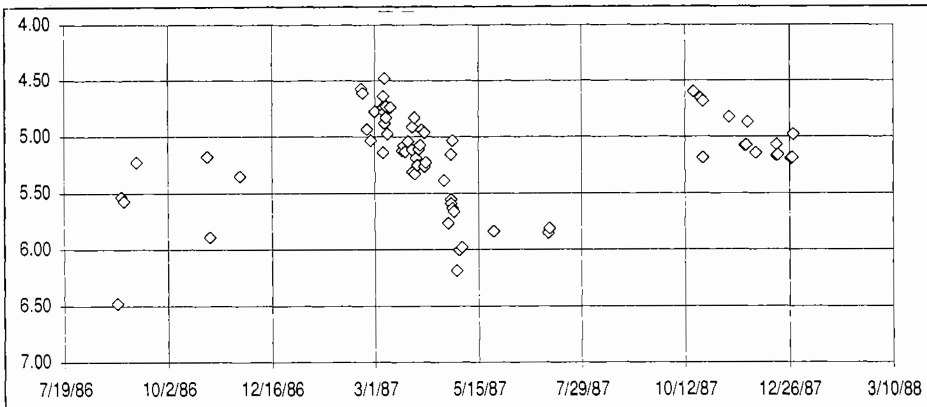

Figure 3. Absolute visual magnitude of Comet Wilson 1987 VII (vertical scale) as a function of date of observation, corrected to standard aperture. Diagram prepared by Gary Kronk.

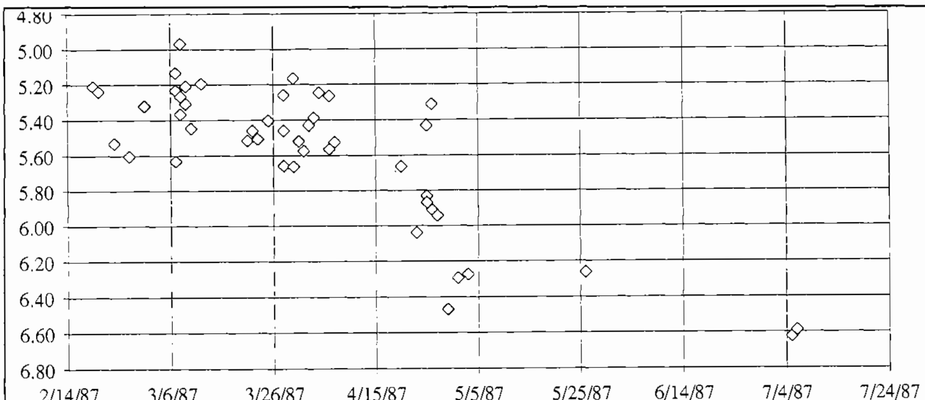

Figure 4. Absolute visual magnitude of Comet Wilson 1987 VII (vertical scale) as a function of date of observation and restricted to the period of February-July, 1987, corrected to standard aperture. Diagram prepared by Gary Kronk.

COMA SIZE

The actual diameter of the coma, or "head" of a comet , is computed from knowing its angular diameter and its distance from the Earth. The observer's eyes, skies, and instrument all affect the apparent diameter of a comet. The actual diameter of Comet Wilson's coma, in thousands of kilometers, is graphed in *Figure 5* (next page) for mid-February to early-May, 1987. In it we see an apparent increase and decrease, perhaps due to real variation but also due to better contrast as the comet moved into a darker sky.

TAIL LENGTH

A tail length of over 1° was reported only once. Usually no tail was detected. When one was reported, it was fan-shaped and under 0°.5 in length; at such times corresponding to an actual length of under 1 million kilometers.

PARTICIPATING OBSERVERS

The observers who contributed observations that were used in this report are listed in *Table 1*, below, where "RL" indicates a reflector and "BI" a pair of binoculars.

Table 1. Participating Observers, 1986-87 Apparition of Comet Wilson

Observer	Observing Site	Telescope(s)	Observation
Clark, M.	Armadale, W. Australia	31-cm RL	Visual
Garrard, G.	Tamworth, Australia	15- & 20-cm RL, BI	Visual
Kronk, G.	Troy, IL, U.S.A.	33-cm RL	Visual
Nowak, G.	Essex Junction, VT, U.S.A.	30-cm RL	Visual
Pearce, A.	Woodlands, W. Australia	32- & 20-cm RL	Visual
Seargent, D.	The Entrance, NSW, Australia	25-cm RL, 8-cm BI	Visual
Stephen, C.	Sebring, FL, U.S.A.	3.5-cm BI	Visual
Williams, P.	Heathcote, NSW, Australia	15-cm RL, 5-cm BI	Visual

REFERENCES

1. Central Bureau for Astronomical Telegrams, *International Astronomical Union Circular*, No. 4241, issued August 6, 1986 by Daniel W.E. Green.

2. *International Comet Quarterly*, No. 59, July, 1986, p. 111, by Daniel W.E. Green.

3. *International Astronomical Union Circular*, No. 4244, issued August 11, 1986 by Brian Marsden.

4. Private Communication, October 31, 1990.

5. *Ibid.*

6. *International Astronomical Union Circular*, No. 4552, issued February 22, 1988 by Daniel W.E. Green.

7. *International Astronomical Union Circular*, No. 4557, issued February 29, 1988 by Daniel W.E. Green.

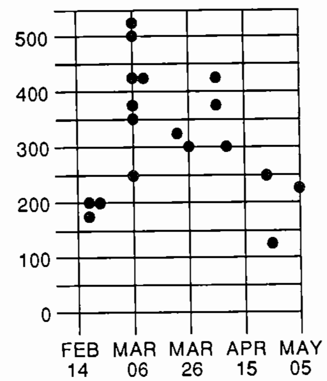

Figure 5. Coma diameter of Comet Wilson in thousands of kilometers. Dates are for 1987.

THE 1986-87 WESTERN (MORNING) APPARITION OF THE PLANET VENUS: VISUAL AND PHOTOGRAPHIC OBSERVATIONS

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

ABSTRACT

This report summarizes visual and photographic observations of Venus for the 1986-87 Western (Morning) Apparition, based on data submitted by A.L.P.O. Venus Section observers, including the instrumentation and sources of data used in obtaining those observations. Comparative studies deal with observers, instruments, and visual and photographic data. The report includes illustrations and a statistical analysis of the categories of features in the atmosphere of Venus, including cusps, cusp-caps, and cusp-bands, seen or suspected at visual wavelengths, both in integrated light and with colored filters. Terminator irregularities, the apparent phase, and the Ashen Light are discussed.

INTRODUCTION

Observers submitted a small but meaningful collection of visual and photographic observations of Venus during the 1986-87 Western (Morning) Apparition. The geocentric parameters of that apparition are given in *Table I* below.

A total of 46 observations consisting of visual drawings and photographs taken at visual wavelengths was received for the 1986-87 Apparition. *Figure 6* (top of next page) illustrates the distribution of observations for each month during that apparition.

Observational coverage was only fair. Nearly half (47.8 percent) of the observations were made during December, 1986, although the observing season, defined by the time span of observations, covered the period 1986 NOV 30-1987 JUN 06. As in previous apparitions, the greatest observational activity during 1986-87 was near the period of greatest brilliancy and greatest elongation from the Sun.

Five individuals submitted visual and photographic observations of Venus during

Table 1. Geocentric Data in Universal Time (UT) for the 1986-87 Western (Morning) Apparition of Venus. [4, 5]

Inferior Conjunction..........................	1986 NOV 05.42
Greatest Brilliancy (-4.7)..................	DEC 11.83
Greatest Elongation West (47°).......	1987 JAN 15.88
Superior Conjunction.......................	AUG 23.25
Apparent Diameter (range).............	48".70 (1986 NOV 30) - 10".62 (1987 JUN 06)
Dichotomy (predicted)....................	1987 JAN 15.66

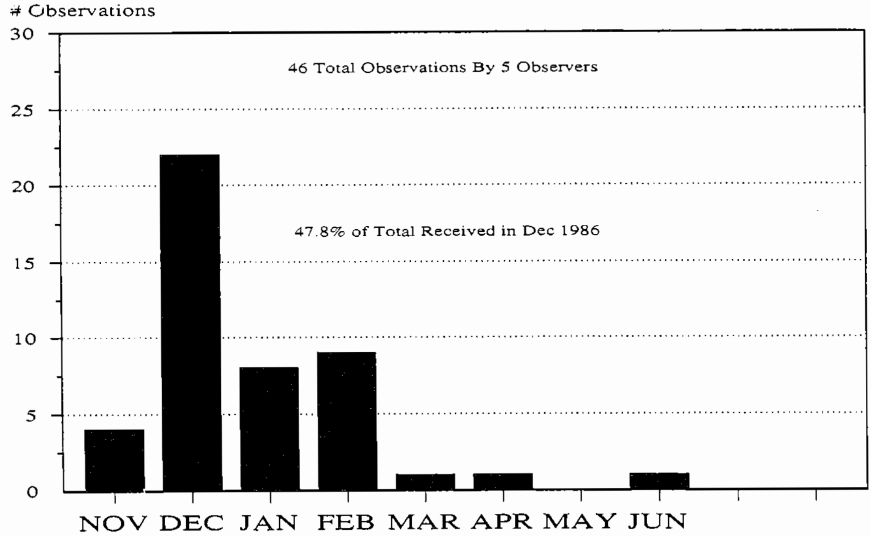

Figure 6. Number of observations contributed to the A.L.P.O. Venus Section by month during the 1986-87 Western (Morning) Apparition.

Table 2. Participants in the A.L.P.O. Venus Observing Program during the 1986-87 Western (Morning) Apparition.

Observer	Observing Site	Number of Observations	Telescope(s) Used
Benton, J.L.	Wilmington Island, GA	2	15.2-cm (6.0-in) Refractor
Graham, D.L.	Brompton-on-Swale, UK	32	15.2-cm (6.0-in) Refractor
Graham, F.	East Pittsburgh, PA	2	17.8-cm (7.0-in) Refractor
Heath, A.W.	Nottingham, UK	9	30.5-cm (12.0-in) Newtonian
Nowak, G.T.	Essex Junction, VT	1	22.9-cm (9.0-in) Refractor
Total Number of Observations.......................		46	

the 1986-87 Apparition. These observers are listed in *Table 2* (above), with their observing sites, number of observations, and instruments used. Three of the five observers were from the United States. The two remaining were British observers, but this industrious duo contributed a full 89 per cent of the observations. It is also interesting that four of the five observers employed refractors, used for 80 percent of the observations, and that all the telescopes used were of at least 15-cm aperture.

In terms of atmospheric conditions, the mean Seeing was 4.1, or "fair," on the standard A.L.P.O. Scale that ranges from 0.0 for worst to 10.0 for perfect. The mean Transparency, expressed as the limiting magnitude, was about +5.0 for those observations made when Venus was in a dark sky.

Observations of Venusian Atmospheric Details

As noted in previous Venus reports that have appeared in this Journal [2], the methods for conducting visual studies of the atmosphere of Venus are described in the appropriate Venus Section publications. [**1**, **3**] We recommend that observers new to the study of Venus consult these sources.

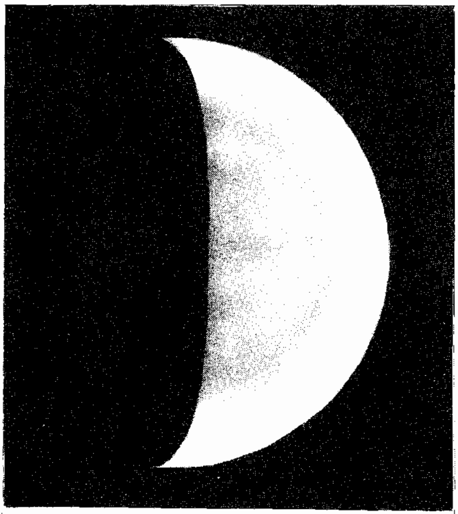

Figure 7. Drawing of the planet Venus by David L. Graham on 1987 Jan 03, 08h 45m U.T. with a 15.2-cm. (6.0-in.) refractor at 166X in integrated light. Disk diameter = 28".9. Predicted phase (fraction illuminated), **k** = 0.430. South is at the top. Note the bright cusp-caps and limb, and the dusky markings.

Figure 8. Three photographs of Venus by Alan W. Heath, using a 30.5-cm (12.0-in) Newtonian reflector and Tri-X Film exposed for 1/25 second. The center photograph was taken at 190X, while the other two were at 318X. South at top. From left to right, the Universal Times, disk diameters (Dia.), and predicted phase coefficients (k) of the photographs were: 1986 DEC 12, 07h 20m, Dia. = 39".9, k = 0.270 ; 1987 JAN 03, 08h 15m, Dia. = 28".9, k = 0.430; and 1987 JAN 08, 07h 20m, Dia. = 27".1, k = 0.459. The center photograph was taken only 30m earlier than Mr. Graham's drawing in *Figure 7*.

The observations used for this report were all at visual wavelengths, and two examples are given here. The first, *Figure 7* (p. 53), is a drawing by David L. Graham. The second sample is a group of three photographs by Alan W. Heath, shown above as *Figure 8* .

The visual and photographic data for the 1986-87 Apparition represented almost all of the categories of dusky and bright markings on Venus, as covered in the literature cited above. **[1, 3]** *Table 3* (below) summarizes the frequency in which the specific forms of markings were reported; note that many observations showed more than one type of marking, so that totals over 100 percent are possible. Undoubtedly, there is a subjective element in the reporting of the vague and elusive markings of Venus which must affect the values in the table. Nonetheless, our tentative conclusions based on these data appear reasonable.

Table 3. Frequency of Occurrence of Types of Markings during the 1986-87 Western (Morning) Apparition of Venus.

Marking Category	Percent. of Observations
Radial Dusky Markings	2.2 %
Banded Dusky Markings.	15.2
Irregular Dusky Markings	6.5
Amorphous Dusky Markings	32.6
Terminator Shading	100.0
No Dusky Markings Seen or Suspected	56.5
Bright Spots or Regions (exclusive of Cusps)	0.0

1. The geometric phase **k** ranged from 0.159 (1986 NOV 30) to 0.931 (1987 JUN 06).

2. Assuming that Venus' bright illuminated hemisphere (all areas devoid of any shadings or other obvious markings) was typically assigned a relative numerical intensity of 8.5-9.2 (using the A.L.P.O. scale ranging from 0.0 for pure black to 10.0 for pure white) in 1986-87, the mean assigned intensity for the first five items above in integrated light (no filter) was about 7.8.

3. The scale of conspicuousness, ranging from 0.0 for definitely not seen to 10.0 for certainly seen, was used rather effectively in 1986-87, when the conspicuousness rating for the first five items was 5.0, indicating that all the features lay somewhere between vague suspicions and strong indications.

The dusky markings of Venus' atmosphere are quite elusive, both to the novice and to the experienced observer. It is usually thought that ultraviolet (UV) photographs of Venus are preferred in order to bring out any dusky features. We certainly do seek UV photographs because many features' appearances in UV are different than in visual wavelengths, particularly radial dusky patterns. However, it is interesting that during 1986-87 almost half the drawings and other visual observations of Venus showed some form of shadings or markings, unlike the case in many of the past apparitions. Nearly all the photographs submitted showed a completely blank disk even though visual observers did occasionally report banded, irregular, amorphous, and radial dusky markings. One important factor here is that observers have been utilizing more standardized, systematic techniques with polarizing and color filters in recent years.

Most of the dusky markings that were reported were in the category of "Amorphous Dusky Markings," reported in almost one-third of the observations. Other dusky atmospheric features were distributed unevenly in the categories of "Banded Dusky Markings" (15.2 percent) and "Irregular Dusky Markings" (6.5 percent), and only 2.2 percent of the observations reported "Radial Dusky Markings" in 1986-87.

Except for the cusp regions, bright areas or mottlings were not reported for the 1986-87 Apparition. On the other hand, a terminator shading was very prominent and visually was always reported in the apparition. There was the usual tendency for the terminator shading to lighten (i.e., assume a higher intensity value) as one proceeded from the terminator toward the illuminated limb of the planet. In some instances, this gradation ended in the bright limb band, and usually this terminator shading extended from one cusp region to the other. Unlike the drawings, photographs submitted in 1986-87 seldom even hinted at terminator shading.

Cusps, Cusp-Caps, and Cusp-Bands

The most contrasting and conspicuous features sometimes seen in the atmosphere of Venus are found at or near the planet's cusps, usually when the phase coefficient **k** lies between 0.1 and 0.8. These cusp-caps are occasionally bounded by dark, often diffuse, peripheral cusp-bands. *Table 4* (below) gives visibility statistics for Venus' cusp features in 1986-87. Note that, when both cusp-caps were seen at all, they invariably were reported to be of equal size and brightness. When the cusp-caps were seen, they were always bordered by dusky cusp-bands. Most of the time, no cusp features at all were reported.

Table 4. Frequency of Occurrence of Cusp-Caps and Cusp-Bands during the 1986-87 Western (Morning) Apparition of Venus.*

Marking Category/Condition	Percent. Obser.
Cusp-Caps:	
No Cusp-Caps Visible	91.3 %
Both Cusp-Caps Visible**	8.7
Only One Cusp-Cap Visible	0.0
Cusp-Bands:	
No Cusp-Bands Visible	91.3
Both Cusp-Bands Visible	8.7
Only One Cusp-Band Visible	0.0

*The mean assigned intensity for the cusp-caps was about 9.5, while that for the cusp-bands was about 7.5.

** Always of equal size and brightness when both were reported.

Given the time span of the observations submitted for 1986-87, it is not surprising that none, with integrated light or with color filters, showed any cusp extension beyond what one would expect from simple geometry.

The Bright Limb Band

In 1986-87, 67 percent of the observation submitted referred to a bright band on the sunlit limb of Venus. This feature usually extended from cusp to cusp, was narrow along the limb, and mostly uniform in intensity throughout its length. The mean numerical intensity assigned to this band was 9.8-9.9. Its visibility was greatly enhanced by the use of selected color filters and polarizers.

Terminator and Phase

The terminator of Venus is the geometric curve that separates the sunlit and dark hemispheres of the planet. All observations made during 1986-87 reported a regular terminator. Amorphous and irregular dusky shadings merged with the terminator shading, but did not cause deformities along the otherwise-geometrically regular terminator.

The "Schröter Effect" on Venus is an often-reported discrepancy between the predicted and the observed dates of dichotomy (half-phase). Since none of the participating observers made phase estimates, we can say nothing about this effect in the 1986-87 Apparition.

The Ashen Light

The Ashen Light, first reported by the Italian observer S. Riccioli in 1643, is an exceedingly elusive, faint illumination of the dark hemisphere of Venus. It resembles Earthshine on the dark portion of the Moon, but it cannot have the same origin. It is often argued that Venus must be viewed against a dark sky in order to detect the Ashen Light, but Venus is low in the sky at such times and suffers from poor seeing and transparency.

The only Ashen Light report for this apparition was by Francis Graham, using a 17.8-cm (7.0-in) refractor at 400X with no filter on 1986 DEC 23, when he recorded "a glow in the dark hemisphere of Venus at about 10:00 - 12:00 UT," which he saw as uniform over the entire dark hemisphere. He took photographs but these did not indicate the Ashen Light.

Conclusions

Very limited atmospheric activity was reported for Venus in the 1986-87 Apparition. However, the continued monitoring of the planet by A.L.P.O. Venus Section observers over many years remains our major program, and we invite interested readers to join our campaign to gather reliable information about our nearest planetary neighbor.

References

1. Benton, Julius L., Jr. (1973). *An Introduction to Observing Venus.* Savannah, GA: Review Publishing Co.
2. ________ (1987). "The 1983-84 and 1985-86 Western (Morning) Apparitions of Venus: Visual and Photographic Observations." *J.A.L.P.O.*, *32*, Nos. 5-6 (Oct.), 93-101.
3. ________ (1988). *Visual Observations of Venus: Theory and Methods (the A.L.P.O. Venus Handbook).* Savannah, GA: Review Publishing Co.
4. U.S. Naval Observatory (1985). *The Astronomical Almanac, 1986.* Washington, D.C.: U.S. Government Printing Office.
5. ________ (1986). *The Astronomical Almanac, 1987.* Washington, D.C.: U.S. Government Printing Office.

THE INTERNATIONAL MARS PATROL IN 1987-89—PART II: METEOROLOGY, NEW, AND RENEWED FEATURES

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

ABSTRACT

This paper concludes an A.L.P.O. International Mars Patrol (IMP) report and observational summary for the 1987-89 Perihelic Apparition of Mars. Martian Polar meteorology, as well as 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, along with the reappearance of four features that had been absent since early in this century.

MARTIAN ANTARCTIC METEOROLOGY

The existence of an extensive Martian South Polar haze canopy or "hood" over the South Polar Region (SPR) during Southern late Autumn and early Winter is still debated among astronomers today. Prof. Clyde Tombaugh (1968) has maintained that a south polar cloudy hood does not form (Wells, 1978; Briggs *et al.*, 1977). Some astronomers theorize that the South Polar Hood (SPH) forms later during Martian Southern Spring when the South Polar Cap (SPC) emerges from its winter darkness. Others say that the SPC does not form until the area is covered by a cloudy hood.

The Martian SPR during its Southern late Autumn and early Winter was photographed extensively by Viking. Astronomers anticipated the SPR to be covered by a dense haze hood or cloud canopy, but when Viking Orbiter 1 (VO1) arrived it found the atmosphere over the SPR to be remarkably clear. Some cloudiness did occur during this period but extensive cloud cover did not develop until after mid-Winter (Wells, 1978).

Two questions must be asked: Are the clouds and hazes that we observe on the southern limb of Mars, apparently covering the SPC, part of the polar region canopy-hood formation? And, is it really the edge of the SPC that we observe, often appearing as far north as latitude 50° south?

Visual observations and photographs of Mars in 1986, taken during its Southern late Winter and mid-Spring (167° through 227° Ls) show definite meteorological activity over the SPR, especially on the morning side. This meteorological phenomenon resembles a cloud canopy or hood; however, it appears to be much less dense and less blue than does the North Polar Hood (NPH) for its same seasonal periods. However, despite an intensive investigation by the Mars Recorders, no hood was observed in the SPR during the 1987-89 apparition (100°-207° Ls) and the SPR has appeared to be very clear during the Martian Southern late Winter and early Spring.

Another problem arises when attempting to observe the Martian polar regions: much of the time one of the polar regions is either on the phase terminator or hidden behind the limb. Because the axial tilt of Mars is 25°.2, regions poleward of 64°.8 latitude can be hidden from view. This leads us to think that the bright aerosols we observe are "ordinary" limb clouds or dense haze on the poleward limb. If hazes do exist over the poles during this time, since they are on the limb, they might appear to be very bright because the observer is looking through several Martian atmospheres of aerosols and ice crystals. The 1987-89 Apparition was expected to be a good time to try to solve this problem.

THE MARTIAN METEOROLOGICAL SURVEY

The A.L.P.O. Mars Section's long-term meteorological survey and computer analysis is an ongoing process (Beish, Parker, & Capen, 1986). To date we have evaluated 19,621 observations of Mars contained in the A.L.P.O. Mars Observational Report Archives (MORA). During the last five apparitions alone (1979-81, 1981-83 1983-85, 1985-87, and 1987-89), the IMP contributed 14,323 observations.

A number of interesting findings about the Martian climate have emerged from this study. First, we found that blue and white clouds were significantly more frequent and numerous from late 1980 through late 1983 than they were during the same seasonal periods observed in the apparitions of 1963-65, 1966-68 and 1969-70. Blue and white cloud counts and frequency distributions appear to have returned to a more "normal" state after 1983. Exactly what this means remains a mystery; however, we believe that Mars has experienced either a warming period in the early 1980's or went through a colder period during the 1960's.

MARTIAN METEOROLOGY DURING 1987-89

The frequency with which particular types of Martian clouds were observed in the 1987-89 Apparition is summarized in *Table 1* (next page). With the exception of some morning limb hazes and a few weak orographic clouds over the Tharsis volcanoes, there has been

Table I. Meteorology of Mars - 1987-89. Seasonal Percentage of Observed Ls degrees for which Specific Meteorological Conditions were Reported.

	Southern Hemisphere Season				
Phenomenon Type	Spring %	Summer %	Autumn %	Winter %	Total %
Evening Clouds (EC)	28	26	62	44	36
Morning Clouds (MC)	42	12	24	32	28
Discrete Clouds (DC)	24	9	16	11	16
Dust Clouds (YC)	17	10	0	0	6
Cloud Bands (CB)	0	4	3	0	2
White Areas (WA)	21	1	3	9	10
Evening Haze (EH)	3	36	24	5	18
Morning Haze (MH)	78	22	0	36	41
Arctic (NPC)	86	42	35	34	55
Antarctic (SPC)	6	0	46	27	14
Violet Clearing (VC)	6	12	0	32	15
Ls Observed	90°	90°	37°	44°	261°

very little for the Martian meteorologist to study in 1987-89. This has perhaps been a disappointment to IMP observers, who were looking forward to the spectacular white clouds seen during the aphelic apparitions, but it means that Mars is "right on schedule!" Our Martian meteorological survey reveals that most white and blue-white cloud activity and surface brightening occurs during the Spring and Summer of Mars' Northern Hemisphere, while there is very little activity during Southern Spring and Summer–the seasons of the current apparition. (Southern-Hemisphere Summer Solstice occurred on 1988 SEP 12.) This difference in water-ice cloud activity is most likely due to the different compositions of Mars' polar caps, mentioned previously. So while our observers are disappointed, we are delighted; for we have proven something that astronomers have suspected all along: that the meteorology of Mars is seasonal, coupled to the retreat and regrowth of its polar caps.

During the second week in September some evening limb hazes appeared. These are prominent on video images by Alan MacFarlane on 1988 SEP 12 and 13.

While meteorological activity remained minimal until November, careful observers employing blue and violet filters were able to detect interesting clouds and hazes in September and October. Conspicuous morning clouds appeared over Solis Lacus (085°, 28°S), Thaumasia (085°, 35°S), and Candor (075°, 5°N) [the Martian west longitude and latitude for each feature will be given at its *first* mention in the text. Ed.]. We were alerted to these by Japan's OAA (Oriental Astronomical Association) astronomers and were able to obtain violet-light photos. Other excellent photos were submitted by Howard Zeh and by Jean Dragesco, who employed the Lowell 24-inch refractor. From 1988 NOV 12-20, the authors observed brilliant small morning clouds in the high southern latitudes. These projected beyond Mars' terminator, indicating great height. That the projections were not illusions due to irradiation was verified by the fact that they were seen when dense violet filters, such as the Wratten 47 and 47B, were employed.

From late September through early December, evening clouds were reported over Libya (272°, 0°N), east of the great slopes of Syrtis Major. These clouds were especially bright in December and were best viewed through blue and blue-green (W38A, W64) filters, suggesting that they were near-surface phenomena. Other evening clouds were seen to grow during November, especially over Ausonia (230°, 60°S), Zephyria (196°, 50°S), and Aethiopis (235°, 5°N).

Elusive equatorial-band clouds were reported in mid-October by Karen Webb and were photographed in violet light by Parker. They were again seen by the authors in mid-November. Another interesting cloud formation, known as the "Tractus Albus," was seen by Klaus Brasch on October 19 and by the authors on the following night. The Tractus Albus is a Y-shaped formation running from Tempe (070°, 40°N) southward and branching north of Solis Lacus. One arm of the "Y" extends into Candor, while the other runs southwest to Claritas (110°, 35°S). The Tractus Albus is best viewed through a green or blue-green filter and probably consists of low-lying hazes forming in valleys east of the Tharsis Bulge. During certain times of the Martian year, especially Northern Summer, this region can be the site of intense meteorological activity. This cloud pattern was not observed again until 1988 NOV 21, when it became very prominent only a few days before the start of a major dust storm in that region.

Orographic clouds over the Tharsis volcanoes, mentioned in a previous article (Beish, Parker, & Hernandez, 1989), were reported more frequently during October and became fairly conspicuous by early November. Afternoon clouds over Arsia Mons (121°, 9°S) were especially prominent and were photographed by several IMP astronomers. A 1988 OCT 26 photograph by Japan's Motomaro Shirao actually shows these clouds beginning to coalesce to form the famous "W-Cloud." It is a pity that many observers missed these clouds by not employing blue and violet filters. Even though the orographic phenomena were subdued in 1987-89 when compared to 1986, they are among the most interesting of Martian features and could be easily seen with proper filtration. Despite the numerous *Sky & Telescope* and *J.A.L.P.O.* articles on filters and gentle but continuous chiding by the Mars Recorders, many amateurs fail to view Mars through color filters. They are missing some of the most spectacular phenomena that Mars has to offer!

DUST STORMS OF MARS

In the past, astronomers have identified Martian dust clouds, obscurations, or both as "yellow clouds." Confusion over the colors of Mars is nothing new. Many observers have reported that several *maria* appear green or even blue at times. This led scientists of the past to speculate that vegetation was growing during the local Martian Spring. When we observe bright Mars against the dark nighttime sky, the planet's color hues are often perceived as complementary to the dark background sky. This effect is known as "simultaneous contrast" (Hartmann, 1989) or the Purkinje effect (Sidgwick, 1971, pp. 428-430).

If we consider that the colors of Mars vary only from a dark gray-orange/brown to a slightly brighter grayish-orange or grayish-brown, it is interesting to attempt to describe Martian dust clouds as "yellow." While they may appear yellowish when observed without the aid of color filters, they are in fact brighter in red and orange filters than they are through a yellow one. Thus, it may be necessary to reclassify these Martian dust clouds with a more natural description, so we propose that they simply be referred to as "dust clouds."

Martian dust clouds usually form rapidly when finely-divided surface materials are raised by the Martian wind. These clouds may be small, localized, and short-lived, or they may expand to cover most or all of the planet in a matter of days. Dust clouds brighten faintly in yellow filters and reveal sharpened boundaries through orange and red filters. During the initial stages of formation, they often appear very bright in violet and ultraviolet light (the latter photographic), suggesting the presence of ice crystals. Thus, these clouds are frequently confused with bright white areas, frosts, or high localized clouds. Because a dust cloud is often confused with bright surface deposits it becomes more difficult to determine the extent of its expansion once the observer identifies one of them as a dust cloud on the move. Fresh surface deposits of dust tend to brighten the area where dust has fallen and thus confusingly appear to coalesce with a moving dust cloud.

In recent years, the popular media have played up the romance of Martian dust storms to such an extent that virtually any form of meteorological activity has been reported as dust. Therefore, in analyzing the IMP data, the authors have had to exercise considerable caution in defining dust clouds. They have applied the following criteria:

1. The *sine qua non* for Martian dust clouds is movement with obscuration of previously well-defined albedo features. This criterion disqualified a candidate from inclusion under "dust cloud" in the present study.

2. They are bright in red light.

3. When these clouds reach heights of several kilometers, we have proposed that they may cast shadows that are observable from Earth. There are numerous reports of anomalous transient dark surface markings appearing near dust clouds, especially when the solar phase angle was reasonably large (Slipher, 1962).

While working with Lowell Observatory and Caltech-JPL astronomers Leonard Martin and Richard Zurek, new guidelines have been established by the Mars Recorders for interpreting Martian dust clouds or storms. As a result, the "Composite List of All Reported Yellow Cloud and Dust Storm Activity on Mars" is being compiled under the following categories:

I. Type of Observation.

1. White cloud or bright area mistaken for dust cloud.
2. Visual observation(s) of dust cloud or storm.
3. Instrumental observation(s) of dust cloud or storm (includes photographic, polarimetric, spacecraft, or other data by instrumental means).

II. Classifications of Martian dust clouds.

1. Obscuration–Not sure if surface or atmospheric.
2. Dust Haze–Partial obscuration with displacement.
3. Bright dust cloud–Bright obscuration with displacement.
4. Limb projection or terminator protrusion by dust cloud.

III. Classifications of a Martian dust storm.

1. Local: Dust storm with major axis not to exceed 2000 km (1,243 miles or less than 34° areocentric).
2. Regional: Dust storm with major axis that exceeds 2000 km (1,243 miles or more than 34° areocentric) but not encircling either or both Northern and Southern Hemispheres.
3. Planet-Encircling: Dust storm with major axis that completely encircles either or both hemispheres of Mars.

Much has been written about the characteristics of these dust clouds and how to detect them; however, these writings appear to have slipped by some of our observers. These dust clouds are very difficult to identify in their beginning stages and, in some cases, go undetected even after they have fully developed. On the other hand, some observers have confused bright Martian desert regions or bright fog areas with dust clouds. Others see the bright orographic clouds in Tharsis (095°, 8°N) as dust clouds. While many observers accept that the yellow-white appearance of some clouds indicates the presence of dust particles, they should not classify all bright clouds that appear to be yellowish as "dust clouds."

Numerous qualitative reports of yellowish hazes have appeared in the literature and in the IMP archives. Such terms as "dusty atmosphere" and "albedo features lacking in contrast, washed out" are frequently used and indeed have been employed by the authors. While such descriptions may have merit, generalized yellow hazes and temporary losses in surface contrast have been excluded from the present study. Even photographic evidence for these phenomena is weak, because proper sensitometric calibration is usually lacking.

Although immense global dust storms are firmly entrenched in Martian lore, they may be rare. Lowell Observatory's Leonard Martin states that there have been only five well-documented planet-encircling Martian dust storms. These storms occurred in 1956, 1971, 1973, and two storms in 1977 which were discovered by Viking (Martin, 1984). Records of observations of Mars indicate that most dust storms occur around the time of southern Summer Solstice (270° Ls), soon after perihelion passage (250° Ls). Many of our observers reported large dust clouds on Mars during May 1988. One transient dust storm was reported in Hellas (290°, 45°S) by Jeff Beish, Donald Parker, and Dave Raden. The storm was first seen on 1988 MAY 05 and was last observed on MAY 07 (189°-191° Ls).

A major dust storm was reported by numerous astronomers from 1988 JUN 03 through JUN 30 (207°-223° Ls). This storm started in Hellas and soon extended several thousand miles east and west of Hellas. The storm was first detected by G. Teichert of France, followed by Kermit Rhea of Arkansas. Dust clouds and haze were observed in regions as far east as Electris (190°, 48°S), to the west into Argyre (035°, 48°S), to the north into Hesperia-Cimmerium Mare (240°, 20°S; 210°, 30°S), and as far south as the South Polar Cap. Remnants of the dust storm could be seen over much of Mars in the early part of July. The Martian atmosphere remained dusty even through the end of August 1988. A complete report on this major dust storm is in progress and will be published soon. See *Table* 2 (p. 60) for a list of dust storms.

Since the dust storm in June, 1988, a few IMP observers have reported seeing massive dust clouds or streaks in Hellas, Solis Lacus, Argyre, and other locations on Mars. Some observers have even claimed to have seen major dust storms on the planet. Unfortunately, a few of these reports reached the media, which appeared to be in a "feeding frenzy" for sensational news about the Red Planet. Please remember that if we are to maintain respect within the astronomical community, we must maintain our objectivity

Much to the surprise of many Mars observer, another major dust storm broke out on 1988 NOV 23 and raged on into the first week of December.

While numerous dust clouds have been seen on Mars in the Northern Spring and Summer, extensive and long-lasting dust storms are extremely rare for these seasons (Beish, Parker, & Capen, 1984). Transient or short-lived and small dust storms have been reported in the past but they were observed to last only a few days and did not expand or move about very much.

What Mars may lack in white clouds and hazes during its Southern Spring and Summer is more than made up for by one of the most spectacular phenomena seen in nature—the great Martian dust storms. The 1987-89 Apparition was termed "perihelic" because Mars was close to the Sun (and therefore to the Earth) when it was at opposition. At perihelion, which occurred on 1988 AUG 12, Mars is some 43 million kilometers closer to the Sun than at aphelion. Current theory holds that the resultant 40-percent increase in solar radiation, compared with the value for aphelion, provides enough thermal energy to raise dust and hold it aloft for prolonged periods. Thus when Mars is near perihelion we frequently see dust clouds form which often spread with tremendous velocities to cover large portions of the planet. Occasionally one of these storms will have enough energy to cover the entire planet and is then termed a "global" dust storm.

During the first half of the 1987-89 apparition, many IMP astronomers reported transient dust clouds. On 1988 MAY 05, during early Martian Southern Spring, Dave Raden noted a dust cloud in the great Hellas basin (refer to the map in Beish and Parker, 1988). The authors watched this cloud expand over the next two days until it extended northwestward through Deltoton Sinus (304°, 5°S) and northeastward into the Libya basin (275°, 0°N). A dull orange haze extended northwest over Sabaeus Sinus (335°, 11°S) and westward into Noachis (350°, 45°S). While this storm rapidly dissipated, it did give us a preview of things to come.

THE JUNE DUST STORM – A WORLDWIDE ALERT

A significant Martian dust storm occurred in June, 1988, during early- to mid-Spring in Mars' Northern Hemisphere. The storm was first detected as a dust cloud in Hellas by Gerard Teichert in France on 1988 JUN 03 and by Kermit Rhea in Arkansas on JUN 07. On JUN 14 this cloud began to expand rapidly, and by JUN 17 it had covered several thousand square kilometers, extending eastward into Electris and westward into Noachis. On that date, the cloud obscured part of Tyrrhenum Mare (255°, 20°S) and extended northward into Hesperia. During this time a number of dark streaks were seen crossing Hellas and Eridania (218°, 45°S). These had not been previously observed, did not correspond to known surface features, and were very transient. We believe that at least one of these dark streaks, extending from Hesperus (223°, 37°S) southward to the South Cap, was a shadow cast by the dust cloud onto the Martian surface. These transient dark mark-

Table 2. Martian Dust Clouds and Dust Storms, 1873 - 1988.

Terrestrial Date	Ls Range of Visibility °	Initial Location	Type	Source(s)
1873 MAY 24-25	147-147	Aeria	Dust Cloud	Antoniadi (1930), 40-43
1890 JUL 05-06	184-184	Tempe	Dust Cloud	Campbell (1890), 248-249
1892 JUL 02-03	208-209	Hellespontus	Dust Cloud	Campbell (1892), 104-112
1892 JUL 11-13	213-215	Hellespontus-Noachis	Transient	Campbell (1892), 104-112
1894 NOV 25-26	324-325	Protei, Arygre	Dust Cloud	Douglass (1895), 127-130
1900 DEC 07-08	035-035	Sabaeus S.-Icarium	Dust Cloud	Lowell (1911), 393
1903 MAY 26-27	130-131	Chryse	Dust Cloud	Lowell (1911), 393
1905 JUL 27-29	186-187	Cerberus I-Elysium	Dust Cloud	Lowell (1906)
1907 JUL 29-30	213-214	Libya-Cimmerium M.	Dust Cloud	de Vaucouleurs (1954), 88
1911 OCT 06-07	310-310	Hellas-Ausonia	Dust Cloud	Jarry-Desloges (1908-46)
1911 OCT 11-18	313-317	Libya-Eridania	Transient	de Vaucouleurs (1954), 88
1911 NOV 13-14	325-325	Hellas	Major	Antoniadi (1930), 40-43
1912 JAN 15-16	004-004	Noachis-Hellas	Dust Cloud	Jarry-Desloges (1908-46)
1913-14 DEC 31-JAN 01	018-018	Argyre	Dust Cloud	Jarry-Desloges (1908-46)
1914 JAN 25-26	030-030	Argyre	Dust Cloud	Jarry-Desloges (1908-46)
1914 JAN 28-29	031-031	Argyre	Dust Cloud	Jarry-Desloges (1908-46)
1914 FEB 02-03	033-034	Deucalionis Regio	Dust Cloud	Jarry-Desloges (1908-46)
1914 FEB 06-07	035-035	Sabaeus S.-Argyre	Dust Cloud	Jarry-Desloges (1908-46)
1914 FEB 10-11	037-037	Hellas-Eridania	Transient	Jarry-Desloges (1908-46)
1914 FEB 17-18	040-040	Phaethontis	Dust Cloud	Jarry-Desloges (1908-46)
1915 DEC 24-25	035-035	Phaethontis-Icaria	Dust Cloud	Jarry-Desloges (1908-46)
1915 DEC 28-29	036-037	Aeolis-Elysium	Dust Cloud	Jarry-Desloges (1908-46)
1922 JUL 09-12	191-193	Margaritifer-Chryse	Transient	de Vaucouleurs (1954), 88
1924 AUG 09-10	237-237	Isidis R.-Libya	Transient	Slipher (1962)
1924 OCT 10-13	276-278	Yaonis-Hellas-Thyle II	Dust Cloud	Antoniadi (1930), 40-43
1924 OCT 20-27	282-287	Hellas	Dust Cloud	Pickering (1914-30)
1926 OCT 25-26	311-312	Libya-Isidis-Ausonia	Transient	de Vaucouleurs (1954), 88
1937 MAY 02-05	145-146	Syrtis Major-Isidis	Dust Cloud	de Vaucouleurs (1954), 88
1937 MAY 25-29	157-159	Candor-Niliacus L.	Transient	de Vaucouleurs (1954), 88
1941 NOV 12-28	312-321	Libya-Phaethontis	Major	de Vaucouleurs (1954), 88
1943 OCT 03-05	314-315	Libya-Hesperia	Transient	Slipher (1962)
1954 JUN 02-02	175-175	Ulysses-Phoenicis L.	Transient	Avigliano (1954)
1956 AUG 22-25	251-253	Argyre-Noachis	Global	Heintz (1958), 203-204
1956 AUG 28-SEP 04	255-259	Noachis-Syrtis Major	Global	Heintz (1958), 203-204
1958 OCT 12-15	309-311	Isidis R.-Hesperia	Transient	Slipher (1962)
1961 JAN 19-21	023-024	Casius-Elysium	Transient	Miyamoto (1961)
1971 JUL 10-29	213-225	Hellespontus	Major	Capen (1971); Capen+ (1972)
1971 SEP 22-1972 APR 24	259-019	Hellespontus	Global	Capen (1971); Capen+ (1972)
1973 JUL 16-SEP 01	244-274	Hellespontus	Major	Rhoads+ (1975)
1973 OCT 13-1974 JAN 30	300-359	Solis Planum	Global	Rhoads+ (1975)
1977 JAN 05-??	180-???	Solis Planum	Transient	Briggs+ (1979); Peterfreunde+ (1979)
1977 FEB 15-??	204-???	Solis Planum	Global	Briggs+ (1979); Peterfreunde+ (1979)
1977 MAY 27-??	268-???	Solis Planum	Global	Briggs+ (1979); Peterfreunde+ (1979)
1981 JUN 14-??	330-???	Chryse	Transient	Beish+ (1983)
1981 NOV 20-??	048-???	Hellas-Yaonis Regio	Major	Beish+ (1983)
1982 MAY 12-??	125-???	Hellespontus	Major	Beish+ (1983); Capen+ (1983)
1983 NOV 27- DEC 28	070-083	Xanthe-Candor-Thau.	Transient	Beish+ (1984)
1984 JAN 05-15	087-091	Chryse-Xanthe	Transient	Beish+ (1984
1984 JAN 29-FEB 14	097-105	Isidis Regio-Libya	Major	Beish+ (1984); Beish (1989)
1986 MAY 28-JUN 04	178-182	Hellas	Transient	(IMP files)
1986 AUG 05-11	219-222	Hellas	Transient	(IMP files)
1986 SEP 12-13	242-243	Hellas	Transient	(IMP files)
1988 MAY 05-07	190-191	Hellas	Transient	Beish (1989a)
1988 JUN 03-30	207-223	Hellas	Major	Beish (1989a)
1988 NOV 23-DEC 05	314-321	Solis Planum	Major	Beish (1989a)

Notes: *Dust Cloud*; stationary dust cloud observed for one to three Sols. *Transient*; localized dust storm that displays movement and expansion. *Major*; large expanding dust storm covering much of a Martian hemisphere. *Global*; entire planet covered by dust (planet-encircling). Sources for the events through 1958 are listed in Gifford (1964). When "+" follows an author's name, there is more than one author.

ings have been seen with other dust storms and have been extensively photographed by the late E.C. Slipher at Lowell Observatory.

Although the dust storm subsided after JUN 21, we had alerted the Marswatch-88 Coordinator Stephen Edberg at the Jet Propulsion Laboratory, as well as amateurs throughout the world. Within 48 hours amateurs and professionals in the United States, Japan, Australia, Germany, France, and England had received word. Unfortunately, because the storm was of brief duration, it was observable mainly from the United States. Thanks to the Marswatch alert by Edberg, American professionals were able to obtain some data, however. On JUN 22 Lowell Observatory's Leonard Martin reported a definite decrease in the intensity of the South Polar Cap, and astronomers at JPL found evidence of considerable dust in the Martian atmosphere well into July.

It may be of some interest that this storm occurred almost exactly on the date of the highest probability that was predicted by Beish in March, 1988 (Beish & Parker, 1988).

INTERNATIONAL COOPERATION

During mid-June, 1988, while we were observing the Hellas storm, members of the OAA (Oriental Astronomical Association) were viewing the other side of the planet. Isao Miyazaki and T. Wakugawa notified us that they had seen and photographed a bright dust cloud in Noachis on JUN 17, verifying our observations. The region of Mars not accessible to American observers, however, was also covered with a thin veil of dust, apparently resulting from a bright dust cloud observed in Argyre I from JUN 17-19. A thin veil partially obscured Meridiani Sinus (000°, 5°S), Margaritifer Sinus (025°, 10°S), and Erythraeum Mare (040°, 25°S) during this time. It would appear that a second transient dust storm began in Argyre at the same time as the Hellas storm—a form of resonance effect.

During the period from JUL 16 through JUL 22 a number of observers, including K. Rhea, C. Macdonald, T. Printy, D. Boyar, W. Haas, and the Recorders, sighted dusty clouds in N. Hellas. On AUG 14, G. Teichert reported fairly extensive cloud activity in Hellas and Ausonia. Between AUG 18 through AUG 26 small dust clouds were reported in N. and W. Hellas by Aerts, Cralle, Troiani, O'Meara, Schmude, Beish, Schneller, Fiorino, Gelinas, Van Loo, and B. Wilson. These clouds, appearing bright in orange light and usually bright white in integrated light, showed some slight motions but remained localized and lasted for only 1-2 days. Of course, one such cloud could represent the start of a major storm, so any such occurrence should immediately be reported to the Mars Record-ers for follow-up. The major diagnostic test for an early dust storm is the expansion of a dust cloud so that it obscures surface features which were seen previously. This is why it is so important to observe Mars regularly so that one may become intimately familiar with the planet's "normal" morphology. By AUG 22, Hellas was free of activity, and details on its floor, such as Zea Lacus (290°, 50°S), were seen and photographed by Parker, Beish, and J. Sanford.

A number of "White Areas" were observed during August and September, 1988 These are often mistaken for dust clouds but show no motion and persist for weeks or even months. They may be ice-fogs or simply regions of high albedo. They tend to be more frequent near opposition, so they may also represent specular reflections. They are seen in Aram (013°, 0°N), Candor, Symplegades I. (190°, 28°S), and the region near Gomer Sinus (230°, 3°S).

THE NOT-SO-RED PLANET

Further evidence for a dusty Martian atmosphere is not nearly so sophisticated as that obtained by JPL instrumentation. In fact, it comes from "the man on the street!" Beginning in early July, 1988, we received numerous phone calls and letters from non-astronomers as well as from IMP observers; stating that Mars was not red in 1987-89, but rather orangish, even when it was near the horizon. Furthermore, IMP astronomers throughout the world commented on the intensely green color of the dark surface features, called "maria" or "albedo features." These dark areas often appear bluish in telescopes of moderate aperture and appear to increase in contrast during Martian local Spring. During the 1987-89 Apparition, however, their contrast was more subdued than usual and visual and photographic colorimetry did indeed frequently reveal greenish hues. A likely cause for these changes is dust high in the Martian atmosphere, subduing the intensities and causing the bluish albedo features to appear green. Perhaps the most compelling evidence for the presence of persistent dust in Mars' atmosphere comes from observations of the most prominent feature on the planet—the South Polar Cap.

THE NOVEMBER DUST STORM

On 1988 NOV 23, Dan Troiani and Robert Robinson independently discovered a bright dust cloud in southern Thaumasia extending eastward across Bosporos (070°, 43°S). On NOV 25, Beish observed two distinct dust cloud formations located over eastern Solis Lacus and a second located extending from southeastern Thaumasia across Bosporos into Argyre I, apparently an expansion of the dust cloud observed on NOV 23. Beish measured the initial dust cloud with a filar micrometer to be centered at 075°W and 25°S.

The Planetary Society's Marswatch'88 astronomers were promptly alerted and, despite inclement weather and holiday travel, a number of American astronomers were able to follow the progress of the dust storm. JPL astronomer Terry Z. Martin traveled to Mauna Kea, Hawaii, where he was able to obtain valuable infrared data that indicated a greater than normal dust load in the Martian atmosphere that persisted for over a week after the dust storm activity had subsided. The Planetary Society sent telegrams to the Marswatch coordinators abroad, and by the end of November a worldwide effort had been mounted to study this storm. On NOV 29, Isao Miyazaki telephoned Parker from Okinawa, informing him of the dust storm and its extent.

Japanese astronomers, who had an excellent view of the regions lying to the west of Solis Lacus, reported that by DEC 01 the storm had spread from Solis Lacus into Daedalia (120°, 30°S) and Phaethontis (150°, 50°S). The storm apparently progressed no farther than 150 degrees west longitude. This was confirmed by excellent photographs sent by Miyazaki. British, and other European IMP astronomers found no dust or unusual activity around the Hellas-Syrtis Major longitudes (240°-320°W). From NOV 28 to DEC 01, American observers recorded dust spreading eastward from Argyre I into Noachis, covering over 1,250 km in 72 hours!

Several finger-like projections emanated from the main body of this enormous dust cloud. Streaks were noted in western Erythraeum Mare, just south of Aurorae Sinus (050°, 14°S), and another extended southeastward from the Noachis portion of the cloud and obliterated the western half of Australe Mare (040°, 60°S). This latter feature had been intensely dark immediately before and during the storm. In fact, the experienced Mars observer Thomas R. Cave reported it as a new albedo feature—he had not seen this region so dark in over 50 years of observing the Red Planet!

After DEC 05, an orange dust veil was reported by all observers to cover the South Polar region, Chryse (035°, 10°N)-Xanthe (050°, 15°N)-Candor, much of Hellas-Hellespontus (330°, 47°S), Noachis)-Argyre I, Erythraeum Mare-Thaumasia (085°, 35°S), and the Solis Lacus-Memnonia (142°, 20°S) regions.

From a preliminary study of this storm, we have calculated the maximum extent of the storm as 5,500 km in its east-west dimension and 1,500 km in its north-south extent. It is of interest that this storm occurred very late in the Martian year (314° Ls), but was close to the probability peak for storms predicted by Beish in the November, 1988, *Martian Chronicle* No. 5.

SURFACE FEATURES

In addition to atmospheric phenomena, Mars exhibits varied and often mysterious changes in the appearance of its surface. The dark blue-green "maria," called "albedo features", appear to darken during early Martian local Spring in such a manner that a "wave of darkening" appears to sweep from the thawing polar cap towards the Equator. This event, which occurs during each hemisphere's Spring, lent credence to the theory that the *maria* were composed of vegetation, which was replenished when water flowed from the melting polar cap towards the equator. Now we know that this concept is false. In fact, the late C.F. Capen had shown that the wave of darkening is in actuality a "wave of brightening." The albedo features only appear to darken because the adjacent ochre desert areas have brightened during early Spring. Viking Lander photographs have actually shown fresh dust deposited during winter frost accumulation and uncovered during Spring when the frost sublimes away.

Other seasonal changes on the Martian surface are most likely the result of redistribution of fine layers of surface dust by seasonal winds. An example is the predictable changes in shape of the Syrtis Major (290°, 10°N). This dark, wedge-shaped feature, always a favorite subject for observers, becomes narrow after perihelion passage (Ls 250°) and broad after aphelion (Ls 70°). In addition, this feature has undergone some rather dramatic long-term, or "secular," changes over the years. During recent apparitions, the Syrtis Major appears to have become narrower and blunted compared to its appearance in the 1950's, and the once conspicuous region to the east, called Thoth-Nepenthes (260°-265°, 15°-28°N), has all but disappeared. During early September Syrtis Major began to narrow, a fact commented upon by a number of IMP observers.

A number of other interesting and often unpredictable changes on the Martian surface are worth watching for. Regions which bear careful scrutiny are described below. Solis Lacus, a large, dark region, often called the "Eye of Mars" because it resembles the pupil of an eye, has undergone dramatic changes in size and shape during recent years. It has become very large and dark as have its surrounding "canals." This feature, lying to the south of the Tharsis volcanoes and southeast of the western end of the Valles Marineris (025-111°, 2°-18°S), is often the site of intense meteorological activity, including dust storms.

During 1987-89, a number of temporary and seasonal changes were reported on the Martian surface. Solis Lacus was again an area of change, appearing to R. Niel of France to be covered by dense clouds on the morning limb on 1988 APR 15 (178° Ls). F. Melillo of New York and D. Troiani of Chicago reported this region to be dull and washed-out during this period. However, by APR 22 the Mars Recorders observed it to be "normal" for the season. In late August the "canal" Nectar (072°, 26°S), which connects Solis Lacus to Nectaris Palus (062°, 25°S), became very broad and dark, giving Solis Lacus the appearance of a pork chop. Another feature, Ganges (060°, 8°N) was observed to be darker, broad, and doubled after 1988 APR 25 by J. Beish, D. Parker, and H. Cralle.

To the west of Solis Lacus lies a normally light ochre area called *Daedalia Claritas* (120°, 30°S). During the 1970's this region underwent an intense darkening but has now returned to its normal intensity. It bears close scrutiny by observers. In 1987-89 this region, as well as the eastern end of Sirenum Mare

(140°, 40°S), has lightened considerably.

During July and August IMP observers noted a pronounced darkening and northwestward elongation of Phoenicis Lacus (110°, 15°S). This appears to be an elongation of Eumenides (145°, 5°S), with Pyriphlegethon (140°, 20°N) also being prominent. By September, however, this region was back to "normal."

In 1978 a new dark area on the western side of the Elysium (215°, 23°N) shield volcanoes was reported by A.L.P.O. Mars observers. It was subsequently confirmed on Viking Orbiter photographs. Capen named this the *Hyblaeus Extension*, after the normally inconspicuous "canal" Hyblaeus (228°, 28°N) which is located in this position. This darkening has persisted into the 1980's, as well as other changes near Elysium, notably the lightening of the wedge-shaped feature, *Trivium Charontis* (198°, 20°N). This whole region near the huge Elysium volcanos appears to be in a state of flux and should be monitored often. Trivium Charontis darkened in 1987-89, but not to the intensity of previous years.

Another recent surface change was the reappearance in 1986 of a conspicuous dark band across Hesperia. This band was first reported in 1901 and again in 1903 by E.M. Antoniadi who named it Cerberus III (212°, 10°S). This feature became much less conspicuous in 1987-89.

During the 1950's, A.L.P.O. Mars observers reported the "canals" Hydraotes (040°, 3°N), Lysis, and Nilokeras II (055°, 30°N) as connected to Oleaster Lacus (058°, 12°N) and Lunae Lacus (068°, 18°N). These features darkened again and were well defined during 1988 APR 26-JUN 03; they can be found on the 1954 A.L.P.O. Mars Chart and in *The Planet Mars*, by E.M. Antoniadi.

Details in Sirenum Mare (140°, 40°S) were very difficult to detect as reported by the Oriental Astronomical Association (OAA) and A.L.P.O. This feature's northern border appeared to be truncated.

NEW AND RENEWED MARTIAN SURFACE FEATURES

New surface features on the Red Planet have always caused excitement among avid Mars observers.

On 1988 AUG 07, Steve O'Meara, using the 60-inch Mt. Wilson Reflector, saw a conspicuous streak extending from Gallinaria Silva along the northern borders of Sirenum Mare and Cimmerium Mare all the way to Gomer Sinus. He saw numerous "festoon-like" markings connecting the streak to the maria to the south (Beish, Parker, & Hernandez, 1989). This feature was also reported by members of the O.A.A. and was drawn and photographed by Parker, Beish, and Miyazaki as early as JUL 04. These observations, as well as excellent photographs and drawings by Wakugawa, Shirao, Asada, Melillo, Pfannerstill, Boyar, Tatum, and Mattei, confirmed the presence of this shadowy line throughout July and August.

The northwestern portion of Hellas' floor remained bright well into January, 1989, leading to some spurious reports of dust storms. This region, as well as many others on the planet, appear bright in yellow light. They are not, however, dust clouds, although they may be associated with low hazes. Dust clouds are not all that easy to diagnose during the early stages of a storm. They often originate over bright desert areas and may be brighter initially in blue light than in yellow or orange. The primary feature of dust clouds, however, is that they move, expanding to obscure nearby dark features. Recognition of these obscurations is the key to early detection and reporting of major dust storms. But such recognition presumes that the observer has a fundamental grasp of the "normal" Martian surface as it appeared prior to the storm.

In September, 1988, however, as opposition drew near, the Gallinaria Silva-Gomer Sinus streak became less conspicuous, especially in its eastern half. Photographs by Parker and Melillo, videotapes by MacFarlane, and numerous visual observations by O'Meara revealed that the streak had become thin and that the region between it and Sirenum Mare and Cimmerium Mare had taken on a half-tone appearance.

O'Meara suggested the name "Valhalla" for this streak. This was the hall through which passed the souls of brave Viking warriors. This appears appropriate, as it connects the "Lake of the Sun" (Solis Lacus) with Cerberus (the three-headed hound who guards the nether regions). The streak also passed through Memnonia (148°, 20°S), named after Memnon, a heroic defender of Troy. Although this name may be fitting we will have to wait until the International Astronomical Union confirms and gives official sanction to this apparent new Martian feature.

In addition to the above completely new feature, several "missing" features reappeared. Four features previously discovered at the end of the 1900's by the great astronomers Schiaparelli, Lowell, and Antoniadi have made their appearance again. They are; Acampsis (095°, 32°S-140°, 15°S), Eosphoros (098°, 20°S-114°, 0°N), Gallinaria Silva (110°, 28°S), and Noctis Lacus (090°, 10°S). Isao Miyazaki (Okinawa), Steve O'Meara (Mass.), Dan Boyar (Florida), and the Mars Recorders observed and identified these resurrected features.

VIOLET CLEARING

Another interesting phenomenon occurring on Mars is called "Violet Clearing", formerly "Blue Clearing", and has been under investigation by astronomers for decades. Observations of Mars in violet light, in wavelengths between 455 and 425 nanometers, normally show only a bright and featureless disk. Clouds and hazes are usually present; however, surface features are not usually seen.

When this "violet clearing" occurs, dark surface features begin to appear in varying degrees of definition. There has been much debate over the cause of this phenomenon but no reasonable explanation of it is generally accepted. To detect violet clearing, the observer should use a violet filter (W47) at the telescope. See *Table 1* (p. 57) regarding the frequency of violet-clearing reports during the 1987-89 Apparition.

CONCLUSION

The A.L.P.O. Mars Section maintains contact with nearly 520 active observers and interested astronomers in 33 countries. We receive thousands of letters and observations each apparition and regularly report on these activities in the *Journal, A.L.P.O.* ("The Strolling Astronomer"); *Astronomy,* and *Sky & Telescope* magazines; other scientific journals, and our newsletter, the *Martian Chronicle*.

Whether it was warmer on Mars during the 1980's, or colder in the 1960's, one very important aspect of our study stands out—we have uncovered significant changes in the Martian climate and they appear to have taken place in the past two decades. Results of the A.L.P.O.'s Meteorological Survey and Survey of the Martian Polar Regions have revealed that Mars is not the unchanging world pictured by many professional astronomers. Mars appears more and more like Earth in many ways—a planet with a dynamic weather system, variable climate, and polar caps that vary in size with the changing seasons.

We must remember that much of this research is made possible by a world-wide network of dedicated amateurs who contribute many hours of their time. Now that we have a beginning statistical model with which to predict trends in the Martian climate, it is more important than ever to obtain high-quality observations of Mars from these IMP astronomers and to insure that their time will not be wasted. As a reward for the great efforts by all A.L.P.O. Mars Section astronomers, many of our scientific reports and findings are regularly quoted or used as references in many international amateur and professional scientific journals. Our findings of the behavior of the North Polar Cap of Mars have gained wide acceptance throughout the astronomical community and we hope that the results of our study of the meteorology of Mars will gain respect among the world's leading planetary astronomers.

While carefully-done drawings, made from appropriate color-filter observations, will remain the backbone of the program, good quantitative data are essential. Today's amateurs are capable of taking photographs of Mars that rival those obtained with large professional instruments. Violet-light photographs of Mars are particularly useful, although the standard violet filters are quite dense and exposure times tend to be excessive with all but the largest telescopes. A satisfactory alternative is to photograph Mars in integrated light with high-quality color slide films and then to rephotograph the best slides onto black-and-white film through a Wratten 47 or equivalent filter. The resulting black-and-white prints show Mars in violet light, dramatically revealing clouds, hazes, polar hood details, and even violet clearing. This technique has proven most useful in providing quantitative checks on visual data. We hope that amateurs interested in photographing Mars will avail themselves of this simple technique (Parker *et al.*, 1986; Dobbins *et al.*,1986).

Due to the great number of Mars observations received, the Mars Recorders propose to publish one observation for each astronomer who participated in the 1987-89 Mars Apparition, giving us all a little something to remember it by.

REFERENCES

Antoniadi, E.M. (1930). *La Planète Mars 1659-1929*. Paris: Herman et Cie. (Translated by Patrick Moore (1975) as *The Planet Mars*. Chatham: Keith Reid, Ltd.)

Ashbrook, J. (1956). "A.L.P.O. Map of Mars," *Sky and Telescope, 15*, No. 11 (Sep.), 502-503.

Avigliano, D.P. (1954). "Mars 1954—Report Number 1, Part 2," *J.A.L.P.O., 8*, Nos. 9-10 (Sep.-Oct.), 109-117.

Beish, J.D.; Capen, C.F.; and Parker, D. C. (1983). "Dust Storms of the Martian Equatorial Zone," *Proceedings, ALCON'83* (National Convention of the Astronomical League, at Jacksonville, FL), 14-25.

________. (1987). "The Meteorology of Mars–Part II," *J.A.L.P.O., 32*, Nos. 1-2 (Mar.), 12-21.

Beish, J.D. and Parker, D.C. (1987). "The Meteorology of Mars–Part III," *J.A.L.P.O., 32*, Nos. 5-6 (Oct.), 101-114.

________. (1988). "1988: A Great Year for Mars," *Astronomy, 16*, No. 3 (Mar.), 58-65.

________. (1988a). "Exploring Mars in 1988," *Sky & Telescope, 75*, No. 4 (Apr.), 370-375.

Beish, J.D.; Parker, D.C.; and Capen, C.F. (1984). "A Major Martian Dust Storm in 1984," *J.A.L.P.O., 30*, Nos. 9-10, (Aug.), 211-217.

________. (1986). "The Meteorology of Mars—Part I," *J.A.L.P.O., 31*, Nos. 11-12 (Nov.), 229-235.

Beish, J.D.; Parker, D.C.; and Hernandez, C.E. (1989). "The Red Planet Shows Off," *Sky & Telescope, 77*, No. 1 (Jan.), 30-35.

Beish, J.D. ; Parker, D.C.; Hernandez, C.; Troiani, D.; and Cralle, H. (1991). "The International Mars Patrol in 1987-89—Part I," *J.A.L.P.O., 35*, No. 1 (Mar.), 4-13.

Briggs, G.A.; Baum, W.A.; and Barnes, J. (1979). "Viking Orbiter Observations of Dust in the Martian Atmosphere," *J. Geophys. Res., 84*, 2795-2820.

Briggs, G.A., Klaasen, K., Thorpe, T., Wellman, J., and Baum, W. (1977). "Martian Dynamical Phenomena During June- November 1976: Viking Orbiter Imaging Results," *J. Geophys. Res., 82*, 4121-4149.

Campbell, W.W. (1890). "Notices of the Lick Observatory," *Publications, Astronomical Society of the Pacific, 2,* No. 10, 248-249.
________. (1892). "Notices of the Lick Observatory," *Publications, Astronomical Society of the Pacific, 6,* No. 35, 104-112.
Capen, C.F. (1971). "Martian Yellow Clouds-Past and Future," *Sky & Telescope, 41,* No. 2 (Feb.), 117-120.
Capen, C.F. and Martin, L.J. (1972). "Mars' Great Storm of 1971." *Sky & Telescope, 42,* No. 5 (May), 276-279.
Capen, C.F.; Parker, D.C.; and Beish, J.D. (1983). "The 1981-82 Aphelic Martian Apparition - A.L.P.O. Report," *Proceedings, ALCON'83* (National Convention of the Astronomical League, at Jacksonville, FL), 53 (abstract).
de Vaucouleurs, G.,(1954). *Physics of the Planet Mars.* London: Faber and Faber.
Dobbins, T.A.; Parker, D.C.; and Capen, C.F. (1988). *Introduction to Observing and Photographing the Solar System.* Richmond, VA: Willmann-Bell, Inc. Chapter 14.
Dollfus, A. (1961). "Polarization Studies of Planets," Chapter 9 in: *The Solar System, Vol. 3, Planets and Satellites,* G.P. Kuiper and B.M. Middlelhurst (eds.). Chicago: University of Chicago Press.
Douglass, A.E. (1895). "A Cloud-Like Spot on the Terminator of Mars," *Astrophysical Journal, 1,* No. 2 (Feb.), 127-130,.
Fischbacher, G.E.; Martin, L.J.; and Baum, W. A. (1969). *Martian Polar Cap Boundaries.* Planetary Research Center, Lowell Observatory, Flagstaff, AZ.
Gifford, F.A., Jr. (1964). "A Study of Martian Yellow Clouds That Display Movement," *Monthly Weather Rev., 92,* No. 10 (Oct.), 435-440.
Hartmann, W.K. (1989). "What's New on Mars?" , *Sky & Telescope, 77,* No. 5 (May), 471-475. (Refer to inset "Mars from Mauna Kea," p. 474.)
Heintz, W.D. (1958). "On Martian Yellow Clouds," *The Observatory, 78,* 203-204.
James, P.B. (1979). "Recession of Martian North Polar Cap: 1977-1978 Viking Observations," *J. Geophys. Res., 84,* No. B14 (Dec.),. 8332-8334.
James, P.B.; Briggs, G.; Barnes, J.; and Spruck, A. (1979). "Seasonal Recession of Mars' South Polar Cap as Seen by Viking," *J. Geophys. Res., 84,* No. B6 (June), 2889-2922.
Jarry-Desloges, M. (1908-1946). *Observations des Surface Planetaires, Vol. 1-9 (1907-1941).* Paris: Gauthier-Villars et Fils.
Lowell, P. (1906). *Drawings of Mars, 1905.* Flagstaff, AZ: Lowell Observatory.
________. (1906a). *Mars and its Canals.* New York: Macmillan Co.
Martin, L.J. (1984). "Clearing the Martian Air: The Troubled History of Dust Storms," *Icarus, 57,* 313-321.
Miyamoto, S. (1961). *Meteorological Observations of Mars During 1960-61 Opposition.* Contribution No. 105, Institute of Astrophysics and Kwasan Observatory, University of Kyoto.
Parker, D.C.; Beish, J.D.; and Capen, C.F., (1984). "The Third Martian Arctic Expedition," *Proceedings, 38th. National Convention of the Astronomical League,* 79-81.
________. (1986). "A Simple Technique for Obtaining Violet Light Photographs of Mars," *J.A.L.P.O., 31,* Nos. 9-10 (July), 181-183.
Parker, D.C.; Beish, J.D.; and Hernandez, C.E. (1990). "The 1983-85 Aphelic Apparition of Mars—Report II." *J.A.L.P.O., 34,* No. 2 (Apr.), 62-79.
Parker, D.C., Capen, C.F., and Beish, J.D. (1983). "Exploring the Martian Arctic," *Sky & Telescope, 65,* No. 3 (Mar.), 218-220.
Peterfreund, A.R. and Kieffer, H.H. (1979). "Thermal Infrared Properties of the Martian Atmosphere. 3. Local Dust Storms," J. Geophys. Res., *84,* 2853-2863.
Pickering, W.H. (1914-1930). "Mars Reports" [Nos. 1-44]. *Popular Astronomy, 22-38.*
Rhoads, R.B. and Capen, V.W. (1975). "Mars 1973-74 Apparition—A.L.P.O. Report I," *J.A.L.P.O., 25,* Nos. 7-8 (June), 130-140.
Sidgwick, J.B. (1971). *Amateur Astronomer's Handbook.* New York: Dover Publications.
Slipher, E.C. (1962). *The Photographic Story of Mars.* Cambridge, MA: Sky Publishing Co.
Tombaugh, C.W. (1968). "A Survey of Long-Term Observational Behavior of Various Martian Features that Affect Some Recently Proposed Interpretations." *Icarus, 8,* 227-258.
Wells, R.A. (1978). *Geophysics of Mars.*New York: Elsevier Scientific Publishing Co., 569.
Westfall, John, 1988. "Mars Opposition 'Favorability Index'," Personal communication.

Erratum:

In Part I of this report, which appeared in our last issue (Vol. 35, No. 1), one person was unintentionally left off the list of contributing observers on pages 6-9: Mr. Matthew Will of Springfield, IL, who contributed 28 drawings, including color-filter and intensity estimates. He employed 6-inch and 8-inch Newtonian reflectors for his Mars studies.

HOW TO MAKE A NON-DISCOVERY: WITH AN EXAMPLE

By: Walter H. Haas; Founder, A.L.P.O.

We have all read accounts of discoveries in science. Examples include Dr. Clyde Tombaugh's famous discovery of the planet Pluto [1] and Mr. David Levy's delightful account of how he found a recurrent nova in the constellation Corvus [2].

This article will be a trivial footnote to the discovery by Mr. Stuart Wilber and Mr. Alberto Montalvo of the 1990 Great White Spot on Saturn. [3.] This discovery was made on 1990 SEP 25 Universal Time (U.T.; September 24, local civil time). Had I been observing on that date, I would surely have recognized something unusual on Saturn. Thus I *might* have been a co-discoverer of the Great White Spot or possibly the first discoverer at the proper time on slightly earlier dates. Of course, this assertion detracts nothing from what Messrs. Wilber and Montalvo actually did, and it must be uncertain how successfully I would have notified the astronomical community of an important new planetary feature. Incidentally, Mr. Montalvo is a long-time member of the A.L.P.O. [We know now that A.L.P.O. member Michael Sweetman of Tucson, Arizona, also sighted the Great White Spot on 1990 SEP 25. Ed.]

The sidereal rotation of Saturn near its equator, where the feature appeared, is accomplished in about 10 hours, 14 minutes, and 0 seconds. [4] Thus seven rotations of Saturn at this latitude take 71 hours, 38 minutes, while three rotations of the Earth require 72 hours, 0 minutes. Accordingly, an equatorial feature on Saturn can be reobserved at 3-day intervals and will then return to the same position on the disc about 22 minutes earlier at each such reobservation. The planetary region where the spot appeared was hence well presented to the discoverers and to myself (we being all near the same terrestrial longitude) before the discovery on Universal Time dates 1990 SEP 22, 19, 16, 13, and so on; and after the discovery on SEP 28, and OCT 01, 04, 07, *et seq.*

And now comes the story of failure. On SEP 13 (U.T.) I made my sixteenth observation of Saturn for its 1990 Apparition. Each observation included at least some of the following: visual photometry of the different parts of the Globe and Rings, color estimates of these same features using color filters, latitude estimates of well-defined belts, and general notes. On SEP 13 nothing at all unusual was remarked. Thus I feel confident that the Great White Spot surely did not exist as anything noteworthy that long before its discovery. Alas, I then concluded that Saturn observations were being rather repetitious and complained about the lack of change in a letter on September 24th (!) to Mr. Alan Heath, the Saturn Director of the British Astronomical Association. I spent several evenings around September 25 watching a television series on the American Civil War instead of looking through an eyepiece. So it was that a superficial interest in history betrayed a deeper interest in astronomy. I did not observe Saturn again until SEP 29—SEP 28 (see above) would have been a better choice. I remarked nothing noteworthy on SEP 29. On October 1 Dr. Donald Parker informed me by telephone of the existence of the new major outbreak on Saturn. I finally observed the new detail on OCT 3, but with Saturn so low in the southwest that its image was bordered with the red and blue fringes of atmospheric chromatic dispersion. A better view on OCT 04 gave rise to this comment in my observing notes: "This EZ oval is the most conspicuous and brightest feature which I have ever seen in the Equatorial Zone of Saturn over the interval 1935-1990, during which I have observed the planet!"

This wordy recital contains an object lesson. That person who would discover a rare event, such as a naked-eye nova or a bright outburst of Comet Schwassmann-Wachmann I, must exercise the greatest persistence. The sought-for phenomenon may easily occur when we turn our attention to something else. We must try to be aware at all times of the significance of what we are observing, and its interpretation. And that awareness is exactly what the actual discoverers of the Great White Spot on Saturn possessed.

REFERENCES

[1] Tombaugh, Clyde W. and Moore, Patrick. *Out of the Darkness: the Planet Pluto.* Harrisburg, PA: Stackpole Books, 1980.

[2] Levy, David H. "Star Trails," *Sky & Telescope*, *81*, No. 1 (Jan., 1991), pp. 89 and 91.

[3] O'Meara, Stephen J. "Saturn's Great White Spot Spectacular," *Sky & Telescope*, *81*, No. 2 (Feb., 1991), pp. 144-147.

[4] *The A.L.P.O. Solar System Ephemeris: 1990*, edited by John E. Westfall, pg. B-1. The degrees of rotation per solar day there given have been converted to the period of rotation.

URANUS, NEPTUNE, AND PLUTO: CONTRIBUTIONS THAT A.L.P.O. MEMBERS CAN MAKE

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

ABSTRACT

This report discusses each of five methods by means of which A.L.P.O. members can contribute to our knowledge of the three Remote Planets: photometry, drawings and other visual observations, photographic and CCD imaging, color measurements, and occultations.

PHOTOMETRY

Photometry is the process by which one measures the brightness of an object. If these measurements are carried out over sufficient time, a light curve of the object can be drawn up, which can be helpful in detecting long-term brightness changes. In fact, one of the major problems regarding Pluto is the changes in its magnitude and light curve over the years. [Stern *et al.*, 1988] There are four ways to carry out photometric measurements of Uranus and Neptune, namely visual, photographs, photoelectric, and CCD imaging. In the case of Pluto, photographic photometry and CCD imaging can yield useful information with amateur-size instruments.

The visual-photometry method involves estimating the magnitude of an object using nearby stars of brightness similar to the object, and themselves of known magnitude. My preference is to use comparison stars which are both brighter and dimmer than the object of interest. Visual photometry has been used in estimating the brightnesses of Uranus and Neptune for several decades [for example, see Robinson, 1955] and is still being used by the British Astronomical Association [Hollis, 1989].

Photographic photometry is a second way to estimate an object's brightness. This method was used by Goddard [1930] to measure the brightness of Uranus. In the photograph, it is essential that the object of interest be included with stars of known magnitudes. I think that this technique can also be used for Pluto. The 1991 and 1992 Apparitions of Uranus present the very rare opportunity of capturing both Uranus and Neptune on the same plate; these two planets will lie about 5° apart near opposition in 1991 and less than 2° apart in 1992. [The apparent positions of Uranus and Neptune during 1991 are plotted on p. J-2 of the *A.L.P.O. Solar System Ephemeris: 1991*.] Also, by the use of color filters, information on the colors of the Remote Planets can be measured.

A third method, photoelectric photometry, can yield brightness measurements of Uranus and Neptune to an accuracy of better than 0.01 magnitude [Lockwood, 1977] and is more accurate than either visual or photographic photometry. Magnitudes can be estimated at several wavelengths, thus allowing color measurements to be made as well. Photoelectric photometers, with suitable sets of color filters, are commercially available for about $1000-2000. [Pluto sadly is too faint to be measured with such photometers with the size of most instruments available to amateurs; however, as pointed out below, CCD imagery of Pluto is possible with such instruments. *Ed.*]

The remaining method of estimating the brightness of the remote planets is by CCD [Charge-Coupled Device] imaging. Just within the last two years, these devices have reached the market at prices of under $2000. Two models have been reviewed in *Astronomy* magazine [Berry, 1990]. This method may also be used to estimate the magnitude of Pluto as well as in capturing detail on Uranus and Neptune, as discussed later [Hammel, 1987; Stevenson, 1989].

DRAWINGS AND OTHER VISUAL OBSERVATIONS

Detail may be occasionally visible on the disks of Uranus or Neptune through a large telescope when the seeing is good [O'Meara, 1989]. For example, I was able to see a bright spot on Uranus' limb on 1988 JUL 16 through the 35.5-cm telescope at Texas A&M University, as confirmed independently by three other people. Similarly, O'Meara [1984] studied a bright area on Uranus for several days and reported rotational periods of 16.0-16.4 hours, which is close to what Voyager 2 observed. Other astronomers have visually studied detail on Uranus, such as E.E. Barnard [Newburn and Gulkis, 1973] and E.M. Antoniadi [Alexander, 1965]. [For an example of two possible early visual sightings of the "Great Dark Spot" on Neptune, see the article by Francis G. Graham on p. 69. *Ed.*]

PHOTOGRAPHIC AND CCD IMAGING

Several persons have been able to record detail on Uranus and Neptune by photography or CCD imaging. Sinton [1972] was one of the first to do this, combining 16 photographic images of Uranus taken through the University of Hawaii telescope in order to make a print that showed a brightening to the southern limb of the planet. Such brightenings have also been seen by A.L.P.O. members in the past. Unprocessed Stratoscope II balloon images of Uranus did not show any detail on that planet [Ashbrook, 1970; but after careful examination of the images some years later with modern image-processing equipment, Franklin *et al.* [1980] found subtle detail on them, including bright limb areas. They also reported that photographs of Uranus taken in 1966, at the New Mexico State University Observatory show a feature that may be a shadow of the Uranian ring system.

Finally, some observers have been able to capture details of Uranus and Neptune with CCD's. The images of Neptune recorded by Hammel in particular are valuable contributions to science. She used an infrared filter with its maximum transmission at 8900 Å, having a 50-percent transmission band 200 Å in width, centered on an absorption band of methane. Although she used the 2.24-meter telescope at Mauna Kea, I believe that telescopes 0.5-1.0 meters in aperture could similarly reveal detail on Uranus and Neptune.

COLOR MEASUREMENTS

Color measurements can provide some valuable information about the chemical composition of the atmospheres of Uranus and Neptune, along with any changes that are occurring there. In addition, color measurements conducted over several years can reveal subtle changes that are occurring on these planets as well as in the radiation that they receive from the Sun. Finally, color measurements of Uranus are especially important at present because of the rare situation that the planet's pole is pointed approximately toward us.

Photoelectric and photographic photometry and CCD imaging are all tools that can be used to determine the colors of Uranus and Neptune if the appropriate color filters are used. [Wide-band **B** (blue) and **V** (visual) filters comprise the minimum; the **I** (near-infrared) filter may also be useful because it includes the methane absorption band. *Ed.*]

OCCULTATIONS

Uranus and Neptune occult about a dozen faint stars (magnitude +13 or brighter) every year, and predictions of these events are published from time to time in the *Astronomical Journal*. There are additional near misses. For example, Mefield reported that he saw the star 41 Librae within 5 arc-seconds of Uranus at 7:20 PM (local time) on September 8, 1897 [Tebbutt, 1897]. As a second example, I observed a fairly-bright star (perhaps magnitude +11-12) within about 10 arc-seconds of Uranus in early June, 1989.The near misses can reveal information about the Rings of Uranus and Neptune, and there may be possible occultations of the star by a satellite.

CONCLUSION

A.L.P.O. members can make useful contributions to our knowledge of the three Remote Planets by using one or more of the techniques that have been outlined above. I hope that the observations discussed here can be secured in the near future and forwarded to this Recorder (address on inside back cover) to be used in regular reports on these bodies.

REFERENCES

Alexander, A.F.O'D. (1965). *The Planet Uranus: A History of Observation, Theory, and Discovery*. New York; American Elsevier.

Ashbrook, J. (1970). "The Latest Flight of Stratoscope II." *Sky and Telescope, 39*, 365-367.

Berry, R. (1990). "*Astronomy* Compares Two CCD Cameras." *Astronomy, 18*, 67-71.

Franklin, F.A.; Avis, C.C.; Colombo, G.; and Shapiro, I. (1980). "The Geometrical Oblateness of Uranus." *Astrophysical Journal, 236*, 1031-1034.

Goddard, R.H. (1930). "Photometric Observations of Uranus 1929-30." *Astronomical Journal, 40*, 98-99.

Hammel, H.B. and Buie, M.W. (1987). "An Atmospheric Rotation Period of Neptune Determined from Methane-Band Imaging." *Icarus, 72*, 62-68.

Harris, D.L. (1961). "Photometry and Colorimetry of Planets and Satellites." pp. 272-342 in: Kuiper, G.P. and Middlehurst, B.M., eds. *Planets and Satellites*. Chicago: University of Chicago Press.

Hollis, A.J. (1989). "Uranus 1954-86." *Journal of the British Astronomical Association, 99*, 59-62.

Lockwood, G.W. (1977). "Secular Brightness Increases of Titan, Uranus and Neptune 1972-1976." *Icarus, 32*, 413-430.

________ (1983). "Photometry of Planets and Satellites." Chapter 2 (pp. 2-1 - 2-19) in: Genet, R.W., ed. *Solar System Photometry Handbook*. Richmond, VA: Willmann-Bell, Inc.

Newburn, R.L., Jr. and Gulkis, S. (1973). "A Survey of the Outer Planets Jupiter, Saturn, Uranus, Neptune and Pluto and Their Satellites." *Space Science Reviews, 14*, 179-271.

O'Meara, S.J. (1984). *I.A.U. Circular No. 3912* (February 1).

________ (1989). "Neptune Through the Eyepiece." *Sky and Telescope, 77*, 486-487.

Robinson, J.H. (1955). "A Note on the Magnitude of Uranus, 1955." *Journal of the British Astronomical Association, 66*, 24-25.

Sinton, W.M. (1972). "Limb and Polar Brightening of Uranus 8870Å." *Astrophysical Journal, 176*, L131-L133.

Stern, S.A.; Traften, L.M.; and Gladstone, G.R. (1988). "Why is Pluto Bright? Implications of the Albedo and Lightcurve Behavior of Pluto." *Icarus, 75*, 485-498.

Stevenson, D.J. (1989). "Looking Ahead to Neptune." *Sky and Telescope, 77*, 481-483.

Tebbutt, J. (1897). "Equatorial Comparisons of Uranus with 41 Librae and a Probable Occultation of the Star by the Planet." *Monthly Notices, Royal Astronomical Society, 58*, 21-24.

PREDISCOVERY IMAGES OF NEPTUNE'S GREAT DARK SPOT

By: Francis G. Graham

The most prominent atmospheric feature on Neptune, the "Great Dark Spot," was discovered by the Voyager 2 spacecraft in August, 1989. However, it may have been glimpsed twice before from the Earth.

The noted Mars Observer Charles F. Capen, long an A.L.P.O. Mars Recorder, caught a dark spot in a drawing published as a slide in 1974 by the Hansen Planetarium (No. C-213), which is shown to the right as *Figure 9*.

In addition, T.J.J. See made a drawing of Neptune in 1899 with the 26-inch refractor of the United State Naval Observatory, the same instrument used by Asaph Hall to discover Mars' satellites. See's drawing, shown to the lower right as *Figure 10*, shows an enhanced gray area at the latitude of the Great Dark Spot, along with some faint banding. Both drawings show their dark spots as similar in appearance to the normal-contrast processed views from the Jet Propulsion laboratory, if viewed out of focus to simulate the much poorer resolution of the two earthbased views.

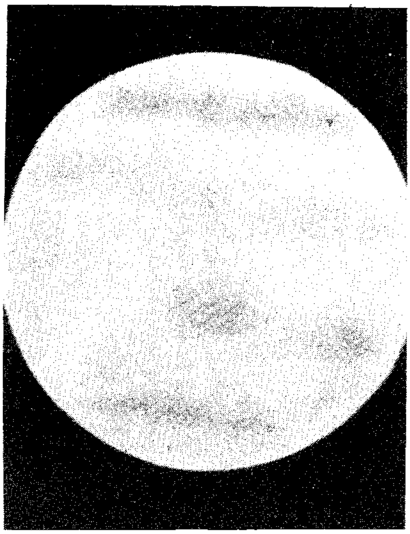

Figure 9. Drawing of the planet Neptune by Charles F. Capen, showing bands and, below center, possibly the Great Dark Spot. South at top. © 1974; reproduced here by the kind permission of Mrs. Virginia W. Capen.

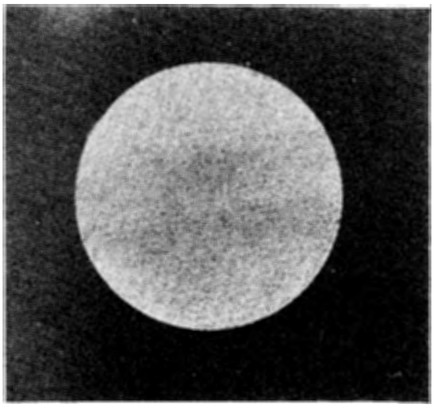

Figure 10. Drawing of Neptune by T.J.J. See on October 10, 1899, using the 26-inch refractor of the United States Naval Observatory. Note the faint equatorial belt. The dark smudge above center may possibly be the Great Dark Spot. (Orientation uncertain.)

References

Capen, C.F. (1974). "Neptune (Drawing)." Slide C-213. Salt Lake City, UT: Hansen Planetarium.

Jet Propulsion Laboratory, Voyager-2 Science Team (1989). "Neptune Encounter Highlights Tape." Pasadena, CA: JPL.

See, T.J.J. (1910). *Researches, Vol. II.* Lynn, MA: Nichols.

Note by Editor: Dr. Hammel's CCD image of tonal features on Neptune, referred to in the previous article (p. 68), confirms that it is possible to detect detail on its disk from the Earth. Opinion is divided on whether amateur telescopes (even large ones) will suffice. Three further references that contain drawings that show features on Neptune are:

de Callataÿ, V. and Dollfus, A. (1974). *Atlas of the Planets*. Toronto: University of Toronto Press. p. 144.

Kuiper, G.P. and Middlehurst, B.M., eds. (1961). *Planets and Satellites*. Chicago: University of Chicago Press. Fig. 45, comment on p. 459.

Phillips, T.E.R. and Steavenson, W.H., eds. (1925). *Splendour of the Heavens*. New York: Robert M. McBride & Co. p. 384.

THE NEW LUNAR DOME SURVEY—AN UPDATE

By: Jim Phillips, M.D., A.L.P.O. Lunar Dome Survey Recorder

ABSTRACT

The new Lunar Dome Survey was begun in 1986, reestablishing the previous program. This article summarizes the history of the project, its present status and contributors, and its possible future.

BACKGROUND

In the 1960's and early 1970's, a joint Lunar Dome Survey was carried out by members of the Association of Lunar and Planetary Observers; headed by Harry D. Jamieson during 1961-1966 and 1971-1974, and by Kenneth J. Delano during 1966-1971; and by members of the British Astronomical Association, directed by W. Rae. During the original survey, the A.L.P.O. published a list of 149 domes. **[1, 2, 3, 4]** When the Lunar Orbiter series of spacecraft transmitted back high-resolution photographs of the surface of the Moon, interest in the Lunar Dome Survey began to decrease because observers thought that those photographs would answer all questions about lunar domes.

In 1985, I contacted the previous Lunar Dome Survey Recorder, Harry D. Jamieson, along with John E. Westfall, regarding restarting the survey. After discussion, the new Lunar Dome Survey was begun. Announcements concerning it were placed in the *J.A.L.P.O.*, *Astronomy*, and *Sky & Telescope*. The Lunar Section of the British Astronomical Association was contacted, and they have recently decided to participate in an official capacity. Data from the original survey were obtained from the previous Recorder, consisting of a large number of index cards describing confirmed or suspected lunar domes. From these, a list of about 600 domes and suspect domes was compiled and was placed on a word processor. A local engineering firm was contacted and plotted the objects on a set of lunar quadrant maps.

The goal of the present survey is to characterize these 600-odd objects, and to complete a final list and a map on which those objects felt to represent actual domes will be plotted. To help with this, the University of Arizona Press and Sky Publishing Corporation were contacted for, and granted, permission to us to republish their *Lunar Quadrant Maps*, on which will be plotted the lunar domes on our list. We hope that, at the end of the present survey, these maps will serve as a basis for future observations.

At present, aided by a series of secretaries, we are extensively modifying our lunar dome catalog, listing domes numerically by *Xi* and *Eta* lunar rectangular coordinates, as well as by lunar latitude and longitude. The catalog is compiled in a manner that allows observational data easily to be transcribed. Unfortunately, changes in our computer system and personnel changes have hindered this project. The damage caused by Hurricane Hugo in September, 1989, further delayed the project. In a promising recent development, Mr. Rob Moseley of the British Astronomical Association contacted me, indicating an interest in now making the Lunar Dome Survey an official project. This interest by the B.A.A. is very welcome.

THE PRESENT PROJECT

Observers who are interested in the new Lunar Dome Survey are given a packet which includes our definition and classification system for domes and photocopies of the lunar quadrant maps on which suspect domes are plotted. Initially, we sent out latitudinal strips from the maps together with lists of coordinates of the objects for observers to use as a guide. These coordinate lists did not prove to be useful; and instead we now plot the objects and their catalog numbers on the lunar quadrant maps, which we make available to observers. We now believe that an amateur observer should be allowed to report any object, using its catalog number, on the entire visible surface of the Moon that is plotted on the map. New objects are not to be reported at this time, as we continue the process of confirming or deleting previous objects. [Certainly, the observer should keep a record of new domes, or suspected domes, for the time when the status of all "old" domes is determined and the list can then be extended. Ed.]

Well over 150 observational packets have been sent out. At present, the following observers have responded and have begun sending in observations on a number of objects:

José Aguirre, Spain
Schuyler Allen, United States
Kocsis Antal, Hungary
Joe Caruso, United States
Karl Fabian, United States
Alika Herring, United States
Harry Jamieson, United States
Charles Kapral, United States
Craig MacDougal, United States
Rob Moseley, England
José Olivarez, United States
Michael R. Porcellino, United States
Zac Pujic, Australia
Robert Robinson, United States
George Rosenberg, United States
John D. Sabia, United States
R. Turner, England
Ed Vinson, United States
John Westfall, United States
Ross Weyburg, United States

As data have come in, it has become clear that there are some areas of the map that are particularly crowded and difficult to interpret, such as the Hortensius-Tobias Mayer region and the region near Marius. These districts have been examined by the Recorder, resulting in three articles. [**5, 6, 7**] Because of the work done on these articles, we believe that the completion of the dome map for Quadrant II may soon be feasible. [The visible face of the Moon is traditionally divided into four Quadrants, Quadrant II being the northwest [in the sense used by the International Astronomical Union), and including Mare Imbrium. *Ed.*].

Of the approximately 600 objects on our list, we have received observations of 326, including multiple observations of a number of domes. Our present goal is to finish the study of any dome clusters in Quadrant II, to closely compare this Quadrant with the appropriate LAC maps [Lunar Aeronautical Charts; a 1:1,000,000-scale series published by the U.S. Air Force in the 1960's. Ed.], to use all the observational data which have been sent regarding this Quadrant, and to identify those areas and suspect objects which need further attention. The present goal is to complete Quadrant II, which contains 204 suspect objects already recorded on our map. We presently have data on 126 of these, in addition to the domes that may exist in the "Marius Hills" region.

The Future of the New Lunar Dome Survey

Thus we are closing in on the completion of lunar Quadrant II of the survey. The future goal is to use the same techniques to complete the remaining three Quadrants in a similar manner. Obviously, we appreciate information on objects that lie in other Quadrants, but it appears reasonable to work on one Quadrant at a time. Again, highly cluttered areas where objects are extremely difficult to see on our map, due to there being so many observations of a small region, will be singled out by the Recorder for study, using as many observations from other individuals as possible.

References

1. Delano, Kenneth J. (1969). "A Revised Catalog of Lunar Domes." *J.A.L.P.O.*, *21*, Nos. 5-6 (Feb.), 76-79.
2. Jamieson, Harry D. (1972). "The Lunar Dome Survey: A Progress Report." *J.A.L.P.O.*, *23*, Nos. 11-12 (Sept.), 212-215.
3. ________ (1974). "The Lunar Dome Survey: A Progress Report (II)." *J.A.L.P.O.*, *24*, Nos. 9-10 (Feb.), 187-192.
4. Jamieson, Harry D. and Rae, W.L. (1965). "The Joint A.L.P.O.-B.A.A. Lunar Dome Project." *J.A.L.P.O.*, *18*, Nos. 9-10 (May), 179-182.
5. Phillips, Jim (1989). "The New Lunar Dome Survey: The Hortensius-Milichius- Tobias Mayer Region." *J.A.L.P.O.*, *33*, Nos. 4-6 (Apr.), 61-72.
6. ________ (1989). "Observations of Lunar Domes North-Northwest of Milichius: An Interpretation." *J.A.L.P.O.*, *33*, Nos. 4-6 (Apr.), 73-74.
7. ________ (1990). "The Marius Hills Region—A Unique Lunar Dome Field." *J.A.L.P.O.*, *34*, No. 3 (July), 104-108.

Observation and Comment: Solar Flare Photographed by Frank J. Melillo

Mr. Frank J. Melillo has sent a fascinating series of three Hydrogen-α solar photographs showing the development of a flare on 1991 MAR 16, one of which is reproduced here as *Figure 11* (right).

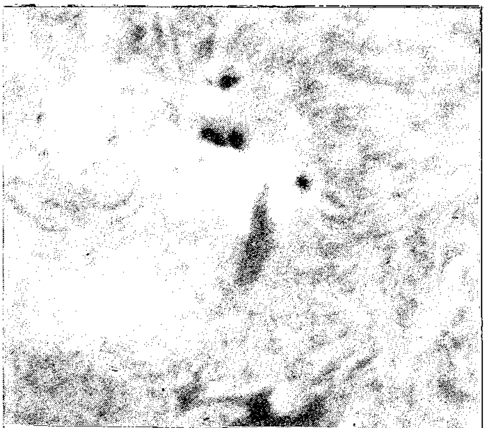

Figure 11. A Solar flare, as photographed in Hydrogen-α light by Frank J. Melillo on 1991 MAR 16, 22h 05m U.T. 1/4-second. exposure. North at top. For further information, see text.

Mr. Melillo writes that he used a 20-cm Schmidt-Cassegrain telescope, stopped down off-axis to 2.5-in aperture at f/30, and a 0.6Å Hydrogen-α filter. Being aware of reports of high solar activity, he began observing a magnetically-complex sunspot region near the center of the disk at 21h 30m U.T. While photographing it at 21h 40m, he saw a flare developing when he was looking through the camera viewfinder! It developed quickly and reached its maximum brightness at 21h 55m. Ten minutes later, when the accompanying photograph was taken, a dark surge was ejected from the flare region, which "looked like a small comet hitting the sun!"

Mr. Melillo is to be congratulated; he was lucky, but he was also prepared.

Comet Corner

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

Abstract

This column considers the types of instruments that amateurs have used to discover comets, and the number of hours that many of them took in their search. The conditions of visibility of any possible Kreutz sun-grazing comet for this July's solar eclipse are presented. This column then discusses an ephemeris interpolation program, and finally describes and provides ephemerides for comets that should be visible to us over the next few months.

Comet Discovery Instruments and Search Times

What type and size of telescopes do amateurs use visually to discover comets, and how many hours does it take? These may be the questions most often asked of comet hunters.

Most successful comet hunters use more than one instrument because comets come in all sizes and magnitudes. As you look over the lists below, you will probably realize that you have a telescope similar to one of those listed. It is not the telescope that finds the comet, but the person behind the eyepiece.

Table 1, below, lists those comets that were found visually between 1975 and 1990, arranged by increasing aperture and by type of instrument. Under "Elongation from Sun," **M** indicates that the comet was found in the morning sky, **E** in the evening sky. "---" indicates that data were not available.

Using this information, we find that the number of hours needed to discover one's first comet, or since one's last comet, ranges from 0 to 3024. The mean time for the 60 discoveries that took non-zero times is 423, but this number is high due to a few very large values. Indeed, half of the comets were found in under 220 hours.

Some comet hunters never do discover a comet. Their totals are not included here. However, I have always felt that if someone wishes to discover a comet, they can—if they are willing to sweep often and sweep smartly.

The number of hours needed to discover comets is graphed in *Figure 12* (p. 74). In that graph, comet search times are rounded to the nearest 100 hours, with the number of discoveries plotted for each group.

Table 1. Comet Discoveries, 1975-1990, by Aperture and Type of Instrument.

A. Discoveries With Binoculars.

Comet	Discoverer	Magnification and Aperture	Visual Magnitude	Elongation From Sun		Time in Hours
1980t	Bradfield	7X35 mm	+6.0	022°	M	113
1983d	Alcock	15X80	6.4	092	M	---
1980k	Petrauskas	12X80	8.5	043	E	100
1978m	Seargent	15X80	5.0	035	M	650
1980k	Cernis	20X110	8.5	043	E	808
1978n	Fujikawa	12X120?	10.0	039	M	525?
1983e	Fujikawa	12X120?	7.0	028	M	800?
1975j	Mori	20X120	10.7	065	M	---
1975k	Mori	20X120	8.8	052	M	1
1984j	Takamizawa	20X120	9.4	171	M	270
1987d1	Ichimura	20X120	8.5	141	M	---
1990b	Nakamura	20X120	8.6	049	E	2236
1986e	Machholz	29X120	10.3	039	M	174
1988j	Machholz	29X120	8.6	067	M	476
1987c	Takamizawa	25X150	8.4	066	E	699
1987c	Tago	25X150	8.4	066	E	---
1987d	Terasako	25X150	6.9	041	E	---
1988r	Yanaka	25X150	9.3	038	M	---
1989a	Yanaka	25X150	10.7	081	M	---
1990b	Kiuchi	25X150	8.6	049	E	1440
1990i	Kiuchi	25X150	8.8	064	E	---

(Table 1 Continued on p. 73)

Table 1—Continued. **B. Discoveries with Reflectors.**

Comet	Discoverer	Telescope Aperture, Focal Ratio, Magnification and Field	Visual Magnitude	Elongation From Sun		Time in Hours
1975h	Milon	4 in., ---,---,---	+7.6	133°	M	0
1975k	Suzuki	5.8 in., ---, 22X, ---	8.8	052	M	460
1975h	Kobayashi	6 in., ---, 30X, ---	7.6	133	M	91
1975j	Sato	6 in., ---, 25X, ---	10.7	065	M	203
1975q	Sato	6 in., ---, 25X, ---	9.8	078	M	16
1975k	Saigusa	6 in., ---, 27X, ---	8.8	052	M	480?
1983e	Sugano	6 in., ---, 29X, ---	7.0	029	M	450
1987c	Nishikawa	6 in., ---, ---, ---	8.4	066	E	3024
1989e1	Skorichenko	6 in., ---, ---, ---	10.3	058	E	360
1975j	Fujikawa	6.2 in., ---, 23X, ---	10.7	065	M	560?
1975a	Boethin	8 in., ---, ---, ---	11.0	061	E	---
1975h	Berger	8 in., f/7.5, ---, ---	7.6	133	M	0
1980u	Panther	8 in., f/4. 35X, ---	9.7	063	E	602
1983e	Saigusa	8 in., ---, 37X, ---	7.0	028	M	750?
1987y	Levy	8 in., f/7, ---, ---	9.5	033	E	105
1989a1	Brewington	8 in., f/4, 27X, 2°.4	9.0	049	E	231
1989c1	Austin	8 in., f/4, 41X, 1°.7	11.1	083	E	49
1978L	Machholz	10 in., f/4, 36X, 2°.8	10.7	072	M	1700
1985e	Machholz	10 in., f/4, 32X, 2°.4	9.3	049	M	1742
1984a	Bradfield	10 in., f/6, 44X, 1°.3	10.7	046	M	384
1989c	Bradfield	10 in., f.5, 44X, 1°.3	11.6	041	E	164
1978f	Meier	16 in., f/5, 56X, 1°.3	10.4	071	E	50
1979i	Meier	16 in., f/5, 56X, 1°.3	11.8	069	E	29
1980q	Meier	16 in., f/5, 56X, 1°.3	10.3	075	E	25
1984o	Meier	16 in., f/5, 56X, 1°.3	11.7	052	E	86
1989e1	George	16 in., f.5, ---, ---	10.3	058	E	65
1984t	Levy	16 in., f/5, 64X, 0°.8	9.4	060	E	917
1987a	Levy	16 in., ---, ---, ---	10.3	042	M	205
1988e	Levy	16 in., ---, ---, ---	11.6	039	M	162
1989r	Levy	16 in., f/5, ---, ---	10.6	075	E	350
1990c	Levy	16 in., ---, ---, ---	10.2	066	M	60
1983L	Cernis	19 in., f/5, 65X, ---	10.7	073	M	297

C. Discoveries with Refractors.

Comet	Discoverer	Telescope Aperture, Focal Ratio, Magnification and Field	Visual Magnitude	Elongation From Sun		Time in Hours
1983d	Araki	3.0 in., ---, 27X, ---	+6.4	092°	M	132
1978j	Haneda	3.3 in., ---, ---, ---	10.0	147	E	463
1990b	Cernis	4.8 in., f/5, 35X, 1°.8	8.6	049	E	631
1978j	Campos	5 in., ---, ---, ---	10.0	147	E	116
1975d	Bradfield	6 in., f/5.5, 26X, 2°.2	9.3	030	M	145
1975p	Bradfield	6 in., f/5.5, 26X, 2°.2	9.7	058	M	106
1976a	Bradfield	6 in., f/5.5, 26X, 2°.2	9.4	056	E	57
1976d	Bradfield	6 in., f/5.5, 26X, 2°.2	8.8	044	M	9
1978c	Bradfield	6 in., f/5.5, 26X, 2°.2	8.0	048	M	360
1978o	Bradfield	6 in., f/5.5, 26X, 2°.2	8.4	032	M	75
1979c	Bradfield	6 in., f/5.5, 26X, 2°.2	10.2	044	E	98
1979L	Bradfield	6 in., f/5.5, 26X, 2°.2	5.0	026	M	67
1987s	Bradfield	6 in., f/5.5, 26X, 2°.2	8.8	081	E	307
1982g	Austin	6 in., f/8, 18X, ---	10.4	068	M	151
1984i	Austin	6 in., f/8, 18X, ---	5.8	069	M	43
1984t	Rudenko	6 in., f/8, 30X, 2°.1	9.4	060	E	247
1987u	Rudenko	6 in., f/8, 30X, 2°.1	9.8	061	E	266
1989r	Rudenko	6 in., f/8, 30X, ---	10.6	075	E	174

(Table 1 is concluded on p.74)

Table 1.—Continued. D. Discovery With Schmidt-Cassegrain.

Comet	Discoverer	Telescope Aperture, Focal Ratio, Magnification and Field	Visual Magnitude	Elongation From Sun	Time in Hours
1977m	Kohler	8 in., ---, 100X, ---	+9.5	068 E	---

SUN-GRAZING COMETS AND THE 1991 JUL 11 TOTAL SOLAR ECLIPSE

It is unlikely that any comets from the Kreutz Sun-Grazing Group will be near the Sun during the 1991 JUL 11 total solar eclipse, but *Table 2* below predicts celestial positions and estimates magnitudes if one is in the area. The data are all for 1991 JUL 11.8 U.T., when the Sun will be at Right Ascension 07h 22m, Dec. +22°.1. The variable factor is the perihelion date for comets in the Sun-grazing orbit. We assume an absolute magnitude [i.e., its theoretical magnitude at 1 Astronomical Unit, or AU, which equals 149,597,870 km, from the Earth and Sun. *Ed.*] of +10.0.

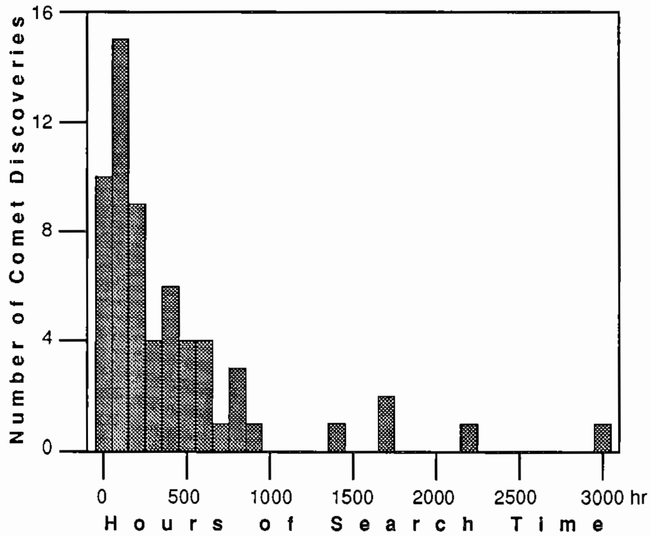

Figure 12. Graph of frequency of visual discoveries of comets, 1975-1990, as a function of hours of search time (rounded to nearest 100 hours.)

Table 2. Ephemeris for Possible Sun-Grazing Comets During the Total Solar Eclipse, 1991 JUL 11.8 U.T.

Perihelion Date (U.T.)	Epoch 2000.0 Right Ascension		Epoch 2000.0 Declination		Solar Elong.	Estimated Magnitude
1991	h	m	°	'	°	
JUL 04.0	07	25.1	+12	01	10.1	+7.0
05.0	07	25.7	+12	41	9.4	+6.6
06.0	07	26.3	+13	25	8.7	+6.0
07.0	07	26.9	+14	15	7.9	+5.4
08.0	07	27.6	+15	11	7.0	+4.7
09.0	07	28.2	+16	18	5.9	+3.7
10.0	07	28.7	+17	40	4.6	+2.3
11.0	07	28.8	+19	30	2.9	-0.3
11.5	07	28.0	+20	52	1.7	-3.4
12.0	07	16.0	+21	33	1.7	-4.7
12.5	07	10.5	+20	13	3.4	-0.7
13.0	07	07.3	+19	13	4.6	+1.0
14.0	07	03.1	+17	40	6.4	+2.9
15.0	07	00.3	+16	28	7.7	+4.1
16.0	06	58.0	+15	26	8.9	+5.0
17.0	06	56.2	+14	32	9.8	+5.6
18.0	06	54.7	+13	45	10.7	+6.2

PRESENT COMET ACTIVITY

During the middle of 1991, the comets listed below will be in our skies; there may be further new discoveries. Their ephemerides are listed later (*Tables 3-9*, pp. 75-76). They will be easier to locate at any particular date if you use an interpolation program for their positions. Several such computer programs have been published that can do this for you. One, written by the late Dr. Edgar Everhart, appears in the February, 1987, issue of *Sky & Telescope*, page 196. I've used this program with much success. Another program, slightly longer, is available by sending a stamped, self-addressed envelope to: Jeffrey Sudol, Macalester College, 1600 Grand Avenue, St. Paul, MN 55105.

Periodic Comet Schwassmann-Wachmann 1.—This comet will occasionally outburst by several magnitudes; last year it reached magnitude +12. It is in a near-circular 15-year orbit more than 5 AU from the Sun. Please report all positive *and negative* observations to this Recorder, whose address is on the inside back cover. [*Table 3*, right]

Periodic Comet Machholz.—I found this comet in 1986, and it is now making its first predicted return. With a high inclination and a small perihelion distance, it races in from the south, passes behind the Sun, and then enters our northern evening sky. In 1986 the comet flared at least once, and it should be monitored for this. This is an "annular" comet, observable all the way out past Jupiter. [*Table 4*, right]

Periodic Comet Hartley 2.—This comet will be at perihelion on 1991 SEP 17, 0.95 AU from the Sun. With an orbital period of 6.3 years, it is making its first predicted return. [*Table 5*, right, and p. 76]

Periodic Comet Wirtanen.—Discovered from Lick Observatory in 1948, this comet orbits the Sun every 5.5 years. It will be closest to the Sun on 1991 SEP 20 at 1.08 AU. [*Table 6*, p. 76]

Periodic Comet Faye.—This is an old periodic comet, taking 7.4 years to orbit the Sun. It reaches perihelion on 1991 NOV 16 at 1.59 AU and is well-placed for observation. [*Table 7*, p. 76]

Comet Helin-Lawrence (1991L).—This comet was discovered by Eleanor Helin, Kenneth Lawrence, and P. Ross using the 18-inch Palomar Schmidt on 1991 MAR 17. It will be closest to the Sun in February, 1992, at 1.52 AU. It is heading south and should be visible for the first half of 1992. The comet may be brighter than suggested her, and we ask our readers to record and submit observations in order to establish a long observational arc. [*Table 8*, p. 76]

Periodic Comet Takamizawa.—This comet was discovered in 1984 after an outburst. It has an orbital period of 7.2 years and should be closest to the Sun on 1991 AUG 17 at 1.59 AU. Our Assistant Comets Recorder Jim Scotti recovered it on 1991 FEB 17 when it was at magnitude +20. Because this comet has had outbursts in the past, I am asking A.L.P.O. comet observers to monitor it over the next few months. [*Table 9*, p. 76]

EPHEMERIDES

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

Table 3. Ephemeris of Periodic Comet Schwassmann-Wachmann 1.

1991 U.T. Date (0h U.T.)	2000.0 Coörd. R.A. h m	Decl. ° '	Elongation from Sun °		Total Mag.
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
SEP 01	03 47.8	+29 49	097	M	+17.4
06	03 48.6	+29 59	101	M	+17.4
11	03 49.1	+30 08	106	M	+17.4
16	03 49.3	+30 17	111	M	+17.4
21	03 49.2	+30 24	116	M	+17.3
26	03 48.7	+30 30	120	M	+17.3
OCT 01	03 48.0	+30 35	125	M	+17.3

Table 4. Ephemeris of Periodic Comet Machholz.

1991 U.T. Date (0h U.T.)	2000.0 Coörd. R.A. h m	Decl. ° '	Elongation from Sun °		Total Mag.
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 5. Ephemeris of Periodic Comet Hartley 2.

1991 U.T. Date (0h U.T.)	2000.0 Coörd. R.A. h m	Decl. ° '	Elongation from Sun °		Total Mag.
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

(TABLE 5 continued on p. 76)

Table 5—Continued.

1991	2000.0 Coörd.				Elongation		Total
U.T. Date	R.A.		Decl.		from Sun		Mag.
(0h U.T.)	h	m	°	'	°		
Aug 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
Sep 01	06	05.8	+29	15	067	M	+9.7
06	06	35.4	+27	27	065	M	+9.6
11	07	02.5	+25	26	064	M	+9.6
16	07	27.2	+23	15	063	M	+9.7
21	07	49.8	+21	01	062	M	+9.8
26	08	10.3	+18	46	062	M	+9.9
Oct 01	08	29.1	+16	32	062	M	+10.1
06	08	46.3	+14	22	062	M	+10.3
11	09	02.2	+12	16	063	M	+10.5

Table 6. Ephemeris of Periodic Comet Wirtanen.

1991	2000.0 Coörd.				Elongation		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
Sep 01	07	00.7	+18	35	054	M	+10.4
06	07	23.8	+18	48	053	M	+10.3
11	07	46.8	+18	50	053	M	+10.2
16	08	09.6	+18	42	052	M	+10.2
21	08	31.9	+18	25	052	M	+10.2
26	08	53.6	+17	59	052	M	+10.2
Oct 01	09	14.7	+17	26	052	M	+10.3
06	09	35.1	+16	46	052	M	+10.4
11	09	54.7	+16	01	052	M	+10.6

Table 7. Ephemeris of Periodic Comet Faye (1991n)

1991	2000.0 Coörd.				Elongation		Total
U.T. Date	R.A.		Decl.		from Sun		Mag.
(0h U.T.)	h	m	°	'	°		
Aug 17	01	02.2	+14	11	123	M	+12.2
22	01	08.3	+14	27	126	M	+11.9
27	01	13.9	+14	38	130	M	+11.7
Sep 01	01	19.2	+14	42	133	M	+11.5
06	01	24.1	+14	37	137	M	+11.4
11	01	28.5	+14	24	141	M	+11.2
16	01	32.4	+14	02	145	M	+11.0
21	01	35.7	+13	30	150	M	+10.8
26	01	38.5	+12	48	154	M	+10.7
Oct 01	01	40.7	+11	58	159	M	+10.5
06	01	42.5	+10	58	164	M	+10.4
11	01	43.8	+09	52	169	M	+10.3

Table 8. Ephemeris of Comet Helin-Lawrence (1991L).

1991	2000.0 Coörd.				Elongation		Total
U.T. Date	R.A.		Decl.		from Sun		Mag.
(0h U.T.)	h	m	°	'	°		
Jun 03	11	46.2	+05	33	103	E	+13.0
08	11	42.2	+04	55	097	E	+13.0
13	11	38.8	+04	15	092	E	+12.9
18	11	36.0	+03	32	086	E	+12.9
23	11	33.8	+02	47	082	E	+12.9
28	11	32.0	+02	01	077	E	+12.8
Jul 03	11	30.8	+01	12	072	E	+12.8
08	11	30.0	+00	22	068	E	+12.7
13	11	29.6	-00	30	063	E	+12.7
18	11	29.6	-01	24	059	E	+12.6
23	11	30.0	-02	19	054	E	+12.5
28	11	30.8	-03	17	050	E	+12.5
Aug 02	11	31.8	-04	16	046	E	+12.4
07	11	33.2	-05	18	042	E	+12.3
12	11	34.8	-06	21	039	E	+12.3
17	11	36.7	-07	27	035	E	+12.2
22	11	38.7	-08	36	032	E	+12.1

(Subsequently too near the Sun for observation)

Table 9. Ephemeris of Periodic Comet Takamizawa (1991h).

1991	2000.0 Coörd.				Elongation		Total
U.T. Date	R.A.		Decl.		from Sun		Mag.
(0h U.T.)	h	m	°	'	°		
Jun 03	13	51.9	+07	08	129	E	+16.0
08	13	52.3	+06	27	125	E	+16.0
13	13	53.7	+05	37	121	E	+16.0
18	13	56.0	+04	39	118	E	+16.0
23	13	59.2	+03	35	114	E	+16.0
28	14	03.3	+02	24	111	E	+16.0
Jul 03	14	08.4	+01	08	108	E	+16.0
08	14	14.2	-00	13	106	E	+16.0
13	14	20.9	-01	37	103	E	+16.0
18	14	28.4	-03	04	101	E	+16.0
23	14	36.7	-04	33	098	E	+16.0
28	14	45.6	-06	04	096	E	+16.0
Aug 02	14	55.2	-07	35	094	E	+16.0
07	15	05.5	-09	06	092	E	+16.1
12	15	16.4	-10	37	091	E	+16.1
17	15	27.8	-12	05	089	E	+16.2
22	15	39.8	-13	32	087	E	+16.2
27	15	52.3	-14	55	086	E	+16.3
Sep 01	16	05.3	-16	14	084	E	+16.4
06	16	18.7	-17	29	083	E	+16.4
11	16	32.5	-18	38	081	E	+16.5
16	16	46.7	-19	42	080	E	+16.6
21	17	01.1	-20	40	079	E	+16.7
26	17	15.8	-21	32	077	E	+16.8
Oct 01	17	30.7	-22	16	076	E	+16.9
06	17	45.7	-22	54	074	E	+17.0
11	18	00.8	-23	24	073	E	+17.1
16	18	15.9	-23	48	071	E	+17.2
21	18	31.1	-24	04	070	E	+17.3
26	18	46.1	-24	14	068	E	+17.4
31	19	01.0	-24	17	067	E	+17.5

A Photometry Opportunity for Saturn's Satellites

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

An unusual opportunity visually to estimate the magnitudes of Saturn's satellites occurs in early August of this year when the planet passes near a star field of precisely-known magnitudes. The reference stars are part of "The Guide Star Photometric Catalog. I," by B.M. Lasker *et al.* in the *Astrophysical Journal Supplement Series*, Volume 68, No. 1 (September, 1988). This catalog (GSPC) was created in order to provide pointing accuracy for the Hubble Space Telescope. The GSPC has BV photometric sequences for 1477 regions of the sky, and a typical sequence includes at least six stars in the magnitude range +9 to +15., each with a photometric precision of ±0.05 magnitudes.

Depending on seeing conditions and apertures employed, observers should be able to estimate visual magnitudes of Saturn's brighter satellites during the period of approximately 1991 AUG 08-12 by utilizing these stars of calibrated brightness. Interested observers should contact this Recorder, at the address given on the inside back cover, for complete details on how to conduct magnitude estimates of Saturn's satellites. This rare opportunity to compare the brightnesses of Saturn's satellites with stars of precisely-known visual magnitudes should not be missed.

------------------*Note by Editor* ---------------

Figure 13 (below) charts Saturn's path in relation to GPSC Field S596 in early August, 1991. The two stars with SAO numbers have approximate visual magnitudes as follows: SAO 189145, +8.1; SAO 189171, +8.7. The GPSC photometric sequence stars, shown by letters, have the following visual magnitudes: A, +9.17; B, +10.06; C, +10.55; D, +12.19; E, +13.26; F, +13.64; and G, +14.75. Thus, a number of Saturn's satellites are nicely "bracketed" by this photometric sequence. To reliably identify the fainter sequence stars, however, you should consult a "deep" photographic star atlas, such as the Vehrenberg atlas or even the Palomar Sky Survey.

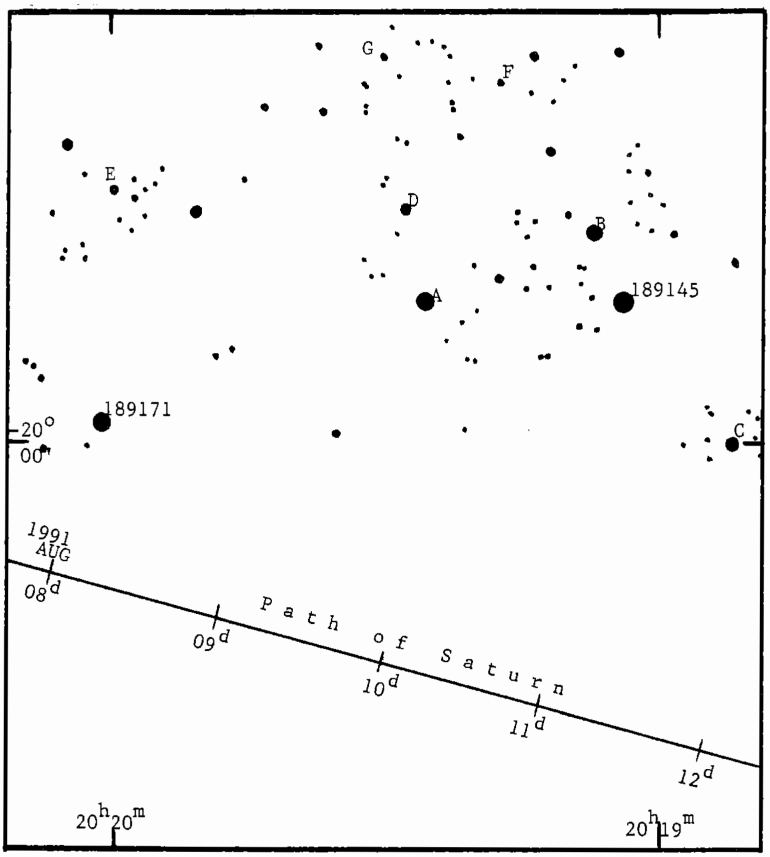

Figure 13. Path of the planet Saturn immediately to the south of (below) *Guide Star Photometric Catalog* Field S596, with photometric reference stars identified by the letters A-G. Faint stars are shown only when near the reference stars. Bright stars are identified by *SAO Catalog* numbers. North at top, Epoch 1991.7 coordinates.

METEORS SECTION NEWS

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

1991 A.L.P.O. PERSEID WATCH

We invite all interested observers to participate in the 1991 A.L.P.O. Perseid Watch. Observations of this shower are important this year because of the possible return of Periodic Comet Swift-Tuttle in 1992, which may be presaged by an upsurge in meteor activity. Although this object was predicted to return in 1981, no sign of it was then recorded. New theories include the possibility that P/Swift-Tuttle and Comet Kegler (1737) may be identical. If this is the case, activity of the Perseid stream may increase substantially.

The popular opinion is that the Perseids peaked near 1980, one year before when P/Swift-Tuttle was originally scheduled to return. Indeed, reports of 150 meteors per hour were made between 1976 and 1982. Rates averaged near 60 per hour for the middle 80's until 1988 and 1989, when rates reached nearly 100 per hour. This upsurge in activity could herald the arrival of the parent comet, or it could merely be caused by a knot of material orbiting behind the main swarm.

To form a clearer picture, we need your data. To contribute to this year's watch, use the following guidelines, where all dates and times used are in local civil time:

1. Observe between August 5th and the 22nd, when the Moon will not interfere with predawn observing. Although maximum activity occurs on the 12th and 13th, stream members are visible throughout this period.

2. For the best results, observe from dark skies away from any light pollution.

3. If you observe alone, face northeast. If you are part of a group, coordinate each other so that the whole sky is covered.

4. Observe between the hours of local midnight and dawn. Peak rates usually occur near 4 AM local time.

5. Be well rested. A sleepy meteor observer may as well stay in bed.

6. Meteor photographs are welcome, but don't let the chores of photography spoil a relaxing meteor watch. The only worthwhile photography nights are August 12th and 13th.

7. If you are part of a group, remember to record independently of each other. Group rates are worthless; send in one data sheet per observer.

8. While recording conditions and meteor sightings, use a cassette recorder with a remote off/on switch. This will allow you to keep your eyes on the sky.

9. Record your data from the tape on the next day. Record each meteor on the A.L.P.O. observing form. Be sure to note any breaks or cloud cover which occurred during your watch.

10. Have fun! Meteor observing is the easiest way in which to make a meaningful contribution to astronomy.

RECENT METEOR OBSERVATIONS

Table 1, below, summarizes the observations made between 1990 NOV 10 and 1991 FEB 20 which have been received at the time of writing (April 4, 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)
NOV 10	Phyllis Eide, HI	08:00-11:00	2 S. Tau; 6 SP	+5.5; 10% cloudy
DEC 10	Leonard Tomko, PA	03:41-04:41	1 Gem	+6.0
	" " "	04:41-05:41	1 Gem; 1 SP	+6.0
11	Mark Davis, VA	03:10-04:10	4 Gem; 1 Mon; 7 SP	+5.9
	Robert Lunsford, CA	10:17-11:17	9 Gem; 2 D. Leo; 8 SP	+6.2; 50% cloudy
	" " "	11:17-12:17	3 Gem; 1 SP	+6.2; 80% cloudy
	" " "	12:17-13:17	5 Gem; 2 SP	+6.1; 60% cloudy
	" " "	13:17-13:47	(none seen)	+5.8; 20% cloudy
12	George Gliba, MD	06:02-07:02	14 Gem; 7 SP	+5.1
	" " "	07:02-08:02	10 Gem; 6 SP	+5.3
14	Kristine Larsen, CT	00:30-01:30	4 Gem; 3 SP	+4.4
	" " "	01:30-02:17	11 Gem	+4.5
	" " "	03:02-03:36	9 Gem	+4.5; 50% cloudy
	Kari Backes, MN	03:10-04:10	22 Gem; 2 SP	+4.5; 5% cloudy
	Stacy Bower, MN	03:10-04:10	18 Gem	+4.5; 5% cloudy

------------------------------------- *Table 1 continues on p. 79 with notes* -----------------------------

Table 1—Continued.

1990-91 U.T.Date	Observer and Location	Universal Time	Number and Type of Meteors Seen*	Comments* (+N = Limiting Magnitude)
DEC 14	Laura Provinzino, MN	03:10-04:10	19 Gem	+4.5; 5% cloudy
	Kelly Geiser, MN	03:10-04:10	14 Gem	+4.5; 5% cloudy
	Bruce Woidyla, MN	03:10-04:10	17 Gem	+4.5; 5% cloudy
	John S. Gallagher, NJ	03:15-04:30	18 Gem; 1 SP	+5.5; 20% cloudy
	Karl Simmons, FL	04:25-05:27	31 Gem; 6 SP	+6.5; 20% cloudy; 2-minute break
	Wanda Simmons, FL	04:25-05:30	36 Gem; 8 SP	+6.5; 20% cloudy
	John S. Gallagher, NJ	04:35-06:50	59 Gem; 3 D. Leo; 4 SP	+5.5; 25% cloudy
	Kristine Larsen, CT	04:45-05:45	24 Gem	+4.5; 50% cloudy
	J. Kenneth Eakins, CA	05:30-06:30	21 Gem	+5.3
	Kristine Larsen, CT	05:53-06:42	36 Gem	+4.5; 50% cloudy
	J. Kenneth Eakins, CA	06:30-07:30	22 Gem; 1 SP	+5.3
	Robert Lunsford, CA	06:47-07:47	58 Gem; 1 D. Leo; 1 χ Ori; 1 Mon; 5 SP	+5.9; ZHR = 130
	John S. Gallagher, NJ	06:55-08:55	85 Gem; 7 D. Leo; 3 SP	+5.5
	J. Kenneth Eakins, CA	07:35-08:35	24 Gem	+5.3
	Robert Lunsford, CA	07:47-08:47	107 Gem; 1 D. Leo; 1 Mon; 8 SP	+6.3; ZHR = 135
	J. Kenneth Eakins, CA	08:35-09:35	33 Gem	+5.3
	Robert Lunsford, CA	08:47-09:47	114 Gem; 1 χ Ori; 2 D. Leo; 2 σ Hya; 8 SP	+6.4; ZHR = 127
	" " "	09:47-10:47	69 Gem; 1 D. Leo; 1 σ Hya; 11 SP	+6.0; ZHR = 164†; 30% cloudy
	" " "	10:47-11:47	72 Gem; 3 D. Leo; 3 σ Hya; 12 SP	+6.2; ZHR = 115; 10% cloudy
	" " "	11:47-12:47	61 Gem; 2 D. Leo; 11 SP	+6.4; ZHR = 89; 10% cloudy
	" " "	12:47-13:47	38 Gem; 1 D. Leo; 1 σ Hya; 14 SP	+5.3; ZHR = 247†; 30% cloudy
15	Leonard Tomko, PA	02:13-03:13	4 Gem; 1 SP	+5.5; 15% cloudy
	" " "	03:13-03:47	2 Gem	+6.0; 15% cloudy
		1991		
JAN 03	George Gliba, MD	10:00-10:30	5 Quadrantids; 1 SP	+4.2; 30% cloudy
04	George Gliba, MD	09:45-10:45	1 Quadrantid; 7 SP	+5.0; 20% cloudy
17	Robert Lunsford, CA	11:00-12:00	(none seen)	+5.6
	" " "	12:00-13:00	2 SP	+5.8
	" " "	13:00-14:00	2 SP	+5.5
22	Robert Lunsford, CA	13:00-14:00	4 SP	+5.4
25	Robert Lunsford, CA	12:48-13:48	1 SP	+5.5
FEB 09	Mark Davis, VA	04:40-05:40	8 SP	+5.5
	Robert Lunsford, CA	12:48-13:48	2 SP	+5.9
10	Robert Lunsford, CA	11:48-12:48	(none seen)	+6.0
	" " "	12:48-13:48	(none seen)	+5.7
17	Kristine Larsen, CT	03:00-04:15	1 δ Leo; 1 SP	+4.8
19	Robert Lunsford, CA	12:33-13:33	1 θ Cen; 6 SP	+5.8
20	J. Kenneth Eakins, CA	08:00-09:00	(none seen)	+5.2
	" " " "	09:00-10:00	3 SP	+5.3

Notes for** ***Table 1: † = ZHR values very unreliable due to cloud cover; χ Ori = Chi Orionid; D. Leo = December Leonid; δ Leo = Delta Leonid; Gem = Geminid; Mon = Monocerotid σ Hya = Sigma Hydrid; S. Tau = South Taurid; SP = Sporadic; θ Cen = Theta Centaurid; ZHR = Zenithal Hourly Rate.

COMING SOLAR-SYSTEM EVENTS: JUNE - AUGUST, 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. 96 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!

There are several noteworthy celestial events that happen in this short period, including but not limited to the Perseid meteor shower; multiple conjunctions of the Moon and several bright planets among each other; a "flyby" of an Earth-gazing asteroid; many occultations of stars by planets and asteroids; and two lunar eclipses. (There is also a total solar eclipse, but that is described in the next article; on pp. 86-88).

A PLETHORA OF PLANETS: SATURN REPLACES JUPITER AND VENUS

Venus and Jupiter remain convenient to observe, but Saturn now is approaching *opposition*. **Venus** begins our period high above the western horizon during evening twilight, reaching Greatest Elongation East, 45°.4, on JUN 13. After this date, though, it approaches the Sun at an accelerating pace, passing through *inferior conjunction* on AUG 22. At that date, Venus will be 8° south of the Sun, so (if you are careful!) you may be able to follow the planet through conjunction. Also, during Jun 01-AUG 22, its disk diameter enlarges from 21 to 58 arc-seconds; the planet's phase diminishes from 56 to 1 percent illuminated. Note that *dichotomy*, predicted half phase, occurs on JUN 13; try estimating Venus' apparent phase for about a week on either side of that date. The planet's *greatest brilliancy*, at magnitude -4.5, is scheduled for JUL 19.

Jupiter is moving from the constellation Cancer to Leo in the evening sky , but is approaching the Sun so that the period of practical observation ends in early July. At magnitude -1.8 to -1.9, it remains second in brightness only to Venus. Besides monitoring the continuing major activity in the revived South Equatorial Belt and in the Equatorial Zone, check the faded Red Spot. The unusual *mutual events* of the Galilean satellites are continuing (see below, pp. 84-85), and the Earth crosses Jupiter's equatorial plane on JUL 19.

Saturn, in Capricornus, is now rising in the evening, and reaches opposition on JUL 27. Its declination then is 19°.8 South, still favorable for Southern-Hemisphere observers, but the planet is now definitely moving north. The Ringed Planet is brightening and growing in apparent size as it approaches opposition, when its *Globe* measures 18 by 17 arcseconds and the *Rings* span 42 by 14 arcseconds. The Rings continue well-presented, and their inclination to our line of sight increases from 19° to 21° in this period.

Uranus and **Neptune** remain somewhat west of Saturn, in Sagittarius, and reach opposition on JUL 04 and JUL 08, respectively. Uranus, at magnitude +5.6, should be visible to the naked eye under good conditions. Neptune will be a binocular object at magnitude +7.9. **Pluto** is now past opposition and thus is visible with an 8-10 inch telescope under dark evening skies.

Mercury has an evening-sky apparition that is favorable for Southern-Hemisphere observers, being over 15° from the Sun between JUL 01 and AUG 13. Its Greatest Elongation East is 27°.0, on JUL 25, and the theoretical time of dichotomy is on JUL 22. (The next, morning apparition, is slightly after our official three-months period, when it is best seen from north of the Equator; from SEP 01 - SEP 15; with a Greatest Elongation West of 18°.0 on SEP 07 and a date of dichotomy of SEP 09.)

Mars, moving from Cancer into Leo, continues slowly to sink in the west in the evening. In July its disk diameter shrinks below 4 arc-seconds and by August it is too near the Sun to be readily observed; about the only encouraging thing we can say is that its North Pole is very well-presented to our line of sight.

A CONFLUENCE OF CONJUNCTIONS

Throughout June, July, and the first part of August four of the bright planets—Mercury, Venus, Mars, and Jupiter—weave among each other, the Moon, and the +1.35-magnitude star Regulus. Even when not technically in *conjunction* (which means having the same celestial longitudes) they will form spectacular groupings. This set of events commences on JUN 14, with a conjunction of Mars with Jupiter, and continues until AUG 07, when Mercury passes by Venus.

Perhaps the clearest manner in which to discuss these complex events is simply to list them chronologically, with occasional notes; in addition, a "moving picture" of the planetary configurations at 1-week intervals from JUN 15 though AUG 03 is given in *Figure 14* (p. 81). Below, on *Table 1* (p. 82), for each particular conjunction, the geocentric circumstances are given: 1991 U.T. day and hour; minimum separation of the bodies, with their apparent magnitudes in parentheses; followed by their elongation from the Sun.

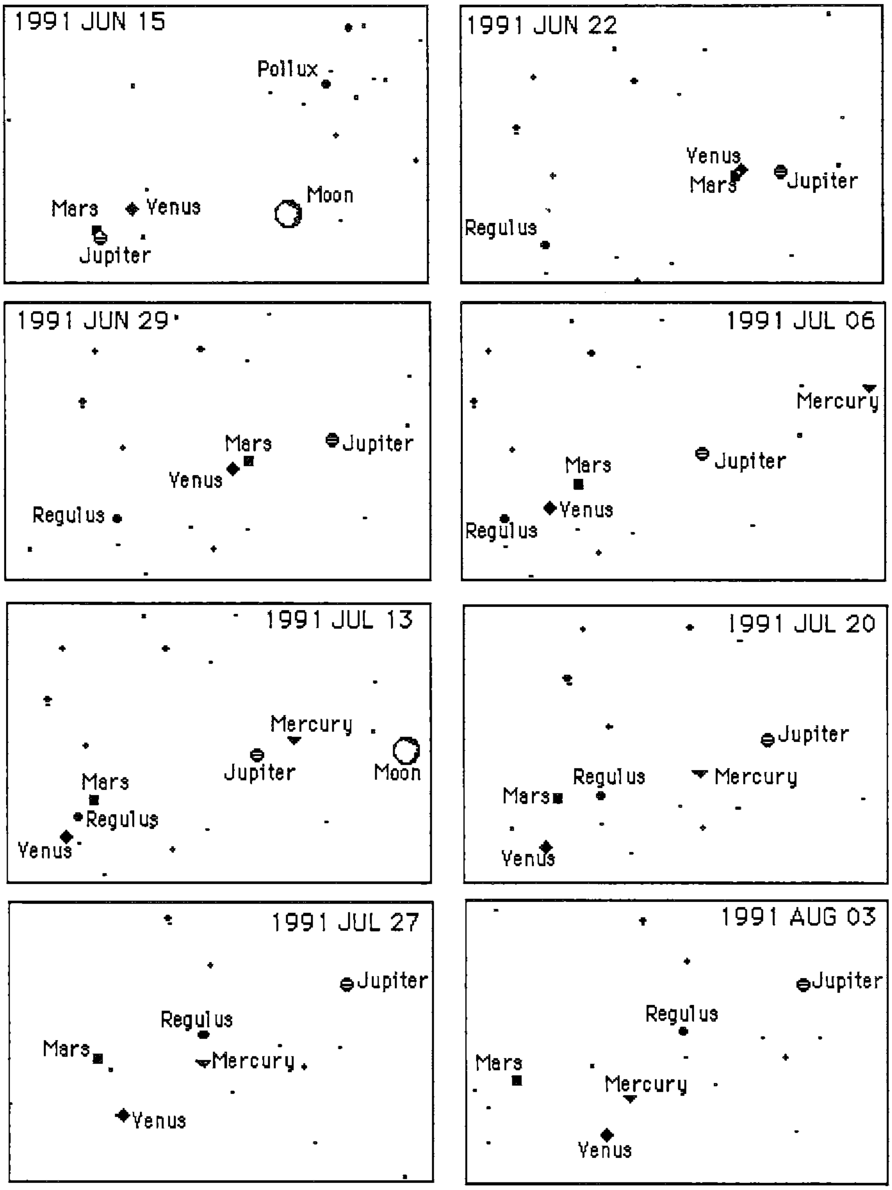

Figure 14. Evening-sky planetary configurations at 1-week intervals from 1991 JUN 15 - AUG 03, 00h U.T. Celestial North is at the top. Each field of view measures 30° East-West by 20° North-South. Modified from output of Voyager Program, © Carina Software.

Table 1. Planetary—Lunar—Regulus Conjunctions; 1991 Jun 14-Aug 07.

June

Mars, Venus, and Jupiter form a spectacular tight grouping near mid-month, then Jupiter pulls away from Mars and Venus, both of which remain close until month's end.
On JUN 15-16, the 3-day old crescent Moon (17 % sunlit) passes all three planets.

14d 05h. **Mars** (+1.7) 0°.6 N of **Jupiter** (-1.9); 48°E.
15d 20h. **Venus** (-4.3) 0°.4 N of **Moon**; 45°E.
15d 22h. **Jupiter** (-1.9) 0°.3 N of **Moon**; 45°E.
16d 00h. **Mars** (+1.7) 4° N of **Moon**; 48°E.
17d 23h. **Venus** (-4.3) 1°.2 N of **Jupiter** (-1.9); 45°E.
23d 12h. **Venus** (-4.4) 0°.3 N of **Mars** (+1.7); 45°E.

July

Several bodies are now approaching each other: Venus-Regulus in the second week of the month; near mid-month, Mars-Regulus, and Mercury-Jupiter; Venus- Mars a week later; and Mercury-Regulus toward the end of the month.
Venus, Mars, and Regulus form a close trio for most of July.
On JUL 13, the 2-day old crescent Moon (5 % sunlit) passes Mercury and Jupiter; on the next day, the 3-day old Moon (12 % sunlit) goes by Mars and Venus.
The Mercury-Jupiter conjunction will be close enough to allow simultaneous viewing under high magnification.

11d 08h. **Venus** (-4.5) 1°.0 S of **Regulus**; 41°E.
13d 14h. **Mercury** (0.0) 3° N of **Moon**; 24°E.
13d 17h. **Jupiter** (-1.8) 3° N of **Moon**; 26°E.
14d 15h. **Mars** (+1.8) 5° N of **Moon**; 38°E.
14d 16h. **Mars** (+1.8) 0°.7 N of **Regulus**; 38°E.
14d 18h. **Venus** (-4.5) 3°N of **Moon**; 40°E.
15d 08h. **Mercury** (+0.1) 0°.08 S of **Jupiter** (-1.8); 25°E.
22d 06h. **Venus** (-4.5) 4°S of **Mars** (+1.8); 37°E.
27d 01h. **Mercury** (+0.6) 2° S of **Regulus** ; 27°E.

August

07d 06h. **Mercury** (+1.4) 2° N of **Venus** (-4.3); 22°E.

MINOR PLANETS; WITH ONE FLYBY

Five of the brightest **minor planets** reach opposition in our period. 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
16 Melpomene	JUN 09	+9.7	6°S Oph
39 Laetitia	JUL 03	+9.9	9°S Sct
3 Juno	JUL 14	+9.4	5°S Aquila
349 Dembowska	AUG 18	+9.7	26°S PscA
6 Hebe	AUG 29	+7.6	18°S Aqr

Besides the "normal" asteroids above, the "Earth-approacher" **3103 1982 BB** zips by us in late July-early August, with its closest approach to Earth on 1991 AUG 06, just 14.1 million km (0.1164 A.U.) distant. At 12th magnitude, the object will be visible in small telescopes and can be identified quickly from its motion, which reaches 626 arc-seconds per *hour* on AUG 06-07.

This minor planet is worth watching on 1991 JUL 01 as well, when it passes across the globular star cluster **M15**, about 3 arc-minutes south of the cluster's center at about 08 h U.T. Thus there is a good chance that the minor planet will occult one or more cluster stars for at least some observing sites. Any such occultation will be very brief because the asteroid is then moving at about 93 arc-seconds per hour. At its distance then of 17.4 million km, this translates into a tangential velocity of 6.6 km per second.

The *A.L.P.O. Solar System Ephemeris: 1991* lists 1-day ephemerides for Minor Planet 3103 1982 BB on p. L-4. Because of its rapid motion, though, we suggest that you use an ephemeris computer program to calculate its position for any chosen time. The minor planet's orbital elements, as derived from the *Ephemerides of Minor Planets for 1991*, published by the Academy of Sciences of the U.S.S.R., are: *semi-major axis* 1.4061 A.U., *eccentricity* 0.354541, *inclination* 20°.9428, *longitude of ascending node* 129°.2577, *argument of perihelion* 253°.7223, and *date of perihelion*, 1991 SEP 29.597.

THE MOON

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

New Moon	First Quarter	Full Moon	Last Quarter
JUN 12.5	JUN 19.2	JUN 27.1	JUL 05.1
JUL 11.8	JUL 18.6	JUL 26.8	AUG 03.5
AUG 10.1	AUG 17.2	AUG 25.4	SEP 01.8

The three lunations above are Numbers 847-849 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:

West	South	East	North
JUN 07	JUN 08	JUN 19	JUN 21
JUL 05	JUL 06	JUL 18	JUL 18
AUG 02	AUG 02	AUG 15	AUG 14

Lunar E and W directions above follow the usage of the International Astronomical Union, with Mare Crisium near the *east* limb. The SW limb can be seen favorably on JUN 06-10, JUL 05-10, and AUG 03-07. The NE limb is well-presented on JUN 16-17, JUL 13-16, and AUG 11-15.

AN ONSLAUGHT OF OCCULTATIONS

Two major, and fourteen minor, planets will occult stars in 1991 JUN-AUG, as shown in *Table 2* below which lists the date, occulting object, visual magnitude of planet followed by that of the star, and *possible* zone of visibility for each occultation. Note that the naked-eye star SAO 58852 is occulted in the AUG 28 event.

An **occultation of Mercury by the Moon** takes place during our time period, **AUG 11**, 09h, when the +2.1-magnitude planet is 18°E of the Sun; visible from Europe, excluding Spain, Italy, and the Balkans; and Central, SE, and E Asia; but only S Japan.

The series of passages of the Moon across the **Pleiades** open star cluster (M45) resumes; with the event of **JUN 11**, 02h, 3-percent sunlit Moon, visible from SW Asia; **JUL 08**, 12h, 15-percent phase, from Mexico and Central America; and **AUG** 04, 21h, 35-percent sunlit Moon, visible from Australia and SE Asia.

AN EXCESS OF ECLIPSES

Three eclipses occur within 29 days of each other: a penumbral lunar eclipses on 1991 JUN 27 and JUL 26, and a total solar eclipse on 1991 JUL 11.

The total solar eclipse is exceptional for several reasons and thus is described in a special article that follows this one (pp. 86-88).

Most people, even astronomers, don't get very excited about penumbral lunar eclipses because the slight shading of the Earth's outer shadow is hardly visible. However, these events do have two uses: (1) lunar *fluorescence* has been reported for features in the penumbral shadow, particularly during times of high solar activity; (2) for lunar photometry, the times just prior to and after any eclipse provide the *minimum solar phase angle* that we can have for the Moon.

The **penumbral lunar eclipse** of **JUN 27** has a penumbral magnitude of 0.339 (the maximum ingress of the Earth's penumbral shadow is 0.339 lunar radii in from the Moon's limb) because the Moon passes 1°.2 S of the center of the Earth's shadow. The slight resulting shading on the N limb will be detectable only by photometry. The *First Penumbral Contact* is at 01h 46.4m U.T., *Mid-Eclipse* is at 03h 14.7m, and *Fourth Penumbral Contact* occurs at 04h 43.2m. The entire eclipse can be seen from E North America, Central and S America, and W and S Africa. The beginning only of the eclipse can be observed from the remainder of North America (except the NW). The end only of the eclipse will be visible from the remainder of Africa, Europe (except the extreme E), and SW Asia.

Table 2. Occultations of Stars by Major and Minor Planets, 1991 Jun - Aug.

1991 U.T. Date	Occulting Object	Visual Magnitudes	Predicted Visibility Zone
JUN 03.34	**25 Phocaea**	+10.6 +6.9	Peru, Colombia, Caribbean
JUN 05.90	**2060 Chiron**	+15.6 +9.6	E Brazil
JUN 10.91	**6 Hebe**	+9.6 +7.5	NE Africa; SE, S, & SE Asia
JUN 11.26	**JUPITER**	-1.9 +7.8	NW U.S.A., Hawaii, Fiji, New Zealand
JUN 13.52	**423 Diotima**	+11.3 +8.1	S Australia, S Pacific
JUN 13.88	**6 Hebe**	+9.5 +8.8	S Central U.S.S.R.
JUN 15.17	**356 Ligura**	+13.1 +7.9	S Africa, S South America
JUN 16.23	**130 Elektra**	+12.6 +8.7	South America
JUN 16.40	**25 Phocaea**	+10.4 +9.6	Mexico, U.S.A.
JUN 19.73	**776 Berbericia**	+12.5 +9.2	SW Australia
JUN 20.39	**65 Cybele**	+13.3 +8.1	Caribbean
JUN 25.57	**476 Hedwig**	+11.9 +9.1	China
JUL 03.05	**130 Elektra**	+11.5 +8.7	S South America, S Africa
JUL 09.32	**111 Ate**	+12.2 +9.3	South America
JUL 22.91	**MERCURY**	+0.4+10.0	South America
JUL 23.16	**1 Ceres**	+8.7+11.6	SW U.S.A., Central America
JUL 25.43	**MERCURY**	+0.5 +9.6	W Australia
AUG 20.50	**8 Flora**	+10.7+10.2	W Mexico
AUG 27.79	**3 Juno**	+9.8 +8.9	Central Europe, N Africa
AUG 28.54	**139 Juewa**	+13.1 +5.8	Hawaii, S California

The **penumbral lunar eclipse** of **JUL 26** is similar to the June event in that the faint shading of the Moon, even at mid-eclipse will be detectable only by photometry. The penumbral magnitude is 0.280, with the Moon passing 1°.3 N of the center of the Earth's shadow, thus slightly shading the S limb. The *First Penumbral Contact* is at 16h 47.5m U.T., *Mid-Eclipse* is at 18h 07.8m, and *Fourth Penumbral Contact* occurs at 19h 27.8m. The entire eclipse can be seen from Asia (except the extreme N and NW), Africa (except the W and NW), and Australasia. The beginning only of the eclipse can be observed from the central Pacific Ocean. The end only of the eclipse will be visible from the remainder of Africa, and Europe (except the extreme W and NW).

COMETS

Several telescopic comets will be present in the sky; including Periodic Comets Machholz, Hartley 2, Wirtanen, and Faye (1991n); and Comet Helin-Lawrence (1991L). For more information, see the article by Don E. Machholz, "Comet Corner," on pp. 72-76.

METEOR SHOWERS

(Contributed by Robert D. Lunsford, A.L.P.O. Meteors Recorder. For more information see "Meteors Section News" on pp. 78-79)

The S. Delta Aquarids and the Alpha Capricornids are spoiled by a bright waning-gibbous Moon. Save your efforts for the upcoming Perseids.

The **Perseids** will peak under ideal conditions this year. High activity will occur between August 9th and the 15th, with the 12th and the 13th being the best mornings. Meteor rates should approach 100 per hour at maximum from a dark-sky site (i.e., with limiting magnitude +6.5 or better). The best hour to watch this shower is between 3 and 4 A.M., local Daylight Time; many people turn in too early for this shower and miss the best part.

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.

Mutual 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.

At least one observer is reporting excellent photometric results through the use of a CCD camera, with data being computer-processed to remove the effect of scattered light from 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 June-August, 1991, are listed in *Table 3* on p. 85. 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*.

Note that, because Jupiter will be in conjunction with the Sun on 1991 AUG 17, the "observing window" during this 3-month period will be a short period. Because of Jupiter's low altitude and the possible presence of evening twilight, photometry will often be precluded. Even under such conditions, visual or photographic observations should be possible, and several of the events in *Table 3* should be observable from your longitude.

When you observe these mutual events, carefully time your observations and let people know your results. Depending on the form of your observations, they 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:

Dr. 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.

Table 3. Schedule of Galilean Satellite Mutual Events, June - August, 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					
0602	*1E4P*	*1054*	*1103*	*00*	*02*
0602	2E3A	1411	1419	32	07
0603	2O1P	0004	0008	16	03
0604	3E4P	0700	0720	26	18
0604	1E2P	0828	0833	37	03
0605	3O2P	0113	0119	14	07
0605	3E1P	0825	0838	98	06
0605	3E1P	2324	2352	45	03
0606	3E1P	0552	0616	38	06
0606	2O1P	1314	1318	20	03
0607	1E2P	2136	2142	31	04
0609	2E3A	1725	1733	45	06
0610	2O1P	0224	0228	25	03
0610	4E3P	0403	0415	15	11
0611	*4E1P*	*0445*	*0458*	*04*	*01*
0611	1E2P	1045	1051	26	04
0611	4E1P	1701	1712	07	05
0612	3O2P	0447	0454	32	08
0612	3E1P	1201	1218	95	06
0612	*3E1P*	*2138*	*2204*	*77*	*00*
0613	3E1P	1006	1019	59	06
0613	2O1P	1534	1538	30	03
0614	1E2P	2354	2359	22	04
0616	2E3A	2039	2048	33	06
0617	2O1P	0445	0449	35	03
0618	*1O2P*	*1139*	*1141*	*01*	*05*
0618	1E2P	1303	1308	18	04
0619	3O2T	0824	0832	36	08
0619	3E1P	1738	1900	19	04
0619	*1E4P*	*2017*	*2019*	*00*	*07*
0619	*3E4P*	*2028*	*2035*	*01*	*07*
0620	*2E4P*	*0444*	*0450*	*00*	*10*
0620	3E1P	1331	1342	83	05
0620	2O1P	1756	1800	40	03
0622	1O2P	0051	0054	05	05
0622	1E2P	0213	0218	13	04
0623- 0624	2E3A	2353	0000	21	05
0624	2O1P	0706	0710	37	02
0625	1O2P	1404	1408	09	05
0625	1E2P	1522	1527	10	04
0626	3O2T	1204	1213	36	08
0626	4O2P	1532	1540	16	09
0626	3O1P	1730	1754	06	06
0626	3O1P	2104	2130	04	04
0627	*4E2P*	*1342*	*1359*	*01*	*02*
0627	3E1P	1639	1649	98	05
0627	2O1P	2017	2020	35	02
0628	4E2P	1921	1935	24	09
0629	1O2P	0318	0322	16	05
0629	4O3P	0354	0409	20	15
0629	1E2P	0432	0437	06	04
0629	*4E3P*	*1007*	*1011*	*00*	*14*
0701	2E3P	0307	0313	05	05
0701	2O1P	0927	0931	27	02
0702	1O2P	1631	1636	22	05
0702	1E2P	1742	1747	04	04
0703	3O2P	1548	1557	22	08
0704	3E1P	1938	1946	91	04
0704	2O1P	2238	2242	20	02
0705	*2O4P*	*0626*	*0629*	*00*	*07*
0706	1O2P	0546	0552	30	05
0706	*1E2P*	*0653*	*0657*	*02*	*05*
0707	*1E3P*	*2028*	*2034*	*14*	*01*
0708	*2E3P*	*0621*	*0624*	*00*	*04*
0708	*2O1P*	*1149*	*1153*	*13*	*02*
0709	1O2P	1901	1907	37	05
0709	*1E2P*	*2004*	*2008*	*01*	*05*
0710	3O2P	1937	1944	07	09
0711	3E1P	2231	2239	64	04
0712	*2O1P*	*0100*	*0103*	*07*	*02*
0713	*1O2P*	*0816*	*0823*	*43*	*06*
0713	*1E2P*	*0912*	*0919*	*01*	*05*
0714	*4O1P*	*0148*	*0154*	*60*	*04*
0714	*4O3P*	*1947*	*1954*	*21*	*04*
0714	*1O3P*	*2200*	*2204*	*08*	*03*
0714	*1E3P*	*2314*	*2320*	*05*	*02*
0715	*2O3P*	*0758*	*0803*	*08*	*03*
0715	*2O1P*	*1412*	*1414*	*02*	*02*
0716	*1O2T*	*2132*	*2139*	*46*	*06*
0716	*1E2P*	*2227*	*2230*	*00*	*05*
0717	*302P*	*2332*	*2334*	*00*	*09*
0719	*3O1P*	*0016*	*0018*	*03*	*04*
0719	*3E1P*	*0121*	*0128*	*39*	*03*
0720	*1O2P*	*1050*	*1056*	*44*	*06*
0720	*1E2P*	*1139*	*1142*	*00*	*05*
0722	*1O3P*	*0101*	*0107*	*23*	*04*
0722	*1E3P*	*0203*	*0208*	*01*	*03*
0722	*1O4P*	*0530*	*0535*	*01*	*06*
0722	*2O3A*	*1128*	*1134*	*23*	*02*
0722	*1O4P*	*1637*	*1650*	*07*	*01*
0723	*1O4P*	*0811*	*0819*	*13*	*05*
0724	*1O2P*	*0007*	*0014*	*38*	*06*
0724	*1E2P*	*0052*	*0054*	*00*	*05*
0724	*3O4P*	*0919*	*0936*	*14*	*14*
0726	*3O1P*	*0318*	*0323*	*20*	*03*
0726	*3E1P*	*0408*	*0414*	*13*	*02*
0727	*1O2P*	*1326*	*1333*	*32*	*06*
0727	*1E2P*	*1406*	*1408*	*00*	*06*
0729	*1O3A*	*0407*	*0414*	*29*	*04*
0729	*1E3P*	*0456*	*0459*	*00*	*04*
0730	*4O3P*	*0658*	*0706*	*19*	*10*
0731	*1O2P*	*0245*	*0252*	*26*	*06*
0731	*1E2P*	*0320*	*0322*	*00*	*06*
0802	*3O1T*	*0619*	*0624*	*40*	*02*
0802	*3E1P*	*0654*	*0658*	*01*	*02*
0803	*1O2P*	*1606*	*1614*	*20*	*06*
0803	*1E2P*	*1636*	*1637*	*00*	*06*
0805	*1O3P*	*0718*	*0726*	*25*	*05*
0807	*1O2P*	*0528*	*0536*	*15*	*06*
0809	*3O1P*	*0918*	*0923*	*37*	*02*
0810	*1O2P*	*1852*	*1900*	*10*	*06*
0812	*1O3P*	*1040*	*1047*	*13*	*05*
0814	*1O2P*	*0819*	*0826*	*06*	*06*
0817	*1O2P*	*2150*	*2157*	*03*	*06*
0819	*1O3P*	*1419*	*1427*	*06*	*06*
0820	*1O3A*	*0318*	*0342*	*29*	*01*
0820	*1E3A*	*0326*	*0353*	*44*	*01*
0820	*1E3P*	*1207*	*1225*	*23*	*06*
0820	*1O3A*	*1219*	*1236*	*29*	*06*
0821	*1O2P*	*1125*	*1131*	*01*	*06*
0824	*3E2P*	*0844*	*0905*	*16*	*09*
0825	*102P*	*0109*	*0116*	*01*	*06*
0826	*1O3P*	*1847*	*1901*	*05*	*06*
0827	*1O3P*	*0102*	*0130*	*27*	*02*
0827	*1E3P*	*0148*	*0215*	*30*	*02*
0827	*1E3P*	*1556*	*1605*	*05*	*05*
0827	*1O3P*	*1627*	*1636*	*15*	*06*
0830	*3O2P*	*0432*	*0541*	*15*	*08*
0830	*3O2T*	*0851*	*1107*	*36*	*05*
0830	*3E2P*	*1131*	*1242*	*98*	*04*
0831	*3E2P*	*1317*	*1338*	*65*	*09*
0831	*3O2P*	*1420*	*1435*	*16*	*09*

The Great Total Solar Eclipse of July 11, 1991

General

The total solar eclipse of 1991 Jul 11 is exceptional for at least five reasons: (1) Its maximum duration of totality is 6 min 58 sec; the longest such between 1973 and 2132. (2) The track of totality will cross several areas that are accessible, densely populated, or both. (3) The Sun will be high and the prospects for fair skies good for some of the path. (4) A group of four bright planets will lie between 24°- 41°E of the Sun. (5) The A.L.P.O. will hold its 1991 Convention in the path of totality; at La Paz, Baja California Sur, Mexico, at a time to coincide with the eclipse.

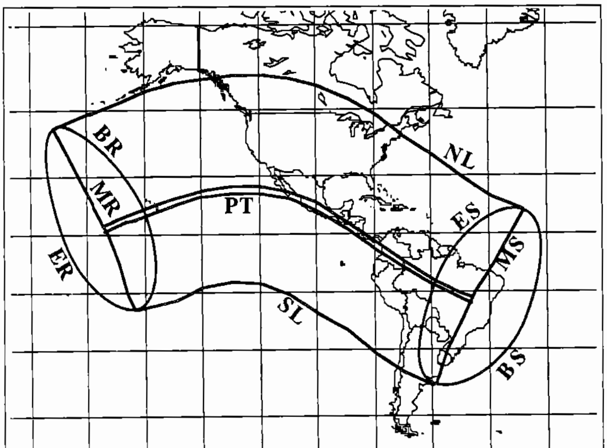

Figure 15. The track of totality and the geographic limits of the total solar eclipse of 1991 Jul 11. Abbreviations are as follows: BR, Eclipse Begins at Sunrise; BS, Eclipse Begins at Sunset; ER, Eclipse Ends at Sunrise; ES, Eclipse Ends at Sunset; MR, Maximum Eclipse at Sunrise; MS, Maximum Eclipse at Sunset; NL, Northern Limit; PT, Path of Totality; SL, Southern Limit.

Totality

The track of totality, and the zone where a partial eclipse can be seen, is shown in *Figure 15* (above right). The total eclipse begins at dawn in the central Pacific Ocean, with the first landfall being the "Big Island" of Hawaii, which will be entirely within the total eclipse path, along with the southernmost shore of Maui. About 80 minutes later, the southern tip of the Baja California peninsula is crossed by the lunar umbra, followed by the coast of mainland Mexico. Mexico City and four Central American capital cities follow, after which totality crosses Colombia in South America, ending at sunset in Brazil.

Table 1 (below) gives data for some sites in the path of totality, where: "1st Contact" is the start of the initial partial phase; "2nd Contact" is the beginning of totality; "3rd Contact" the end of totality; and "4th Contact" marks the end of the final partial phase.

Hawaii will be a popular site for eclipse watchers, with good prospects for fair skies on the leeward (west) coast from Kailua-Kona north. In Baja California, the probability of clear skies is quite good, with the only possible local problem being orographic cumulus clouds in the mountains. Of course, any tropical storm in the area of the Gulf of California will pose a danger for both the southern Baja Peninsula and western mainland Mexico. Otherwise, prospects for clear skies are moderate in the Mazatlán-Puerto Vallarta axis.

Sadly, the chances for cloudiness increase as we go southeast toward Mexico City and past it into Central and South America. In this zone, perhaps the Andes Mountains in Colombia and the Amazon Basin in central Brazil have the best likelihood of clear skies.

Table 1. 1991 Jul 11 Eclipse Data, Selected Locations in Path of Totality.

Location	Universal Time, 1991 Jul 11: 1st Contact	2nd Contact	3rd Contact	4th Contact	Duration of Totality	Altitude of Sun
	h m s	h m s	h m s	h m s	h m	°
Kailua-Kona, HI	16 30 40	17 27 54	17 32 03	18 37 02	4 09	21
Mauna Kea Observatory, HI	16 30 42	17 28 09	17 32 21	18 37 39	4 12	21
La Paz, Mexico	17 23 17	18 47 40	18 54 07	20 18 47	6 27	82
San José del Cabo, Mexico	17 24 59	18 50 12	18 56 37	20 21 37	6 25	83
Mazatlán, Mexico	17 32 42	18 58 49	19 04 30	20 28 25	5 41	88
Tuxpan, Mexico	17 36 06	19 02 26	19 09 22	20 32 34	6 56	90
Mexico City, Mexico	17 54 00	19 20 52	19 27 34	20 47 38	6 42	80
Oaxaca de Juarez, Mexico	18 03 06	19 30 26	19 36 03	20 55 06	5 36	75
Guatemala City, Guatemala	18 22 40	19 47 07	19 52 30	21 07 02	5 23	65
San Salvador, El Salvador	18 27 22	19 51 01	19 56 22	21 09 53	5 21	62
Managua, Nicaragua	18 36 50	19 59 29	20 02 41	21 15 00	3 12	57
San José, Costa Rica	18 45 12	20 05 08	20 10 20	21 19 51	5 12	53
David, Panama	18 51 01	20 09 26	20 14 54	21 22 58	5 28	50
Palmira, Colombia	19 09 58	20 23 16	20 28 12	21 31 55	4 56	39
Manicoré, Brazil	19 39 41	20 42 06	20 46 02	21 41 31	3 56	18

THE PARTIAL PHASES

Possibly more persons will see totality in this eclipse than in any previous one. However, many more will see the July 11th eclipse as partial because the zone of partiality covers most of North and South America. The conditions at a selected few of the places that will lie in the partial-eclipse region are given in *Table 2* (below). Note that the Sun will be more than half-covered by the Moon in the United States south of the approximate line San Francisco–Dallas–New Orleans.

OBSERVING THE ECLIPSE

When watching or photographing any of the partial phases of this eclipse, even if only a thin crescent of solar photosphere is visible, *be sure to protect your eyes and instrument by observing by one of these methods:*

–A full-aperture solar filter (this includes naked-eye views); either: (1) *Two* layers of fully-exposed and processed *black-and-white* film. (2) A No. 14 Welder's Filter. (3) Aluminum-coated glass or mylar (e.g., "SolarSkreen"), heavy enough so that you can *barely* see a lightbulb filament through it.

–Projecting the Sun's image onto a shaded screen: (1) Through the telescope's eyepiece (but this produces an intensely-hot beam near the eyepiece and can damage cemented eyepieces). (2) Through a pinhole. (3) As cast by a mirror covered by a card with a small punched hole; this allows a greater "throw" distance, and thus a larger image, than by a pinhole alone.

Using these methods, it is quite safe to view the partial phases, including making a photographic or video record.

During totality (if you are in its path) no filters need, or should, be used to view or record the prominences and corona. Likewise, no filters need be employed in observing the shadow bands, atmospheric colors and shading, lunar shadow, or planets and bright stars in the darkened sky.

The books and articles listed in the References section on p. 88 give more details on the many forms of observation that you can make during a partial or total solar eclipse. In particular, besides written notes and drawing, the Solar Eclipse Recorder (his address is on the inside back cover) welcomes photographs and videotapes of the sequence of events, whether of the partial phases, the total, or both.

THE SKY DURING THE ECLIPSE

The total phase of this eclipse is unusually long because the Earth is relatively far from the Sun (it being only 5 days after aphelion) and the Moon is relatively near to Earth (9 hours after perigee). This means that the Moon appears noticeably larger than the Sun and that the umbral shadow on the Earth is exceptionally wide. Thus the sky should be quite dark within it. *Figure 16* (p. 88) shows the appearance of the entire sky as seen from La Paz, Mexico, during totality. First, the bright stars Sirius, Canopus, Capella, Rigel, Procyon, Betelgeuse, Aldebaran, Pollux, and Regulus are in the sky. Second, there are four major planets in a band to the east of the Sun:

Table 2. 1991 JUL 11 Eclipse Data, Selected Locations in Zone of Partiality.

Location	Universal Time, 1991 JUL 11: 1st Contact		Maximum		4th Contact		Maximum Obscuration	Altitude of Sun
	h	m	h	m	h	m	%	°
Honolulu, HI	16	31.5	17	29.8	18	35.4	96.3	20
San Francisco, CA	17	11.1	18	20.3	19	33.6	54.8	61
Vancouver, Canada	17	36.0	18	22.2	19	09.8	15.0	55
Seattle, WA	17	32.1	18	22.7	19	14.8	19.6	56
Los Angeles, CA	17	12.3	18	27.8	19	47.1	68.8	67
San Diego, CA	17	12.8	18	30.4	19	51.5	74.2	69
Phoenix, AZ	17	22.7	18	40.6	20	00.0	67.6	74
Tucson, AZ	17	23.9	18	43.6	20	04.4	71.9	76
Denver, CO	17	43.9	18	50.6	19	56.9	37.3	72
El Paso, TX	17	33.0	18	53.4	20	13.0	69.1	80
Kansas City, MO	18	07.1	19	08.9	20	08.4	27.9	71
Dallas, TX	17	56.7	19	11.9	20	23.6	51.5	76
Chicago, IL	18	28.7	19	16.2	20	02.0	12.8	64
New Orleans, LA	18	13.8	19	27.8	20	36.5	49.4	70
Pittsburgh, PA	18	48.5	19	28.0	20	06.0	7.7	58
Atlanta, GA	18	30.3	19	31.6	20	29.0	28.2	63
Washington, DC	18	55.2	19	33.8	20	10.9	7.4	56
New York, NY	19	09.1	19	34.6	19	59.4	2.2	53
Miami, FL	18	41.0	19	49.6	20	51.9	43.5	57
Panama City, Panama	18	56.7	20	15.4	21	24.2	96.2	47
Caracas, Venezuela	19	20.1	20	25.7	21	24.2	61.2	33
Bogota, Colombia	19	12.6	20	26.7	21	31.6	97.3	37
Lima, Peru	19	32.8	20	38.2	21	36.4	48.7	29
Buenos Aires, Argentina	20	10.2	20	46.5	(after sunset)		11.7	1

Mercury (24°E of the Sun, magnitude -0.1), Venus (41°E, -4.5), Mars (39°E, +1.8), and Jupiter (28°E, -1.8). Mars, Venus and the star Regulus will form a compact triangle. During the eclipse, these planets will be above the horizon for all the sites listed in *Table 1* and *Table 2*, with the exception of Hawaii.

Even during the partial phases, Venus should become visible in the daylight sky, and possibly Jupiter as well. One experiment during the total phase would be to determine what the limiting magnitude is in different parts of the sky. If we view the vicinity of the totally-eclipsed Sun with binoculars, the star Delta Geminorum (*Wasat*, visual magnitude +3.53) may be visible, just 13 arc-minutes WSW of the Sun's limb.

Whether or not you are fortunate enough to be in the path of totality for this exceptional solar eclipse, it will be well-worth viewing.

References

Bangert, John A.; Fiala, Alan D.; and Harris, William T. (1989). *Total Solar Eclipse of 11 July 1991*. U. S. Naval Observatory Circular No. 174. Washington, DC: U.S. Naval Observatory (Dec. 7, 1989).

Brewer, Bryan (1991). *Eclipse*. Seattle: Earthview.

Espenak, Fred (1988). *Predictions for the Total Solar Eclipse of 1991*. Greenbelt, MD: N.A.S.A. Laboratory for Extraterrestrial Physics.

Harris, Joel K. (1991). "Travel Tips for the Big Eclipse." *Astronomy*, Vol. 19, No. 6 (June), 68-75.

Heney, Paul J. (1989). *Baja 1991*. Cleveland, OH: Cuyahoga Astronomical Assoc.

Littmann, Mark; and Willcox, Ken (1991). *Totality. Eclipses of the Sun*. Honolulu: University of Hawaii Press.

Rao, Joe (1989). *Your Guide to the Great Solar Eclipse of 1991*. Cambridge, MA: Sky Publishing Corp.

Robinson, Leif J. (1989). "The Big One is Coming!" *Sky & Telescope*, Vol. 77, No. 2 (Feb.), 134-139.

Sweetsir, Richard A.; and Reynolds, Michael D. (1979). *Observe: Eclipses*. Washington, DC: Astronomical League.

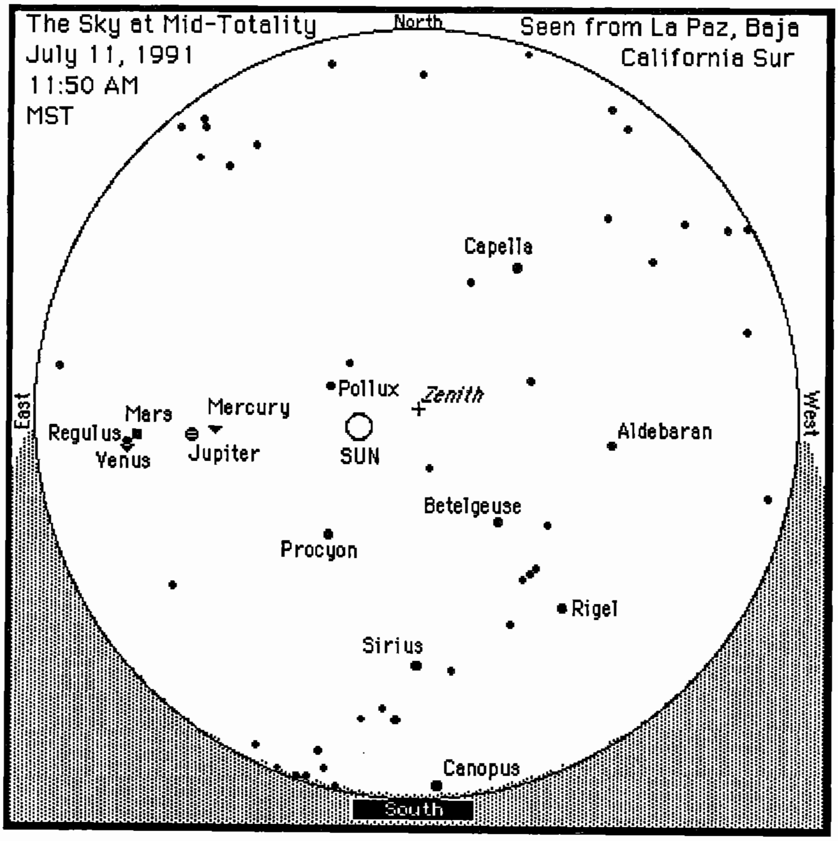

Figure 16. The visible celestial hemisphere during the total phase of the solar eclipse of 1991 JUL 11 as seen from La Paz, Baja California Sur, Mexico. Limiting visual stellar magnitude +2. Based on output from the *Voyager* program © Carina Software.

GETTING STARTED: WHAT TIME IS IT?

By: John E. Westfall, A.L.P.O. Executive Director

Any lunar or planetary observation that we make is useless or at least greatly reduced in value for science unless we record and report the date and time that the observation was made. As pointed out by Walter Haas in a previous issue of this column (Vol. 34, No. 4, November, 1990, p. 178), how precisely the time should be expressed depends on the type of observation. What is our concern here is that, to avoid ambiguities, all times reported should be expressed in the same system—*Universal Time.*

Universal Time (UT), called "Z Time" in the military and aviation, is simply the civil (local mean solar) time used for the Meridian of Greenwich, England (or would be if they never went on Daylight Saving Time).

CONVERTING FROM UT TO LOCAL TIME AND FROM LOCAL TIME TO UT

If you are in most standard time zones, you need only add or subtract an integer number of hours to your civil time to find UT, and the opposite to convert from UT to your civil time. The world system of time zones is mapped in *Figure 17* below. The amount of the correction that you need to add to (+) or subtract from (-) UT to convert to your local *standard* time is given in the table at the bottom of *Figure 17*. This form of conversion is necessary if, for example, you wish to know when a celestial event will occur in terms of your civil time. Remember that if your area is on Daylight Saving Time you need to subtract one hour less if your correction is negative, or add one hour more if the correction is positive.

More often, you will need to convert from your civil time to UT. Use the same numerical value from *Figure 17* but do the opposite of the above: add instead of subtract for a negative correction, or subtract instead of add for a positive correction.

Two more points: Work in terms of the 24-hour clock, it's simpler than "A.M." versus "P.M." and it's the convention for UT. Second, your subtracting can give a negative result—no problem, add 24 hours but subtract one calendar day. If your addition gives a result over 24 hours, subtract 24 hours but add one whole day.

Example 1. A penumbral lunar eclipse begins at 03h 58m UT, 1991 JAN 30. When is this in San Francisco's civil time? Referring to *Figure 17*, we see that San Francisco is in Zone "U" (PST), which has a time difference of -8 hours. This would give a negative result, so: (i) We add 24 hours, changing 03:58 to 27:58; *now* we subtract the 8 hours, giving **19:58 PST** (or 7:58 P.M.). (ii) Having done this, we need to subtract one day, making the local date **January 29, 1991**.

Example 2. You photograph a comet from Arkansas at 3:10 A.M civil time, May 14, 1991. What is the UT? From the figure below, Arkansas is in Zone "S." The indicated correction is -6 hours, but this becomes -5 hours because we are now on Daylight Saving Time. Then, because we are converting from local time to UT, we change the sign and *add* 5 hours to obtain UT. In this case the date remains unchanged, so the final result is **1991 MAY 14, 08h 10m UT.**

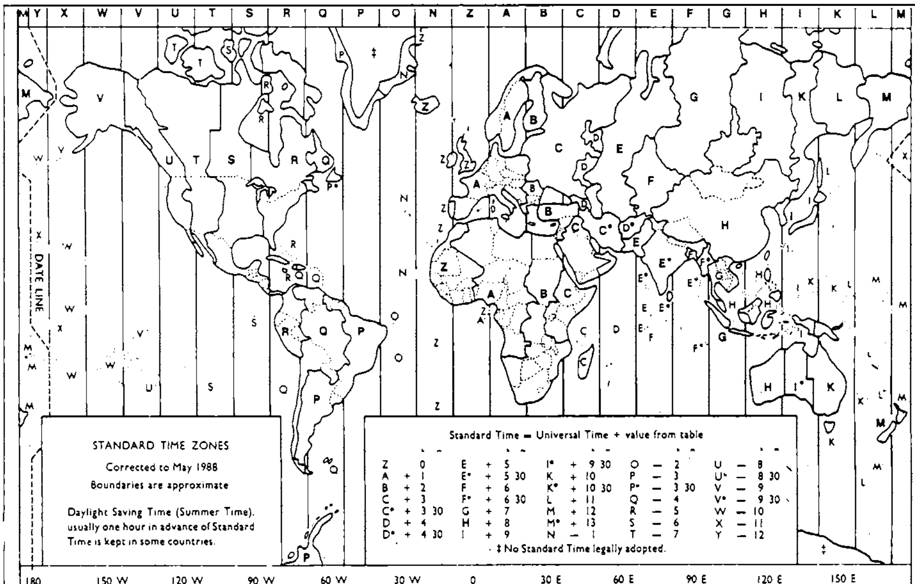

Figure 17. Map of World Standard Time Zones, current to May, 1988. From *Astronomical Phenomena for the Year 1992* (The Nautical Almanac Office, United States Naval Observatory, 1989), p. 22.

Note that we are making a typographical distinction between UT and local civil time: 1991 JAN 14, 15h 16m is UT; but January (or Jan.) 14, 1991, 15:16 is local time. We advise observers to do the same so that, even if they forget to write "UT" or their civil time, the distinction will be clear.

Most people are not familiar with the letter-designated time zones in *Figure 17*. For North America and Hawaii the more commonly-used equivalents; where *ST* is Standard Time and *DT* is Daylight Time, are:

P°—*Newfoundland*; -3h 30m NST, -2h 30m NDT.
Q—*Atlantic*; -4h AST, -3h ADT.
R—*Eastern*; -5h EST, -4h EDT.
S—*Central*, -6h CST, -5h CDT.
T—*Mountain*; -7h MST, -6h MDT.
U—*Pacific*; -8h PST, -7h PDT.
V—*Alaska*; -9h AIST, -8h AIDT.
W—*Hawaii*; -10h HST, -9h HDT.

FINDING THE TIME IN THE FIRST PLACE

The system that you express time in is not relevant if you don't know the time. For many of our observations, where a 1-minute accuracy suffices, radio, television, and telephone voice time announcements can be used, although they use civil time and have to be converted to UT.

For greater accuracy, one can use a *time signal*, which is usually in UT (to be precise, "Coordinated Universal Time" or UTC). If you employ one of these, we suggest that you note your *watch correction*. Many digital watches are accurate to a second per day or better, so you needn't consult a time signal more frequently than that. (Some observers set an extra digital watch to UT and avoid repeatedly having to do conversion arithmetic.)

In the United States, you can obtain telephone UT signals by dialing a toll number: 900-410-8463 (the cost is 50 cents for the first minute and 35 cents for each subsequent minute up to 3 minutes). This number uses land lines to provide 1/40-second accuracy throughout the contiguous United States. In Canada, use 613-745-12576 (English) or 613-745-9426 (French).

Despite the initial investment in a receiver, short-wave radio time signals are less expensive in the long run. They have the added advantage that you can record the time signals in the background when recording observations on a tape recorder or video recorder. Unfortunately, parsimonious governments are cutting back on this service. Stations that we *believe* are currently operating are:

WWV (Fort Collins, CO); 2.5, 5, 10, 15, 20 MHz.
WWVH (Kauai, HI); 2.5, 5, 10, 15 MHz.
CHU (Ottawa, Canada); 3.330, 7.335, 14.670 MHz.
MSF (Rugby, England); 60 KHz.
Y3S (Nauen, Germany); 4.525 MHz.
OMA (Liblice, Czechoslovakia); 50 KHz, 2.5 MHz.
ATA (New Delhi, India); 5, 10, 15 MHz.
VNG (Llandilo, Australia); 5, 10, 15 MHz.
JJY (Sanwa, Japan); 2.5, 5, 8, 10, 15 MHz.
YVTO (Caracas, Venezuela); 6.1 MHz.

TECHNICAL ADDENDUM: WHAT DOES UT MEASURE?

Universal Time (UT or, better, *UT1*) is the mean solar time on the Greenwich Meridian. This linkage with the Sun's position means that UT reflects the Earth's rotation. Sadly, the Earth's rotation is irregular, with a long-term tendency to slow down. Thus UT1 drifts off the more-accurate time given by atomic clocks or by the movements of the Moon and planets. UTC is a compromise between "atomic time" and UT1; it always lags *TDT* (Terrestrial Dynamic Time; equivalent to ET, or "Ephemeris Time," used prior to 1985) by *n*.184 seconds (*n* is an integer; currently 58 sec.) and *TAI* (International Atomic Time) by *(n - 32.184)* seconds. The only way that this can be done is to add or subtract a "leap second" to prevent UTC differing from UT1 by more than 0.7 seconds. This was last done on 1990 DEC 31, 23h 59m 60s, which *preceded* 1991 JAN 01, 00h 00h 00s .

For almost all our observing, UTC is all we need. The *A.L.P.O. Solar System Ephemeris* uses UTC throughout, but does this by assuming the value of "ΔT", the amount that UT1 lags TDT. The assumed lag for 1991 is 58 seconds. Unfortunately, we have to extrapolate this value from recent Earth-rotation history because it can only be accurately determined *after* the date it applies to!

There is, of course, a difference of up to ±0.7 seconds between the UTC that you obtain and the UT (or UT1) that accurately reflects the Earth's rotation. If this difference is of concern, the difference ΔUT1 (equal to UT1 - UTC) is coded on the radio signals as follows: If ΔUT1 is positive, second markers ("beeps") beginning at the 1-second marker of each minute are doubled; if the value is negative, double-markers begin at the 9-second beep. Each such double-marker indicates a 0.1-second positive or negative difference between UTC and UT1.

Fortunately, most A.L.P.O. observers will never have to deal with TDT, UT1, or TAI. However, the motions of the Earth, Moon, planets, and indeed all celestial bodies are initially computed in TDT, so if you make such calculations yourself you will have to deal with that time standard. The distinction between TDT and UTC can make a difference; for example, in timing lunar and planetary occultations or the eclipses and occultations of Jupiter's Galilean satellites, or when computing the paths of totality in future solar eclipses. For example, when the writer first computed the 1991 JUL 11 solar eclipse in the mid-1970's, the extrapolated ΔT value for 1991 was +75 sec., making the northern limit of totality pass several hundred meters south of the south shore of the Hawaiian island of Maui. The more recent estimate of +57.540 sec. changes the predicted path to include about 40 kilometers of Maui's southeast coastline!

Book Reviews

Edited by José Olivarez

End in Fire. By Paul Murdin.
Cambridge University Press. 40 West 20th Street, New York, NY 10011. 1990. 250 pages, Illus., references, index. Price $27.95 cloth (ISBN 0-521-37495-2).

Reviewed by Richard W. Schmude, Jr.

This work is a thorough review of the discovery and scientific results of the supernova that occurred in the Large Magellanic Cloud in 1987. It is well illustrated with figures, drawings and photographs, some of the latter in color. It also contains many tables and references, and a thorough index. Written on an undergraduate level, the work is organized into three main parts which focus on the discovery of the supernova, neutrino observations, and the expansion of the supernova.

The first six chapters deal with the discovery of the supernova and the first few days after its discovery. An "Introduction" defines what a supernova is and discusses some aspects of them, such as their energy and frequency of occurrence. Chapter 2, "The First Two Days: Discovery and Pre-Discovery," treats the discovery and includes the photographs used for the discovery. Chapter 3, "The Astronomers React," covers the frantic moments right after discovery. Many of the large observatories were not prepared for such an occurrence. One problem was that the supernova was too bright for the sensitive detectors in use. One also gets a glimpse into some of the politics involved in obtaining telescope time in order to study this event. The specific star that exploded, along with how scientists identified it, are the main topics of Chapter 4. In the fifth chapter, "The Life of a Supernova Progenitor," we learn how stars are formed and are introduced to the Hertzsprung-Russell Diagram. Chapter 6, "The Explosion of a Supernova," is an overview of stellar physics, and presents the forces that created the explosion. Thus, after reading the first six chapters, one gains an understanding of stellar physics and why the supernova explosion took place.

Chapter 7, "Neutrinos from the Inferno: the Core Collapse of SN 1987A," and Chapter 8, "The Neutrino Observatories and the Supernova Neutrinos," describe these particles and their significance with regard to the supernova. The reader also learns how these elusive particles are detected.

Chapters 9-12 are titled "The Supernova Expands," "Creation of the Elements," "The Neighborhood of a Supernova," and "Neutron Star or Black Hole." They discuss the events that occurred after the supernova explosion. Here we gain insight into the expansion rate of the supernova, how heavy elements such as iron are created, the mass loss of a supernova, and the fate of the remnant of SN 1987A. Some of the techniques that were used in gaining this information, such as speckle interferometry, are also discussed.

Chapter 13, "A Beacon Across Space," described how the supernova can be used as a tool to probe intergalactic space. The final chapter covers the likelihood of another bright supernova occurring the the future, and is titled "SN 1987A and Our Next Supernova."

This book is well written and scientific concepts are adequately presented for the undergraduate-level audience. One problem is that the plate captions are listed behind the index and are not in the same sequence as the plates which they describe. Nevertheless, *End in Fire* gives an up-to-date account of Supernova 1987A and some of the processes that go on in such an event. I recommend this book to anyone who is interested in SN 1987A.

Uranus: The Planet, Rings, and Satellites.
By Ellis D. Miner. Prentice Hall, Book Distribution Center, 110 Brookhill Drive, West Nyack, NY 10995-9901. 1990. 344 pages, Illus., references. Price $59.95 cloth (ISBN 0-13-946880-3).

Reviewed by Julius L. Benton, Jr.

Ellis D. Miner was a project scientist on the Voyager Team at the Jet Propulsion Laboratory, and it is no surprise that much of the content of the book is occupied by an account of the Voyager flyby of Uranus in 1986.

The story unfolds with details relating to planning and administration of the Voyager encounters, problems that took place, and corrective measures. Miner calls attention to the personnel that were involved, along with the computer hardware and software they used.

The information about Uranus in this book is comprehensive, covering the planet and its moons and rings. The description is chronological, which makes interesting reading, allowing one to experience the drama of the Voyager-Uranus encounter as it occurred. The book appeals to the technical specialist as well as the amateur astronomer in its material contents, because information about Uranus was relatively scarce before Voyager.

This volume has numerous illustrations, diagrams, and tables to enhance the reader's understanding of the text. Given the price of the book, it is unfortunate that there are no color photographs! *Uranus* serves the useful function of a meaningful reference volume, particularly for those who do not desire to read it from cover to cover, but who yearn for a specific fact about the planet. The logical layout of the book makes it easy to find data about Uranus quickly, and it has an extensive bibliography and references.

This reviewer recommends the volume to all students of the Jovian Planets, and it fits in well with books already in print on the Voyager rendezvous with Jupiter, Saturn, and Neptune, supporting rigorous exercises in comparative planetology.

NEW BOOKS RECEIVED

Notes by José Olivarez

The British Astronomical Association: The First Fifty Years. By Howard L. Kelly and Richard McKim. British Astronomical Association, Burlington House, Piccadilly, London W1V9AG, England. 1989. 132 pages. Price £8.00 paper postpaid.

This history of the BAA from its founding in 1890 until 1940 was first published in 1948 and has long been out of print. It has been reprinted for the BAA's Centenary Year with the addition of 50 rare photographs depicting all the past presidents; and selected famous members, observatories, and observations.

The number of copies available is limited, so orders should be submitted as soon as possible. An upcoming companion volume, *The Second Fifty Years*, will bring the story up to date. A.L.P.O. members should find the history of the BAA interesting reading, particularly because it is the astronomical association after which the A.L.P.O. was largely modeled.

Rockets Into Space. By Frank H. Winter. Harvard University Press, Cambridge, MA 02138. 1989. 156 pages. Price $22.50 cloth (ISBN 0-674-77660-7).

Rockets Into Space is an authoritative guidebook for all who are interested in the history of the development of the modern launch vehicle. It surveys the history, current development, and possible future of space boosters, from the work of the pioneers to the complex events of the last three decades. Although brief, this book fills a significant gap, because most books on rocketry are general histories that cover the entire field from weapons to boosters, or are studies focussed upon specific vehicles. This work also traces, where possible, key technological trends and ideas that led to the successful evolution of launch vehicles.

Rockets Into Space is the first volume in a new Harvard University Press series, *Frontiers of Space*, that will explore the various facets of space science and technology. The author, Frank J. Winter, is Assistant Curator in the Space Science and Exploration Department of the National Air and Space Museum, Smithsonian Institution.

Astronomy With Your Personal Computer, Second Edition. By Peter Duffett-Smith. Cambridge University Press, 40 West 20th Street, New York, NY 10011. 1990. 258 pages. Price $59.50 cloth (ISBN 0-521-38093-6), $24.95 paper (ISBN 0-521-38995-X).

This book is for those who wish to use their personal computer to make astronomical calculations with a minimum of fuss. It is not specific to any make of machine, and you are not confined to specific calculation. Rather, you are given a set of linking subroutines, each doing a specific task, which you can combine to form a complex program designed to your own requirements. You need have only a broad understanding of the problem; the subroutines themselves take care of the details. Also, this edition has several new routines and more handling programs, in response to requests from users of the first edition. The 30 useful programs in this book are also on floppy disks for some computers, available from the author on request at additional cost.

Black Holes and the Universe. By Igor Novikov. Cambridge University Press, 40 West 20th Street, New York, NY 10011. 1990. 176 pages. Price $39.50 cloth (ISBN 0-521-36657-7), $14.95 paper (ISBN 0-521-36683-6).

Black holes are the most-condensed state of matter in the Universe, and this book is a guide to their properties and importance. In this translation from a Russian edition, Igor Novikov accounts for the physical environment of a black hole, explains how astronomers search for them, and places them in the context of the expanding Universe. In short, this is a guide to the most intriguing form of cosmic matter discovered by modern physics and should appeal to those who love profound scientific mysteries. Also, perhaps to further underscore the book's non-technical approach to the subject at hand, the text is peppered with attractive pen-and-ink cartoons.

Cambridge Air and Space Dictionary. By Peter M.B. Walker, ed. Cambridge University Press, 40 West 20th Street, New York, NY 10011. 1990. 216 pages. Price $29.95 cloth (ISBN 0-521-39439-2), $12.95 paper (ISBN 0-521-39763-4).

The *Cambridge Air and Space Dictionary* is unique, being concerned with the sciences and technologies of everything above the Earth's surface. It has been developed from the database of the acclaimed *Cambridge Dictionary of Science and Technology*, with many new and revised definitions. It contains some 6,000 definitions, including 1,500 in aeronautics, 600 in astronomy, 500 in meteorology, and 400 in space and radar. The aim has been to be a comprehensive treatment of subjects which interact with each other in many ways; Aircraft and Meteorology, and Spacecraft and Astronomy, are examples.

There are also special illustrated articles on separate panels, giving more detailed information on major topics. Overall, this book is an excellent reference resource for teachers, students, aeronautical engineers, and technical or scientific writers.

ANNOUNCEMENTS

ASSOCIATION BUSINESS

***Upcoming A.L.P.O. Convention.*—**As announced in previous issues, we will hold our 41st convention as part of the *Symposium for Research Amateur Astronomy*, to be held at the Hotel Palmira in La Paz, Baja California Sur, Mexico, on July 7-12, 1991. One drawing point of this meeting is the fact that the total solar eclipse that is described on pp. 86-88 of this issue will give our meeting 382 seconds of totality on July 11th.

The tentative program for this meeting is as follows. *Sunday evening, July 7*—Welcome Party. *Monday, July 8—Registration;* Paper Sessions: Archaeoastronomy, Amateurs and Research, Solar System; Public Star Party (evening). *Tuesday, July 9*—Paper Sessions: Public Education, Comets, International Organizations, Electronic Observing, Professional Research, Historical, Problem-Solving. *Wednesday, July 10*—Paper Session and Workshop: The Sun and Solar Eclipses; Forum: International Union of Amateur Astronomers Business Session. *Thursday, July 11*—TOTAL SOLAR ECLIPSE; Celebration Banquet and Party (optional). *Friday, July 13*—Historical Tour to Los Cabos (optional); Star Party (evening).

A.L.P.O. papers will be given mainly on Monday, with some comet and solar papers on Tuesday and Wednesday morning. We will also have our usual Members' Meeting, Board of Directors' Meeting, and A.L.P.O. exhibits.

The above paragraphs are intended mainly for those who have already made their convention arrangements. *Registration spaces are still available, but we can no longer make transportation or lodging arrangements.* Thus, if you have already made plans, on your own or as part of a group, to be in Baja California Sur during eclipse week, you are still welcome to register and attend our Symposium.

***Mars Recorder Moves.*—**Effective July 1, 1991, the address of Mars Assistant Recorder **Carlos E. Hernandez** will be: 8691 S.W. 32nd Terrace, Miami, FL 33155.

***Foreign Mailing Experiment.*—**A.L.P.O. members who live outside of North America often report that it takes them 2-3 months to receive their copies of *Journal, A.L.P.O.* For this issue, we are using a commercial foreign-air-mailing service for such persons; the firm estimates that they can deliver our Journal in 7-14 days. Because this service is somewhat more expensive than the surface mail we have been using, *we would like to hear from our overseas members as to when they receive their copies of this issue.* If service is indeed significantly improved, it is likely that we will continue this service although a small dues increase for overseas members would probably be warranted.

***Foreign Membership Fund.*—**This fund, referred to in the immediately previous issue, remains distressingly low. Indeed, A.L.P.O. memberships have now expired for several deserving foreign amateurs. Unfortunately, we continue to have a balance of only $17, sufficient for just one such complimentary membership. Donations of any amount are very welcome; remember that they may well be tax-deductible for you. Contributions 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.

***Hubble Space Telescope Proposal Dead-Line Extended.*—**As announced in our July, 1990 issue, the amateur observing program for the Hubble Space Telescope (HST) has been extended to a second year. Despite the HST's spherical-aberration problem, *four of the five amateurs whose proposals for the first year were accepted will be able to conduct their observing programs.* Thus the Amateur Astronomy Working Group (AAWG), which evaluates amateur proposals, continues to encourage submissions, even if in some cases project execution may have to wait for the HST to be repaired.

The A.L.P.O. is represented on the AAWG and naturally hopes to see many good Solar System projects submitted. Thus, *we are pleased to announce that the deadline for submission of proposals has been extended to July 31, 1991.*

The first step in doing your proposal is to send for an application form and a handbook that describes the technical capabilities of the HST. Address your request to:

Janet Mattei
The American Association of Variable Star Observers
25 Birch Street
Cambridge, Massachusetts 02138.
(Telephone 617-354-0484).

OTHER ORGANIZATIONS: LOTS OF MEETINGS

***Astronomical Society of the Pacific.*–**The first of this summer's major meetings is the 103rd Annual A.S.P. Meeting, held at the University of Wyoming, Laramie on June 22-28, 1991. Some of its events are technical symposia on high-resolution astronomy (June 25-27), robotic telescopes (June 22-24), astronomy in the 1990's (June 24), and on the history of astronomy (June 26). There will also be *Universe '91*, consisting of nontechnical lectures on new developments in astronomy and amateur astronomy, along with a workshop on teaching astronomy (June 22-23). To find out more, call the A.S.P. at 415-337-1100, or write: Wyoming Meeting Info., A.S.P., 390 Ashton Avenue, San Francisco, CA 94112.

ALCON '91—45th Astronomical League Convention.—This major east-coast meeting is on August 7-9, 1991, at the University of Massachusetts in Amherst, Massachusetts. There are numerous guest speakers, reports on the July 11th solar eclipse, workshops, commercial exhibits and swap tables, and observing with the 18-inch Clark Refractor of Amherst College. Note that *Stellafane*, the famous annual star party in Vermont, is held immediately following on August 10-11, about a 75-minute drive distant. For information, contact: John Reed, ATMoB/ALCON'91, 1437 Mass. Avenue, Lexington, MA 02173.

Western Amateur Astronomers.–The annual W.A.A. conference will meet on August 7-11, 1991 at Mammoth Lakes, California. This excellent dark-sky location is on the east slope of the Sierra. Amateur paper sessions will include a July 11th solar eclipse roundup. There will be a Perseid Meteor Shower Star Party. Optional field trips will visit the Inyo Craters, Mono Lake and Mono Craters, the ghost town of Bodie, and other places. For conference information and registration, write: Margaret Matlack, 13617 E. Bailey Street, Whittier, CA 90601.

International Conference on Near-Earth Asteroids.—Several astronomical and space organizations are sponsoring this conference on the nature and observation of near-Earth asteroids, their role in Earth's history, the present risk they pose; and their utilization for science, space flight, and natural resources. The meeting will be on June 30-July 3, 1991, at the San Juan Capistrano Research Institute, San Juan Capistrano, California. To obtain more information, contact: Dr. Clark W. Chapman, Planetary Science Institute/SAIC, 2421 E. 6th Street, Tucson, AZ 85719 (telephone 602-881-0332; FAX 602-881-0335).

Gordon Research Conference on the Origins of Solar Systems.—This meeting is on July 8-12, 1991, at Colby-Sawyer College in New London, New Hampshire. Nine paper sessions have the titles: Star Formation, Comets and Planetary Volatiles, Physical and Chemical Processes in the Solar Nebula, Violent Activity Associated with Young Stars, Search for Protostars and Planetary Systems, Meteoritic Components, Planetary Accumulation, Planetary Evolution, and Comparative Planetology. With a maximum of 135 conferees, all spaces may already be filled. To find out more, telephone 603-526-2870 (FAX 603-526-4717).

CCD School.—This is a 3-day series of lectures at Hotel Park, Tucson, Arizona on September 5-7, 1991. It is intended for novice and potential CCD users. Some tentative topics are: introduction to CCD's, noise sources and reduction processes, photometric methods and standard magnitude systems, time series and differential photometry, astrometric techniques, Solar System observations, point-source spectroscopy, extended spectroscopy, and IR arrays. We do not know the cost yet, but limited travel support may be available from the National Science Foundation. For further information, write: Steve B. Howell, Chair, CCD School, Planetary Science Institute, 2421 E. 6th Street, Tucson, AZ 85719 (telephone 602-881-0332).

Division for Planetary Sciences.—The 23rd annual meeting of the DPS will be held in Palo Alto, California at Rickey's Hyatt House hotel, on November 4-8, 1991 (Monday-Friday). This is one of the two major annual planetary science meetings, the format involving *hundreds* of short papers, longer invited papers, poster sessions, workshops, "NASA Night," a banquet, and a public session. Paper abstracts will be distributed in a program book. The meeting host is the Space Science Division of NASA Ames Research Center. To be placed on the mailing list, contact the conference conference coordinator: Pam Jones, Program Services, Lunar and Planetary Institute, 3303 NASA Road 1, Houston, TX 77058 (telephone 713-486-2150; FAX 713-486-2160).

New A.S.P. Catalog.—The Astronomical Society of the Pacific has recently issued their 32-page *Summer 1991 Astronomy Catalog*, which includes slide sets, video tapes and disks, audio tapes, computer software, observing aids, and posters covering all branches of astronomy. There is a wide selection of Solar System materials. For a copy, send your name and address with two first-class stamps to; ASP, Catalog Requests Dept., 390 Ashton Avenue, San Francisco, CA 94112.

PUBLICATIONS OF THE ASSOCIATION OF LUNAR AND PLANETARY OBSERVERS

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

◆◆

Order from: Mark Davis, Pioneer Apts., Apt. E-10, Christiansburg, VA 24073, U.S.A.

The A.L.P.O. Solar System Ephemeris: 1991. $6.00 in the United States, Canada, and Mexico; $8.50 elsewhere (airmail included). 115 pages of tables, graphs, and maps describing the positions and appearances of the Sun, Moon, each major planet, the readily observable planetary satellites, Minor Planets, meteors, and comets. Make payment to "A.L.P.O."

◆◆

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

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

◆◆

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

① ***A.L.P.O. Section Directory--1991/92.*** *Free*; just send a stamped, self-addressed envelope. An 8-page description of each Observing Section's personnel, projects, and publications.

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

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

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

1 (1947); 6. *8* (1954); 7-8. *11* (1957); 11-12. *20* (1967-68);9-10.
21 (1968-69); 3-4 and 7-8. *23* (1971-72); 3-4, 7-8, 9-10, and 11-12.
25 (1974-76); 1-2, 3-4, 7-8, and 11-12.
26 (1976-77); 1-2, 3-4, 5-6, and 11-12 [each $1.75].
27 (1977-79); 3-4, 5-6, 7-8, 9-10, and 11-12 [each $1.75].
28 (1979-81); 3-4 [each $1.75]. *31* (1985-86); 1-2, 3-4, 5-6, and 9-10 [each $2.50].
32 (1987-88); 1-2, 5-6, and 11-12 [each $2.50].
33 (1989); 1-3, 4-6, 7-9, and 10-12 [each $2.50]. *34* (1990); 1, 2, and 4 [each $2.50].
35 (1991); 1 [$2.50].

Current Issue [*35*, 2]—$3.00.

KEEPING YOUR MEMBERSHIP CURRENT—

Because all regular A.L.P.O. memberships include a subscription to the *Strolling Astronomer (J.A.L.P.O.),* the top line of your mailing label gives the volume and issue number for which your membership will expire (e.g., "35.2" means Volume 35, Number 2). We also include a *Renewal Notice* in that issue.

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

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

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

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

THE ASSOCIATION OF LUNAR AND PLANETARY OBSERVERS

Founded in 1947, the A.L.P.O. now has approximately 700 members. Our dues include a subscription to this quarterly Journal, *The Strolling Astronomer*, and are $14.00 for one year ($24.00 for two years) for the United States, Canada, and Mexico; and $16.00 for one year ($29.00 for two years) for other countries. One-year Sustaining Memberships are $20.00; Sponsorships are $40.00. Associate Memberships, which do not include a Journal subscription, are $3.00 per year. There is a 20-percent surcharge on all memberships obtained through subscription agencies or which require an invoice.

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

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

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